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INTRODUCTION

We had the great honor of organizing the ICSAR 2024. It was truly a great pleasure for us togreet a lot of participants from many different countries attending ICSAR 2024! We firmly believe that the conference will become an important international event in the field of cross-industry discussion about innovations in Academic Studies.

ICSAR 2024 was organized by All Science Academy located in Konya, Turkey.

Three cooperating organizations supported the two-day conference. There were 426 papers accepted for presentation at ICSAR 2024, contributed from different countries. We had plenary speeches and several well-known scientists and experts, to give invited talks at differentsessions.

The purpose of ICSAR 2024 was to provide a forum for the participants to report and review innovative ideas, with up-to-date progress and developments, and discuss novel approaches to the application in the field of their own research areas and discuss challenges of doing science.

We sincerely hope that the exchange of ideas on doing research, science and improving education will help the participants, and international cooperation sharing the common interest will be enhanced.

On behalf the Organization Committee of ICSAR 2024, we would like to heartily thank our cooperating organizations for all they have done for the conference. We would also like to thank the authors for their contribution to the proceedings; the participants and friends of ICSAR 2024, for their interest and efforts in helping us to make the conference possible; and the Editorial boards for their effective work and valuable advice, especially the ICSAR 2024 secretariat and the ICSAR 2024 staff, for their tireless efforts and outstanding services in preparing the conference and publishing the Proceedings.

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84	Impedance Modeling and Stability Analysis of Renewable Energy Sources with LCC-Based HVDC Power Transmission	Sarfraz Anwar, Syed Nasir Shah, Muhammad Zafar, Muddassir Ali	Pakistan, Pakistan, United Arab Emirates, Pakistan	Submission 1346
85	Breakthrough in Shear Viscosity Prediction: Superior Performance of ANN and Swarm Intelligence in Starch Suspensions	Mohamed Kouider Amar, Achouak Madani, Faiza Omari	Algeria, Algeria, Algeria	Submission 1349
86	Transport parameters of a homogeneous DBD discharge of the Ar - NH3 gas mixture	Barkahoum LAROUCI, Amar Benmoussa, Ahmed BELASRI, Soumia BENDELLA	Algeria, Algeria, Algeria, Algeria	Submission 1350
87	Ferrofluid flow through an annulus	Jaswinder Singh Mehta	India	Submission 1352
88	Maximum Power Point Tracking Based on FLC Using DC/DC Boost Converter for PV System	Kellal Cherif, Mazouz Lakhdar, Ouacel Abdelkader, Kouzou Abdellah, Matilde Pietrafesa	Algeria, Algeria, Algeria, Algeria, Italy	Submission 1353
89	Tuning the PI controller for optimum performance in a VSC based HVDC system	Kellal Cherif, Mazouz Lakhdar, Ouacel Abdelkader, Kouzou Abdellah, Matilde Pietrafesa	Algeria, Algeria, Algeria, Algeria, Italy	Submission 1355
90	Effect of milking frequency on the hygienic and nutritional quality of raw milk in the Mid-Northern region of Algeria	SILARBI Tayeb, LAABAS Saadiya, CHAHBAR Mohamed, TEFIEL Hakim, GADOUM Abdelkader, ABDELLAH Fatiha, HAMDEN Khaled	Tunisia, Algeria, Algeria, Algeria, Algeria, Tunisia, Tunisia	Submission 1356
91	A comparison of FEM and FIT techniques for the optical modeling methodology used in the new nanostructured hybrid STPV cells	Oussama Baitiche, Fathi Bendelala, Ali Cheknane	Algeria, Algeria, Algeria	Submission 1426
92	Design and Simulation of Logic Circuits Using Phase Change Materials in a Kagome Structure	Ibrahim CINAR	Turkey	Submission 1500
93	The Effects of Lycopene on Health and Fields of Use	Halil İbrahim Binici, Adem Savaş	Turkey, Turkey	Submission 1532
94	Süspansiyon Parçalarından Rot mili Parçasının Yağlama Operasyon Sürecinin Ürün Performansına Etkisinin İncelenmesi	Semih KÖSE, Muhammed Abdullah ÖZEL, Mehmet Yasin GÜL	Turkey, Turkey, Turkey	Submission 1479
95	DFT study and Spectral Analysis of a novel synthesized ketone derivative	SMATI Sabrina, BOUKABCHA Nouredine, MENAD Karima, CHOUAIH Abdelkader	Algeria, Algeria, Algeria, Algeria	Submission 1334
96	Processing of data from a PCR-RAPD genetic fingerprint by UPGMA (Unweighted Pair Group Method With Arithmetic)	LAABAS Saadiya, CHAALAL Hichem, SILARBI Tayeb	Algeria, Algeria, Tunisia	Submission 1358
97	Antimicrobial properties of thyme (Thymus vulgaris L.) essential oil	Amara Nacira, Amara Sabrina, Touati Souad	Algeria, Algeria, Algeria	Submission 1361
98	Therapeutic effect of curcuma longa L and geranuim rosat Pelargonium Graveolens essential oils against lead acetate-induced testicular toxicity	Nacera Boulila, Lynda Lakabi, Massinissa Madouche, Samira Oudahmane-Akdader, Assia Kamel, Menad Rafik, Ferroudja Bensaad-Medjdoub	Algeria, Algeria, Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1363
99	Exploring the impact of allelopathic crops on surrounding competitorscometitors in Agricultural systems	Soltane Sabrine, Benmeddour Tarek	Algeria, Algeria	Submission 1364
100	Global and local stability analysis of a heroin epidemic model	Zirar Imane Hana, Lakmeche Abdelkader, Touaoula Mohamed Tarik, Helal Mohamed, Bensid Yazid	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1365
101	Fabrication Of Flexible Thin Film Substrates By The Extraction Of CNCs From Cellulosic Materials	Abdul Basit, Hafeez Anwar	Pakistan, Pakistan	Submission 1366
102	Enhancing Electricity Theft Detection in Smart Grids Using Temporal Convolutional Attention Networks and Variational Autoencoders	Hafiz Muhammad Azeem Akram	Azerbaijan	Submission 1371
103	Energy Efficiency in Gas Turbine Cooling: Techniques and Computational Fluid Dynamics Analysis Using ANSYS Fluent	Kamal ABOUELMAJD, Isamil LAGRAT	Morocco, Morocco	Submission 1375
104	Phase transitions in magnetic materials magnetic materials: Application to energy storage and heating systems	Abdelhak Boukhal, Youssef Chegrane, Nabil Hachem, Mohammed El Bouziani	Morocco, Morocco, Morocco, Morocco	Submission 1378
105	Control by AES spectroscopy and photoluminescence of Oxygen point defects in	Zakia.LOUNIS, M.Salah HALATI, Moussaab BELARBI,	Algeria, Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1379

	SnO2 thin films	Malika ACHOURI, Djamel GHAFFOR, Chawki Zegadi		
106	Evaluation of Antibacterial Activity of Thymus vulgaris Extracts	Khiari Mohamed, Kechrid Zine	Algeria, Algeria	Submission 1383
107	On the regularity in Colomeau's algebra	Mohamed Helal, Mohamed El Amine Kherarba	Algeria, Algeria	Submission 1384
108	Machine Learning Supported Antenna Design for UHF RFID Applications	Emre Aksoy, Merih Palandöken	Turkey, Turkey	Submission 1524
109	Ochratoxin-A Toxicity in Broiler Birds and its Amelioration with N-Acetylcysteine Supplementation	Muhammad Imran, Muhammad Kashif Saleemi, Al-Hafiza Shafia Tehseen Gul, Aisha Khatoon, Mughees Aizaz Alvi, Muhammad Imran	Pakistan, Pakistan, Pakistan, Pakistan, Pakistan, Pakistan, Pakistan	Submission 1392
110	Three-Dimensional Analysis of Free Vibration of Sandwich Plates with Composite Laminated Face Sheets and a Porous Functionally Graded Core	A. Guenanou, M. Hachemi, M.S.E. Hamroun, F. Touahra, R. Chebout, K. Bachari	Algeria, Algeria, Algeria , Algeria, Algeria , Algeria	Submission 1396
111	Analysis of Porous Sandwich Plates FGM Subjected To Free Vibration	MERDACI Slimane, HADJ MOSTEFA Adda, BOUCHAFA Ali	Algeria, Algeria, Algeria	Submission 1410
112	AI-Powered Fault Detection in MPPT Algorithms Utilizing Artificial Neural Networks for Enhanced Photovoltaic System Performance	Abdelouadoud Loukriz, Mohamed Dahmani, Zine Elabadine Dahmane, Abderrahim Zemmıt	Algeria, Algeria, Algeria, Algeria	Submission 1411
113	Sıhhi Seramik Makinesi Milinin Statik Yük Altında İncelenmesi	Fatih Karpat, Mehmet Kıvanç Turan, Murat Mandıracı	Turkey, Turkey, Turkey	Submission 1516
114	Control Battery Storage Strategy in Stand-Alone Photovoltaic Systems: A Study Under Irradiation Effects	Layate Zakaria, Bahi Tahar, Lekhchine Salima	Algeria, Algeria, Algeria	Submission 1519
115	Servis Uygulamaları İçin Kural Tabanlı Proses Takip Yazılımının Geliştirilmesi	Cengiz SERTKAYA, Fidan Khalilbayli	Turkey, Turkey	Submission 1526
116	Microalgae Based Bioplastics and Their Utilization as Fertilizer	Wiem Jebahi, Bengü Özuğur Uysal	Turkey, Turkey	Submission 1533
117	Farklı Gedik Tiplerinden Kaynaklanan Ani Baraj Yıkılması Akışının Bir Binaya Etkisinin Sayısal Olarak İncelenmesi	Emrah Sevinç	Turkey	Submission 1551
118	Effects of Supplemental Feeding of Fenugreek and Fennel Seeds on Milk Production Properties in Assaf Sheep	Ömer Berk KARABACAK, Birol DAĞ	Turkey, Turkey	Submission 1563
119	Myofascial Release Exercises in the Treatment of Plantar Fasciitis: A Traditional Review	Mehmet SÖNMEZ	Turkey	Submission 1567
120	Free Vibration Analysis of Functionally Graded Nanoplates	Soufiane Benounas, Mohamed-Ouejdi Belarbi	Algeria, Algeria	Submission 1413
121	Bending Analysis of Functionally Graded Nanoplates	Soufiane Benounas, Mohamed-Ouejdi Belarbi	Algeria, Algeria	Submission 1414
122	Bending Analysis of Functionally Graded Sandwich Hyperbolic Paraboloid Shells with Different Boundary Conditions	Soufiane Benounas, Mohamed-Ouejdi Belarbi	Algeria, Algeria	Submission 1415
123	Hysteresis behavior of a graphene monolayer in the presence of a transverse crystal field	M. Salama, T. Mouhrach, N. Hachem, E.B. Choubabi	Morocco, Morocco,Morocco,Morocco	Submission 1420
124	Analyzing Fuzzy Differential Equations: Application of Tarski's Fixed Point Theorem to Establish Solution Existence and Uniqueness.	Bellabes Zineb, Naima Boussekine	Algeria, Algeria	Submission 1422
125	Polyamide-Graphene oxide: synthesis, characterization, and electrochemical properties for different applications	Assia Tounsi, Ouafia BELGHERBI, Leila LAMIRI, Boussaha BOUCHOUL, Meriem MESSAOUDI, Nourdinne BOUMAAZA, Farid HABELHAMES, Ahmed BAHLOUL	Algeria, Algeria, Algeria, Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1423
126	Study of the effect of marble powder on the subsidence potential	Mohamed DACHER, Ouassila BAHLOUL, Samir BENMOUSSA, Chafai BECHTELLA	Algeria, Algeria, Algeria, Algeria	Submission 1424
127	Optimization of Robotic Manipulator Structure for Strawberry Harvesting Applications	Inas SAOUD, Asaad CHAHBOUN	Algeria, Algeria	Submission 1430
128	Bioethanol Production by Alcoholic Fermentation Using Saccharomyces cerevisiae and Valorization of Prickly Pear Juice Waste	FERROUDJ Nawal, BENSEFIA Chaima, KAHALERRAS Fatma	Algeria, Algeria, Algeria	Submission 1431
129	Influence of Urban Play Areas on Children's Social Integration in Cities	Marouane Samir Guedouh, Mohamed Amine Khadraoui, Soumaya Besbas	Algeria, Algeria, Algeria	Submission 1436
130	Numerical optimization of the workpiece positioning errors	CHAMI M, RAHOU M, SEBAA F	Algeria, Algeria, Algeria	Submission 1439
131	THE INFLUENCE OF THE ELECTRIC FIELD ON THE ELECTRONIC AND MECHANICAL PROPERTIES OF NONOTUBES	BAIRA Fayçal	Algeria	Submission 1447

132	Analysis of the mechanical properties of biopolymer - natural filler composite systems	Marcell János Tóth, Annamária Polyákné Kovács	Hungary, Hungary	Submission 1453
133	Flexural and thermal characterization of a lightweight clay and sawdust based compressed bricks	Belkacem MEZIANI, Mohamed Amin BOUZIDI, Chabane SI AHMED	Algeria, Algeria, Algeria	Submission 1459
134	Characterization and bioactivity of lepidium sativum seeds polysaccharide	Achat yasmine, Lefsih Khalef, Boulekbache Lila, Djenad Fatima, Beddar Siham, Idir Sabrina	Algeria, Algeria, Algeria , Algeria, Algeria , Algeria	Submission 1461
135	Plakanın Serbest Titreşiminde Öz değerlerin Galerkin Yöntemiyle Bulunması	Birkan DURAK	Turkey	Submission 1560
136	Modeling the Stability of Nanofluids Using Artificial Neural Networks and Investigating Their Effects on Thermal Conductivity	Fevzi SAHIN	Turkey	Submission 1571
137	İÇSEL PAZARLAMA UYGULAMALARI VE ÖRGÜTSEL BAĞLILIK İLİŞKİSİNİN İŞ PERFORMANSINA ETKİSİ: BARTIN ÜNİVERSİTESİ'NDE BİR ÇALIŞMA	Gizem BAYLANÇİÇEK, Selman KARAYILMAZLAR	Turkey, Turkey	Submission 1575
138	Microorganisms isolated from local soil as a tool for efficient bioremediation	Barbara Bertović, Monika Šabić Runjavec, Marija Vuković Domanovac	Croatia, Croatia, Croatia	Submission 1603
139	Artificial Intelligence Supported Optimization of Nanofluid Usage in PV Panel Cooling	Omer GENC	Turkey	Submission 1607
140	IMPACTS OF CLIMATE CHANGE ON THE PRODUCTIVITY OF TOBACCO CROP IN PAKISTAN	Haroon Khan, Ömer Süha Uslu, Osman Gedik	Turkey, Turkey, Turkey	Submission 1522
141	A multi-objective scheduling of renewable energy sources in a smart grid system	Rameez Hassan, Muhammad Bilal, Hasnain Ali Shah, Fazal Muhammad	Pakistan, Pakistan, Pakistan, Pakistan	Submission 1601
142	Migration Processes in Azerbaijan and their Effects on the Sustainable Development of the Enterprise Economy	Maryam Adli	Azerbaijan	Submission 1261
143	Numerical study of the effect of focusing the absorber relative to the mirror in a parabolic trough concentrator (PTC) on mixed convection	Hassene Boutelis, Dalila Titouna, Ammar Benderradji, Lazhar Serir	Algeria, Algeria, Algeria, Algeria	Submission 1344
144	Regional Consensus on Political Settlement to the Principal Conflicts in Afghanistan	Maria Adli	Azerbaijan	Submission 1460
145	Evaluation of The Nanotoxicity of TiO2-NPs on Wistar rats	Sara BOUZENZANA, Rachid ROUABHI, Tahar GOUDJIL, Abdellali BOUZENZANA	Algeria, Algeria, Algeria , Algeria	Submission 1465
146	An Innovative Program to Train Future Nobel Laureates Belonging to Türkiye and Pakistan	Syed Arif Kamal	Pakistan	Submission 1469
147	Water trapping Technical changes in barrier trap selectivity for the management of coastal lagoons	Zakaria Adjou, Djamila Boufades, Mustapha Miloudi	Algeria, Algeria, Algeria	Submission 1470
148	Experimental investigation of the efficiency of CO2 enhanced oil recovery (CO2-EOR) in sandstone cores from an Algerian oil field using NMR technology	Zakaria Adjou	Algeria	Submission 1471
149	Thermal and mechanical properties of lightweight mortar and its constituents at elevated temperatures	Mohamed sadak Merrakchi, Smain Benyamina	Algeria, Algeria	Submission 1473
150	Hidden Curriculum: Shaping Students' Character in Religious Studies	Doni Abadi Nababan, Tetty Suriani, Marlen Bailao, Joice Patty	Indonesia, Indonesia, Indonesia, Indonesia	Submission 1477
151	Experimental Analysis of High-Velocity Impact Damage in CFRP Laminates	Mustapha RABOUH, Kamel ZOUGGAR, Khelifa GUERRAİCHE	Algeria, Algeria, Algeria	Submission 1483
152	Modeling and Analysis of Impact-Induced Damage in Carbon Fiber Reinforced Polymer Composites Using ABAQUS	Mustapha RABOUH, Kamel ZOUGGAR, Khelifa GUERRAİCHE	Algeria, Algeria, Algeria	Submission 1484
153	Structural and tribological behaviour study of porous TiNiCu shape memory alloys processed by powder metallurgy method	Zineb Sadaoui, Latifa Kahloul, Soumaya Meddah	Algeria, Algeria, Algeria	Submission 1485
154	Existence for Caputo-Fabrizio Random Fractional Differential Equations	BEKADA FOUZIA	Algeria	Submission 1486
155	Effect of Crosslinkers on Swelling Behavior of Chitosan grafted Poly(Acrylic Acid) Hydrogel	Abir Derbali, Djallel Bouzid, Amel Sadji	Algeria, Algeria, Algeria	Submission 1488
156	Discontinuous Nonlinearities in Fractional p-Laplacian Problems: A Study of Solution Existence and Multiplicity	Hanaa Achour, Sabri Bensid	Algeria, Algeria	Submission 1489
157	Impregnation of an Ion Exchange Resin for a Pharmaceutical Application	DJERADA Thiziri, MOULAHCENE Lamia, SENHADJI Ounissa	Algeria, Algeria, Algeria	Submission 1490
158	Forecasting company failure using ensemble machine learning methods	Kaoutar El Madou, Moad El Kharrim, Mohamed El Merouani	Morocco, Morocco, Morocco	Submission 1491
159	STUDY OF THE ENZYMATICAL	Khaoula Menaiaia, Hana	Algeria, Algeria	Submission 1493

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160	Ab-Initio Analysis of Structural and Mechanical Properties of Novel Lithium Tetrafluoroaurate (III) LiAuF4	Ishak Mebarkia	Algeria	Submission 1502
161	Improvement of fine Soil Properties with CKD for Road Project Applications	Zemouli Samira	Algeria	Submission 1507
162	Enhancing Earth Blocks with Alfa Fibers: A Sustainable Approach to Building	SI AHMED Chabane, BOUZIDI Mohamed amin, LILLOUCH Samir, MEZIANI Belkacem	Algeria, Algeria, Algeria, Algeria	Submission 1509
163	Enhancing Key Responses in Composite Bricks through Experimental Design Optimization	Boutaina Moumni, Karima Dokkar, Abdallah Oulmekki, Hayat Benmoussa	Algeria, Algeria, Algeria, Algeria	Submission 1510
164	Contribution to the study of a characterization of mining waste, case of poor iron ore from the El Ouenza – Tébessa mine	BOUZERIBA Hadjer, BOUZIDI Nedjima, IDRES Abdelaziz, LAALA Imen	Algeria, Algeria, Algeria, Algeria	Submission 1512
165	Flood Hazard Assessment and Mapping in Arid and Semi-Arid Regions of Algeria Case Study of Doucen City, wilaya Ouled Djellal	Djafri Sid Ali, Houria Athmani, Djouheina Boukehlifi Kouider, Sofiane Bensefia	Algeria, Algeria, Algeria, Algeria	Submission 1515
166	Enhancing the soils geotechnical properties by using plastic waste	Lina ZAIDI, Fatima Zohra BENAMARA, Messaouda BENCHEIKH	Algeria, Algeria, Algeria	Submission 1517
167	Study on the Effect of Metallic Ion Concentration on the Physical Properties and Thickness of Ternary FexNiyCuz Alloy Thin Films (X+Y+Z=100) Prepared by Electrodeposition	Ala. Boulegane, Ikhlas Bar, Hadia Almi, Abderrahim Hadj Larbi, Delloula Lakhdari	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1520
168	Study of Alpha-Amylase and Urease Inhibitory Activities of an Endemic Plant from the Genus Achillea	Renda CHAHNA	Algeria	Submission 1521
169	Picture Fuzzy B-spline Curve Approximation Model	Nur Azlida Ahmad, Mohammad Izat Emir Zulkifly	Malaysia, Malaysia	Submission 1528
170	Computational Analysis of Structural, Elastic, and Thermoelectric Properties of NbRhGe half-Heusler alloy Employing the Density Functional Theory Approach	Righi Aya, Bendahma Fatima, Labdelli Abess, Mechehoud Khedidja, Mana Mohamed, Achir Bilel	Algeria, Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1534
171	Elimination with bio-coagulant the mixture of two dyes (malachite green and Gentian violet)	MOKHATI Aya, AISSOUS Bochra, FERROUDJ Nawal, BENALIA Abderrezzaq, DERBAL Kerroum	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1538
172	Bioplastics: A Green Approach in Materials for Green Environment	Nadia Akram	Pakistan	Submission 1547
173	Turbo Ventılate Selector Phosphate Rejects From The Processing Chain Of Djebel-Onk Mine - Tebessa (NE Algeria) : Characterization	LAALA Imen, BOUZIDI Nedjima, ELICHE-QUESADA Dolores, BOUZERIBA Hadjer	Algeria, Algeria, Algeria, Algeria	Submission 1549
174	On Minimum Distance Density Estimation	Bensaber Fatna, Benyahia Wahiba	Algeria, Algeria	Submission 1553
175	Comparative Study of K-Nearest Neighbors and Random Forest for Predicting Lung Cancer	Samira Tared	Algeria	Submission 1556
176	Random Forest for Lung Cancer Prediction	Samira Tared	Algeria	Submission 1557
177	NanoVaccines Design and Development	Abdelali BOUSSIF, Khadidja LEMOUI	Algeria, Algeria	Submission 1558
178	Valorization and characterization of citrus peel by product	Sabrina SAHI-BOUBEKRI, Ounissa KEBICHE-SENHADJI, Fadila HEMMACHE-OUGHLIS	Algeria, Algeria, Algeria	Submission 1559
179	Preparation of activated carbon based on vegetal waste: Application to adsorption, kinetic and thermodynamic study	Z. Mekibes, K. Khalili, M. Benzekri Benallou, N. Douara, N. Benderdouche, B. Bestani	Algeria, Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1565
180	Comparative Hepatoprotective Potency of Green-Synthesized Moringa Nanoparticles in Ameliorating Oxidative Stress	Ayesha Rasool, Razia Noreena	Pakistan, Pakistan	Submission 1581
181	Green Synthesis and Characterization of Manganese Oxide Nanoparticles using Olive Leaf Extract: Thermal Stability and Phase Transformation Analysis	Abdelmalik Zemieche, Loubna Chetibi, Djamel Hamana, Slimane Achour	Algeria, Algeria, Algeria, Algeria	Submission 1583
182	Enhancement of the Efficiency of the CISSe/CdS/ZnO Solar Cell by optimization of the performances layers using SCAPS -1D	A. bayoud , S. Lachhab, A. Bliya, A.Raidou, Al Ibrahmi, L. Dlimi, S. el bahjaouy	Morocco, Morocco, Morocco, Morocco, Morocco	Submission 1590
183	A Review of Artificial Intelligence and Machine Learning Algorithms	Amine Bayoud, Abderrahim Raidoua, Soulaimane El Bahjaouy, Saadeddin Lachhab	Morocco, Morocco, Morocco, Morocco, Morocco	Submission 1592
184	Characterization and comparative study of the adsorption of toxic heavy metals lead and cadmium from aqueous solution using a chemically modified green waste of the Euphorbiaceae family	Terkhi Mohammed Cherif, Belhadji Kinza Amel, Terkhi Sabria	Algeria, Algeria, Algeria	Submission 1593
185	Experimental Assessment of the Effects of Building Materials on Wi-Fi signal 2.4GHz and	Sylhane Bytyqi	Kosovo	Submission 1595

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186	Polyaniline-Modified Iron and Copper Doped Cerium Oxide Nanocomposites for Enhanced Photocatalytic Degradation of Organic Dyes: Synthesis, and Characterization	MADI Kamilia, BENKOUACHI Oumnia Rayane, TAHRAOUI Hichem, CHEBLI Derradji	Algeria, Algeria, France, Algeria	Submission 1597
187	Mechanical characterization of recycled HD-PE Biocomposites reinforced with Esparto grass and natural Pozzolan	Bouchra Achour, Abdelkader Ziadi	Algeria, Algeria	Submission 1609
188	Modeling of a GaN-Based Betavoltaic Cell	Fayçal Bouzid, Ammar Haboussi, Mohamed Salah Halati, Samir Gouga	Algeria, Algeria, Algeria, Algeria	Submission 1610
189	Analytical Modeling of InGaP/GaAs Heterojunction Stacked on a Ge Tandem	Fayçal Bouzid, Ammar Haboussi, Mohamed Salah Halati, Samir Gouga	Algeria, Algeria, Algeria, Algeria	Submission 1611
190	Histopathological changes in the liver of adult rats following repeated exposure to methyl thiophanate	CHELBI Narimene, MALLEM Leila, ABDENNOUR Cherif	Algeria, Algeria, Algeria	Submission 1614
191	Identification and Improvement of Defects in the Forging Production Process of 1040 Steel Suspension Part	Kemal NURVEREN, Serkan ERİKLİLİ	Turkey, Turkey	Submission 1619
192	New Hotend Design for 3D Printers for Highly Efficient Filament Flow	Caglar SEVIM	Turkey	Submission 1620
193	High-Efficiency Buck-Boost Converter for Rapid Active Balancing of Lithium-Ion Battery Packs in Electric Vehicles	Assia Redouani, Kamal Zared, Najiba El Amrani El Idrissi	Morocco, Morocco, Morocco	Submission 1622
194	A Novel Mobile Speed ConvNeXt Model for Accurate Gallbladder Cancer Detection	Ishak Pacal	Turkey	Submission 1626
195	Treatment of textile effluents with EPS waste	Dahdouh Nadjib, Hafesa Haroun, Chaabane Toufik	Algeria, Algeria, Algeria	Submission 1627
196	Arıcılıkta İn Vitro Yetiştiricilik	Dilek KABAKCI, Nuray ŞAHİNLER	Turkey, Turkey	Submission 1629
197	Optimizing Greenhouse Management through IoT-Enabled Automation and Sustainability	Ibrahim El Khalil MEKKI, Mohamed Bilel BELHAOUARI	Algeria, Algeria	Submission 1631
198	Sustainable Wastewater Treatment: Kinetic Modelling and Microbial Strategies in Bioremediation	Monika Šabić Runjavec, Ivana Stojmilović, Marija Vuković Domanovac	Croatia, Croatia,Croatia	Submission 1632
199	Investigation of Drilling Operator Efficiency for Drilling and Blasting Operations in an Underground Lead-Zinc Mine	Tugce Ongen	Turkey	Submission 1634
200	ENERAL SITUATION OF ORGANIC BEEKEEPING AND ORGANIC BEE PRODUCTS PRODUCTION	Nuray ŞAHİNLER, Dilek KABAKCI	Turkey, Turkey	Submission 1635
201	Control of Single Degree of Freedom Magnetic Pendulum with Non-Linear Feedback Linearization Method	Huseyin Yildiz	Turkey	Submission 1637
202	Industrial economic performance indicators: an international comparison	Yasmine Hariti, Nacira Boukhezer-Hammiche	Algeria, Algeria	Submission 1649
203	Modeling of soil consolidation around tunnels-Case study of Algiers Metro	Ibrahim MAHROUG, Abdelhafid MAHROUG	Algeria, Algeria	Submission 1655
204	Enhancing wool dyeing with clove bud (syzygium aracmatics) based natural dyes via microwave treatment using a central composite design	Muhammad Yameen, Fariha Asghar, Shahid Adeel	Pakistan, Pakistan, Pakistan	Submission 1656
205	GG25 Dökme Demirde Karbon Eşdeğerinin Mikroyapı ve Mekanik Özelliklere Etkisi	Cevat Mehmetali, Gökhan Arıcı	Turkey, Turkey	Submission 1657
206	Evaluation of Sun Protection Factor Value and Antiaging Potential of Citrus clementina Hort. essential oil	Rukiye Boran Gülen	Turkey	Submission 1661
207	A techno-economic optimization of Renewable energy sources within a smart grid and battery system through evolutionary algorithms	Hasnain Ali Shah, Muhammad Bilal, Saddam Hussain, Rameez Hassan, Fazal Muhammad	Pakistan, Pakistan, Pakistan, Pakistan, Pakistan	Submission 1664
208	Exploring Phonological Processes in Child Language Development: A Comprehensive Study on Reduplication, Deletion, Consonant Cluster Reduction, Epenthesis, Diminutization, Coalescence, and Assimilation	Om Kumar, Tabish Mubeen	Pakistan, Pakistan	Submission 1666
209	Structure elucidation, and Combined Empirical-Computational studies of a hybrid chloride material with potential NLO properties	Ikram Jomaa, Noureddine Issaoui, Houda Marouani	Tunisia, Tunisia, Tunisia	Submission 1667
210	Design and Implementation of a Shunt Active Power Filter Based on Electric Vehicle Integration for Power Quality Improvement	Ahmed ELOTTRI, Lakhdar MAZOUZ, Abdellah KOUZOU, Nihel Bouthaina SALLAI, Ali TETA, Imad Eddine MOHAMMEDI	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1670
211	In Silico Study of Chalcone Reductase from Diverse Fabaceae Family of Pakistan	Kamishka Ifttikhar, Muhammad Akram	Pakistan, Pakistan	Submission 1674

212	DETERMINATION OF THE EFFECT OF AZITHROMYCIN ON UTERINE CYTOKINE LEVELS IN SEPTIC PREGNANT RATS	Gonca SONMEZ, Oznur TUFAN, Muhammed Hudai CULHA, Tugba Melike PARLAK, Burak DIK, Ayse ER	Turkey, Turkey, Turkey, Turkey, Turkey, Turkey	Submission 1681
213	Full Factorial design applied for the optimization of CdS thin films deposed by Chemical bath deposition technique	Sara BOULAHDJEL, Samira SALI, Souad BOUAFIA, Salim KERMADI, Lyes ZOUGAR, Hadjira LABECHE, Massaouda AYACHI	Algeria, Algeria, Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1682
214	Towards the Optimization of Microstructure and Mechanical Properties of NbC-based Cermets	Abdul Basit, Asad Malik, Sadaqat Ali, Adeel Umer, Rafi-ud-Din	Pakistan, Pakistan, Pakistan, Pakistan, Pakistan	Submission 1684
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Generative Artificial Intelligence (GenAI) Literacy Scale: Validity and Reliability

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Abstract **–** Generative Artificial Intelligence (GenAI) chatbots can make positive contributions to education processes thanks to their advanced natural language processing capabilities. This is a new technology, and it is important to know its proper use. GenAI literature students have more potential to use chatbots effectively. In the literature, there are a limited number of measurement tools to measure the literacy level of AI chatbots, which are in the productive artificial intelligence category. The aim of this study is to adapt an instrument to measure the GenAI literacy of university students. The AI literacy scale developed by [1] was adapted into Turkish with the participation of 297 undergraduate and graduate university students. The scale consists of four dimensions and ten items. The Cronbach's alpha internal consistency coefficient for the four dimensions was calculated to be 0.74. The total test scores showed a significant difference between the upper and lower 27% groups. The fit indices were examined to demonstrate the adequacy of the model, and it provides a good foundation to build upon. With this structure, the instrument can be used as a suitable tool to measure the level of GenAI literacy, the effectiveness of learning activities to improve this level, and to conduct research on this topic.
Keywords – Artificial intelligence (AI) chatbots, GenAI literacy, measurement tool, university students

I. INTRODUCTION

We can think of artificial intelligence (AI) as a field of research that focuses on producing intelligent machines and intelligent computer programs [2]. Today, AI applications developed for many different purposes are used. Chatbots are also a type of AI applications. ChatGPT, a chatbot, works with Generative Artificial Intelligence (GAI) logic, collects data with its own algorithm, performs operations on this training data and provides information as a result of interaction with people [3]. The text-based information it provides is as if it were created by a human [4]; [5] and uses statistical correlations to choose the next word when constructing sentences [3]. ChatGPT, a good representative of chatbots, has impressed its users with its performance since it became available for free use in November 2022 [6].

Traditionally, when looking at the working logic of computer technology, computers operate and produce results according to the commands given by people. When we perform this search process through chatbots, we assign the task of selecting and synthesizing the resources to it. However, the ability of chatbots used to produce text-based content to select valid and reliable sources is unclear. Because chatbots cannot distinguish between right and wrong [7], they can present information that is biased, tends to maintain existing power dynamics, and has the potential to manipulate people [8]. A chatbot can return very good, completely wrong, or even irrelevant results to the given prompts. The text it produces

may contain errors. Therefore, text-based content produced by a chatbot should be checked by an expert for accuracy, bias, appropriateness, and logic [9].

II. Literature Review

Generative AI Literacy

Chatbots are tools that can communicate with people via text or voice by combining technologies such as artificial intelligence and language processing [10]; [11]. In addition to having the potential to improve workplaces and daily life, chatbots bring many opportunities as communication and information tools for digital learning [12]; [13]; [14]. Chatbots play an important role as a tool that emphasizes individualized teaching and supports accessibility [10]. A systematic review study reports that research on the use of chatbots in education generally focuses on language, engineering, and computer courses [15]; [16]. Chatbots might offer significant support in helping students and reinforcing repetitive tasks [10]; [17]. However, in cases where there are no repetitive processes and require in-depth and instant decisions, chatbots inadequacy can be mentioned. For example, it is reported that there are limitations in ensuring that chatbots are matched with learning strategies in the design of e-activities [18]. Therefore, it is suggested that more comprehensive and student-focused studies are needed to evaluate their effectiveness in education [15]. At this point, students' artificial intelligence literacy and their awareness of it are important [19]; [20].

AI knowledge encompasses the proficiency to assess AI technologies critically, engage in effective communication and collaboration with AI systems, and utilize AI as a versatile tool across online platforms, households, and professional environments [21]. It is an important starting point for learners to have AI literacy, to understand the underlying mechanisms of these technologies and thus to gain awareness about their capabilities and limitations, and to develop a critical attitude towards the information produced [22].

The Present Study

Various conceptualizations and frameworks have been proposed in the literature regarding AI literacy. Recently, there have been studies conducted by researchers on how AI literacy can be measured for different education levels. There are studies focusing on the scope of AI literacy or how it can be improved for early childhood education [23], secondary school [24] or K-16 [1] Although it is important to prepare students in AI literature from an early age, GenAI has very quickly entered the business world and has begun to be seen as an innovation that has the potential to transform and change expectations from the workforce. In this respect, it is necessary to first measure the GenAI literacy levels of university students so that their current situation can be determined. The concept of AI literacy is applicable to intelligent agents, automata, problem-solving through data structures, sorting, searching, and machine learning, with the exception of the latter in terms of measuring AI literacy in students within the computer science education system. The instrument that refers to digital literacy to measure the AI literacy of users in the general population is based on the emotions and behaviours that users exhibit in relation to knowledge and skills, along with values, attitudes and ethics. The term "AI literacy" is defined as "awareness and understanding of AI technology in practical applications; the ability to apply and use AI technology to perform tasks competently; and the ability to analyse, select, and critically evaluate data and information provided by AI, while promoting awareness of one's own personal responsibilities and respect for mutual rights and obligations." Four constructs have been proposed for AI literacy: awareness, use, evaluation, and ethics. These dimensions cover the general skills of the general population related to AI. While the measurement tool is adapted to productive AI, which is a type of artificial intelligence, there is no adaptation that would disrupt this scope. In this respect, the adapted instrument was used for measuring general productive AI literacy in the general population.

In this way, educators can have the necessary starting data to prepare them to adapt to their professional lives. Based on this point, the current study aims to adapt AI literacy survey developed by [1] to Turkish culture and obtain the necessary findings regarding its validity and reliability.

MATERIALS AND METHOD

A. *Study Group*

In this study, 66.7% of the 297 participants were female and 33.3% were male. Their mean age was 21.75 years. 85.9% were associate and undergraduate students, 14.1% were graduate students. This demographic distribution provides a diverse representation of young adults in higher education, primarily focusing on those in early stages of their academic careers.

B. *Data Collection Instrument*

The measurement tool developed by [1] to measure AI literacy was adapted to generative AI. A 12-item instrument was obtained to measure AI literacy. The scale items have a 5-point Likert scale. A high score on the instrument indicates a high level of AI literacy. 12 items provide a general measure of generative AI literacy. These general statements were subjected to confirmatory factor analysis with GenAI adaptation.

C. *Data Collection*

Data collection was conducted through an online Google Form, which allowed for an efficient and widespread distribution among the target audience. "Voluntary status of the participants" was accepted as the main criterion for data collection.

D. *Data Analyses*

The collected data were then analyzed using Lisrel 8.0 and IBM SPSS 24. These statistical software tools enabled detailed examination of the data, including confirmatory factor analysis and other relevant statistical tests. The use of Lisrel 8.0 enabled an understanding of whether the AI literacy instrument adapted by confirmatory factor analysis was both reliable and valid for measuring AI literacy in productive AI contexts. IBM SPSS 24 was used for additional validity and reliability analyses.

RESULTS

Descriptive Findings

Table 1 presents the mean, standard deviation, skewness, and kurtosis statistics and standard error values of the items in this scale.

Table 1 Mean, standard deviation, kurtosis and skewness

Items	Mean	Standard Deviation	Skewness		Kurtosis	
			Statistic	Std. Error	Statistic	Std. Error
L1	5.38	1.208	-0.202	0.141	-0.981	0.282
L3	4.39	1.321	0.233	0.141	-0.461	0.282
L4	4.77	1.333	-0.063	0.141	-0.588	0.282
L6	5.46	1.205	-0.325	0.141	-0.844	0.282
L7	5.25	1.226	-0.235	0.141	-0.844	0.282
L8	5.32	1.163	-0.185	0.141	-0.778	0.282
L9	5.05	1.155	0.040	0.141	-0.730	0.282
L10	4.96	1.538	-0.392	0.141	-0.603	0.282
L11	2.40	1.528	1.064	0.141	0.384	0.282
L12	4.96	1.505	-0.176	0.141	-1.037	0.282

Table 1 indicates that the mean scores of the items range from 5.47 to 2.40, with standard deviations varying from 1.733 to 1.155. The skewness and kurtosis values calculated for each item fall within the range of +1.5 and -1.5. Upon analysis of the normal distribution curve of the items, it was concluded that the scores were normally distributed.

Confirmatory Factor Analysis

In order to adapt the scale to Turkish, confirmatory factor analysis was applied. The fit indices of the confirmatory factor analysis were as follows: $\chi 2(29)=60.85$, $\chi 2/df=2.063$, RMSEA= 0.061, GFI= 0.96, NFI= 0.96, NNFI=0.97, CFI=0.98, IFI=0.98. The fit indices were examined to demonstrate the adequacy of the model, and it was found that they demonstrated acceptable and excellent fit values. Items 2 and 5, which had estimated factor loadings of 0.2 and 0.3, were not removed from the scale. The presented analyses are the values obtained after item removal.

Confirmatory factor analysis was employed to assess the factorial validity of the model comprising four factors and 12 items. Dimensions are: FF1: Awareness, FF2: Usage, FF3: Evaluation, FF4: Ethics. The resulting model is presented in Figure 1.

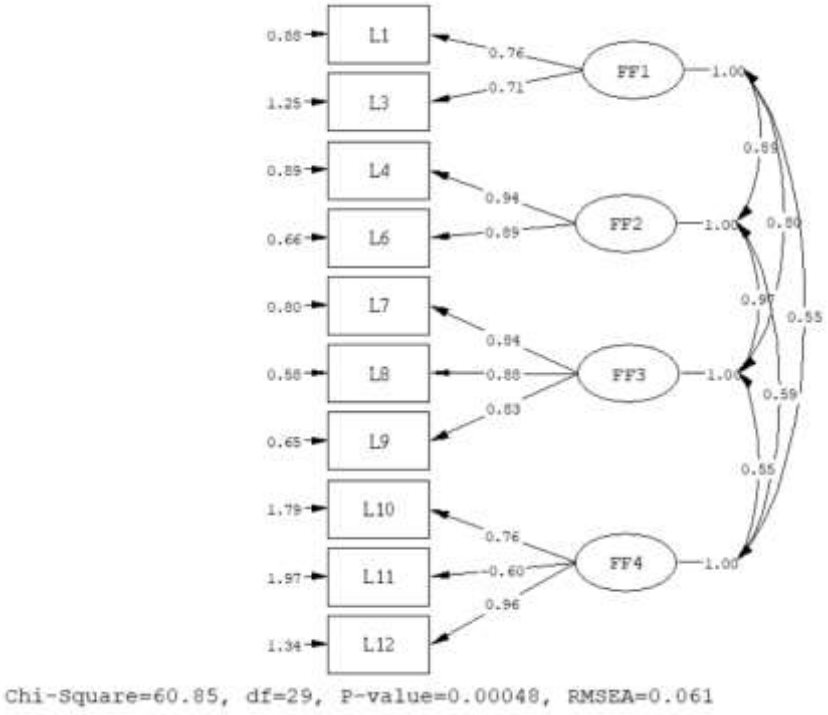

Figure 1: CFA Model

Factor loadings are between 0.94 and 0.60. According to the t-test findings, all connections are statistically significant. It can be said that factorial validity is achieved.

Internal Consistency Analysis

The Cronbach α internal consistency coefficient of this scale was calculated as 0.739. The Cronbach α internal consistency coefficients for the sub-factors of the scale were 0.60, 0.682, 0.761, 0.60, respectively.

Item-Total Scores Correlation and Item Discrimination Index

Item-total score correlations were calculated on the relationship between the score for each item and the total score obtained from the scale. It was found that the item-total score correlation values ranged between 0.300 and 0.656 and had a significant relationship.

In addition, it was examined whether there was a statistically significant difference between the scores of the group in the upper 27% group (N=80) and the group in the lower 27% group according to the total score obtained from the scale. According to the total test scores, a significant difference was observed between the upper and lower 27% groups (t=26.301, p=0.000).

CONCLUSION AND RECOMMENDATIONS

The results of confirmatory factor analysis for the GenAI literacy scale (Appendix 1), adapted into Turkish by integrating with the GenAI structure, indicated that the fit indices were acceptable and had an excellent fit. The scale comprises four dimensions and ten items. The Cronbach α internal consistency coefficient for the four dimensions was calculated as 0.739. The Cronbach α internal consistency coefficients for the sub-factors of the scale were 0.60, 0.682, 0.761, and 0.60, respectively. These values of 0.60 and above provide evidence of reliability, as stated by Dijkstra and Henseler (2015). The low

number of items in the dimensions may explain the Cronbach alpha level. The item total score correlation values were found to range between 0.300 and 0.656, with a significant relationship. According to the test total scores, a significant difference was observed between the upper and lower 27% groups (t=26.301, p=0.000). This structure enables the instrument to be used as a suitable tool for measuring the level of GenAI literacy, evaluating the effectiveness of learning activities to improve this level, and conducting research on this topic.

This study has some limitations. A larger number of participants can be reached. Hair et al. [25] argued that the number of items should be at least 5 times. Nunnally [26] argues that at least 10 times the number of participants should be reached. Although more than 10 times the number of participants was reached in this study, the number of participants can be expanded. The instrument is limited to the adaptation of general AI literacy to generative AI literacy. Recently, GenAI tools have been rapidly integrated into social systems, which may lead to the perception of artificial intelligence being associated only with large language models. On the other hand, artificial intelligence works with many disciplines and has many application areas, such as modeling and simulation. In addition, rapid developments in GenAI tools, expansion of the capacity, and the increase in the diversity of the problems they solve may lead to the need to update the adapted instrument, perhaps more quickly than another measurement tool. Another limitation is that countries still need more institutional and government work on ethical concerns in productive artificial intelligence tools. Although this is not a limitation of the research, it should be kept in mind that awareness of the violation of ethical use of productive artificial intelligence tools is in its early stages, not only at the individual but also at the system level.

Another point is related to the fact that the data collection process is self-reported. However, the current study shows that the measurement tool has achieved sufficient statistical findings regarding the construct validity and reliability. It should be considered that errors may arise due to social desirability. Therefore, in the future, it is recommended that task- and performance-based tools be developed that consider users' actual usage.

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Appendix 1

Generative Artificial Intelligence Literacy Scale for University Students

Üretken Yapay Zeka Okuryazarlığı Ölçeği Maddeleri Turkish	GenAI Literacy Scale Items English
1. Akıllı (yapay zekayı kullanan) ve akıllı olmayan araçlar arasındaki farkları ayırt edebilirim.	1. I can distinguish between intelligent vehicles (using AI) and non-intelligent vehicles.
2. Üretken yapay zekanın bana nasıl yardımcı olabileceğini bilmiyorum (ölçekten çıkarılmış madde).	2. I do not know how generative AI can help me (removed item).
3. Üretken yapay zeka uygulama ve ürünlerinde kullanılan teknolojiyi tespit edebilirim.	3. I can identify the technology used in generative AI applications and products.
4. Günlük işlerime yardımcı olması için üretken yapay zeka uygulamalarını veya ürünlerini ustalıkla kullanabilirim.	4. I can skillfully use productive AI applications or products to help me in my daily work.
5. Yeni bir üretken yapay zeka uygulamasını veya ürününü kullanmayı öğrenmek genellikle zordur. (ölçekten çıkarılmış madde).	5. Learning to use a new productive AI application or product is often difficult (removed item).
6. İş verimliliğini artırmak için üretken yapay zeka uygulamalarını veya ürünlerini kullanabilirim.	6. I can use productive AI apps or products to improve work efficiency.
7. Bir süre kullandıktan sonra bir üretken yapay zeka uygulamasının veya ürününün yeteneklerini ve sınırlamalarını değerlendirebilirim.	7. I can evaluate the capabilities and limitations of a productive AI application or product after using it for a while.
8. Üretken yapay zeka tarafından sağlanan çeşitli çözümler arasından uygun bir çözüm seçebilirim.	8. I can choose an appropriate solution from a variety of solutions provided by generative AI.
9. Farklı görevler için çeşitli üretken yapay zeka uygulamaları arasından en uygun ürünü seçebilirim.	9. I can choose the most suitable product from a variety of generative AI applications for different tasks.
10. Üretken yapay zeka uygulamalarını kullanırken her zaman etik ilkelere uyarım.	10. I always follow ethical principles when using generative AI applications.
11. Üretken yapay zeka uygulamalarını veya ürünlerini kullanırken gizlilik ve bilgi güvenliği konularına hiç dikkat etmem.	11. I never pay attention to privacy and information security issues when using generative AI applications or products.
12. Üretken yapay zeka teknolojisinin kötüye kullanımına karşı her zaman dikkatliyim.	12. I am always alert to the misuse of generative AI technology.

*FF1-Awareness:1,3; FF2-Usage: 4,6; FF3- Evaluation: 7,8, 9; FF4- Ethics: 10,11,12

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SAE1050 İmalat Çeliğinin Farklı Soğutma/Yağlama Koşullları Altında İşlenmesinin Enerji Tüketimi Üzerine Etkileri

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Özet **–** İmalat endüstrisinde sıklıkla kullanılan SAE1050 çeliği otomotiv sanayisinde ve makine parçalarının yapımında tercih edilmektedir. Bu çelik ısıl işlem ve yüzey sertleştirme işlemleri uygulanabilen bir malzeme olarak bilinmektedir. İşlenebilirlik özelliklerinin iyi olması sebebiyle talaşlı imalat sektöründe kullanılabilmektedir. İşleme sırasında malzeme ile kesici takım arasında oluşan yüksek sıcaklıklar olumsuz durumlara neden olabilmektedir. Bu olumsuz durumlar soğutma/yağlama sistemleri kullanılarak ortadan kaldırılabilmektedir. Son yıllarda hem insan sağlığına zarar vermeyen hem de az miktarda soğutma sıvısı kullanılarak yapılan çalışmaların sayısı artmaktadır. Tüm bu işleme koşulları ve imalat sektöründe kullanılan tezgahlarının tükettiği enerji bir bütün olarak ele alındığında tüketilen enerjinin azaltılması oldukça önem arz etmektedir. Bu çalışmada imalat endüstrisinde sıklıkla kullanılan SAE1050 çeliğinin farklı kesme parametreleri ve farklı soğutma/yağlama koşulları altında frezelenmesi sonucunda harcanan enerji tüketimi araştırılmıştır. Bu amaçla iki farklı kesme hızı (140-160-180 m/dak), iki farklı ilerleme hızı (0.050-0.075-0.100 mm/dev) ve üç farklı soğutma/yağlama (kuru, hava ve MMY) ortamı kullanılmıştır. Ayrıca Taguchi istatistiksel analizi kullanılarak en etkili kontrol faktörleri belirlenmiştir. Uygulanan girdi parametrelerinin enerji tüketimi üzerindeki etkileri araştırılmıştır. Elde edilen sonuçlara göre MMY ortamının SAE1050 çeliğinin frezelenmesinde enerji tüketimi açısından en iyi seçenek olduğu tespit edilmiştir. Ayrıca Taguchi istatistiksel analizi kullanılarak en etkili kontrol faktörleri belirlenmiştir. İstatistiksel analiz sonuçlarına göre enerji tüketiminde en etkili faktör ilerleme hızı olarak kaydedilmiştir. Ayrıca yapılan istatistiksel analizin anlamlı olduğu belirlenmiştir.

Anahtar Kelimeler – SAE1050 çeliği, Frezeleme, Kesme hızı, İlerleme hızı, MMY ortamı, Enerji Tüketimi

I. GİRİŞ

SAE 1050, Amerika Demir ve Çelik Enstitüsü (AISI) tarafından sınıflandırılmış bir karbon çeliği sınıfıdır. SAE 1050, orta karbonlu bir çelik türü olup, genellikle yüksek mukavemet ve sertlik gerektiren uygulamalarda kullanılır. Bu tür çeliklerin bileşimi ve özellikleri, endüstriyel standartlara göre tanımlanmıştır. SAE 1050 çeliği, yüksek mukavemet ve aşınma direnci gerektiren çeşitli uygulamalarda kullanılır. Akslar, şaftlar ve dişli çarklar gibi parçaların imalatında, Mil ve yatak gibi bileşenlerin üretiminde ve pulluk ve disk bıçakları gibi aşınmaya maruz kalan parçalarda yaygın olarak kullanılmaktadır. Orta karbon içeriği sayesinde yüksek mukavemet ve sertlik sağlar. Yeterli işlenebilirlik özelliklerine sahiptir, bu da çeşitli imalat süreçlerine uygun olmasını sağlar [1]. Isıl işlemle mekanik özellikleri geniş bir aralıkta ayarlanabilir. Karbon içeriğinin yüksek olması, kaynak yapılabilirliği azaltabilir ve özel önlemler gerektirebilir. SAE 1050 çeliği, dengeli kimyasal bileşimi ve ayarlanabilir mekanik özellikleri ile çeşitli endüstriyel uygulamalarda yaygın olarak kullanılmaktadır. Yüksek mukavemet ve sertlik gerektiren yerlerde tercih edilen bu çelik türü, ısıl işlem ve diğer üretim süreçleri ile özellikleri optimize edilebilen güvenilir bir malzemedir [2].

Talaşlı imalat sanayisinde enerji tüketimi, üretim süreçlerinin verimliliği ve sürdürülebilirliği açısından kritik bir öneme sahiptir [3]. Talaşlı imalat, malzemelerin işlenmesi sırasında kesme, delme, tornalama ve frezeleme gibi yöntemlerle istenilen geometrik formların elde edilmesini sağlar. Bu süreçler genellikle yüksek enerji gereksinimi olan makine ve ekipmanların kullanımını içerir [4]. Enerji tüketiminin yüksek olması, işletme maliyetlerini artırmanın yanı sıra, çevresel etkileri de önemli ölçüde yükseltir. Dolayısıyla, enerji verimliliğinin artırılması, maliyetlerin düşürülmesi ve çevresel sürdürülebilirliğin sağlanması açısından büyük bir öneme sahiptir. Enerji tüketiminin yönetimi, sadece doğrudan enerji maliyetlerini azaltmakla kalmaz, aynı zamanda üretim sürecinin genel verimliliğini artırır ve karbon ayak izini azaltır. Enerji verimliliği, gelişmiş kesici takım teknolojileri, optimize edilmiş kesme parametreleri ve modern CNC (Bilgisayarlı Nümerik Kontrol) makinelerinin kullanımıyla artırılabilir. Ayrıca, enerji tüketiminin izlenmesi ve yönetilmesi için gelişmiş izleme sistemlerinin entegrasyonu, enerji kullanımını daha etkin bir şekilde kontrol etmeye olanak tanır [5]. Bu bağlamda, talaşlı imalat sanayisinde enerji tüketiminin optimize edilmesi, hem ekonomik hem de çevresel açıdan sürdürülebilir bir üretim sistemi oluşturmak için hayati bir rol oynamaktadır. Enerji verimliliğine yönelik yenilikçi yaklaşımlar ve teknolojik gelişmeler, sanayinin rekabet gücünü artırırken, sürdürülebilir kalkınma hedeflerine ulaşılmasına da katkı sağlar. Ayrıca kesme parametrelerinin optimize edilmesi ve soğutma/yağlama stratejilerinin kullanılması da enerji tüketiminin azaltılmasına yardımcı olabilmektedir.

Bu çalışmada SAE1050 imalat çeliği farklı kesme parametreleri ve farklı soğutma/yağlama stratejileri altında frezelenerek enerji tüketimi araştırılmıştır. Ayrıca Taguchi istatistiksel analizi kullanılarak hem deney sayısı azaltılmış hem de maliyetler azaltılarak enerji tüketimi üzerindeki en etkili kontrol faktörleri belirlenmiştir.

II. MATERYAL VE YÖNTEM

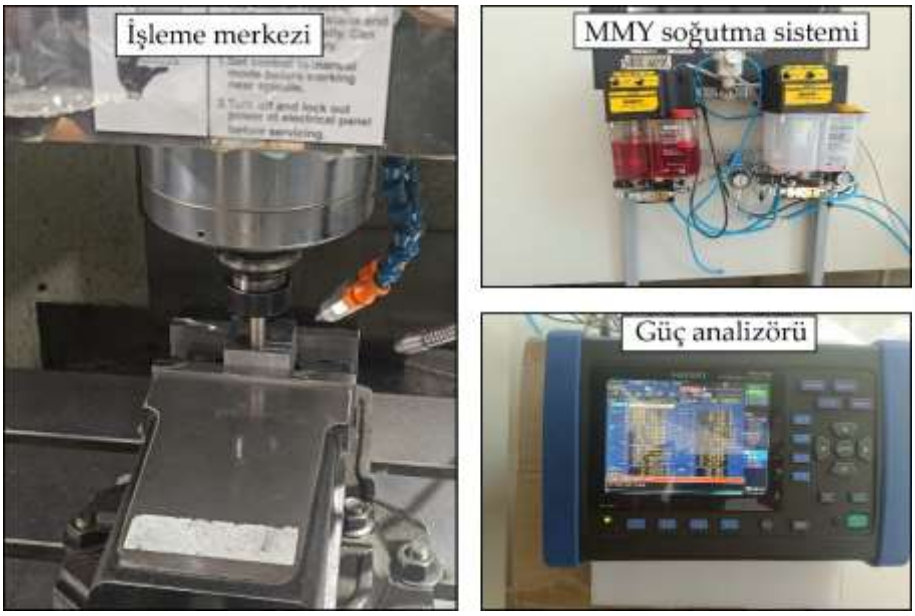
Bu çalışmada SAE1050 çeliği deney numunesi olarak kullanılmıştır. Bu malzeme metal endüstrisinde sıklıkla kullanılmaktadır. Numune boyutları 50x50x20 mm olarak kesilmiştir. Deneyler üç eksenli bilgisayar kontrollü bir işleme merkezinde yapılmıştır. Deneylerde üç farklı kesme hızı (140-160-180 m/dak), üç farklı ilerleme hızı (0.050-0.075-0.100 mm/dev) ve üç farklı soğutma/yağlama (kuru, hava ve MMY) tekniği kullanılarak gerçekleştirilmiştir. Tek kesme derinliği (0.5 mm) seçilmiştir. Ayrıca deney sayısını ve maliyetleri azaltmak amacıyla Taguchi L_9 ortogonal dizisi kullanılmıştır. Tablo 1, deney tasarımını temsil etmektedir.

Tablo 1. Deneysel tasarım (Taguchi L_9) [6]

Deney no	**Kesme hızı (m/dak)**	**İlerleme hızı (mm/dev)**	**Soğutma/ Yağlama**
1	140	0.050	Kuru
2	160	0.075	Kuru
3	180	0.100	Kuru
4	140	0.075	Hava
5	160	0.100	Hava
6	180	0.050	Hava
7	140	0.100	MMY
8	160	0.050	MMY
9	180	0.075	MMY

İşleme tezgahına bağlı olan bir nozuldan kompresör yardımıyla basınçlı hava kesici takım ile malzeme arasına gönderilmektedir. Werte Micro STN-15 model bir cihaz ile MMY tekniği kullanılarak pülverize hale getirilen kesme sıvısı buhar şeklinde kesici takım ve iş parçası üzerine püskürtülmektedir. MMY tekniğinde nozul kesme bölgesine yaklaşık 50 cm mesafede konumlandırılarak püskürtme işlemi gerçekleştirilmektedir. Deneylerde kesici takım olarak AlTiN (Alüminyum Titanyum Nitrür) kaplanmış karbür uçlar kullanılmıştır. Bu karbür uçlar frezeleme işlemlerinde genellikle tercih edilmektedir. Her bir deney için yeni bir kesici uç kullanılmaktadır. Freze tezgahından çekilen enerjiyi ölçmek için bir güç analizörü (HIOKI) kullanılmıştır. Güç analizörünün kabloları freze tezgahına monte edilerek bağlantı

işlemleri tamamlanmıştır. Deneyler tamamlandıktan sonra güç analizöründen elde edilen veriler özel bir yazılım aracılığıyla kayıt altına alınmıştır. Şekil 1.'de deneysel şema görülmektedir.



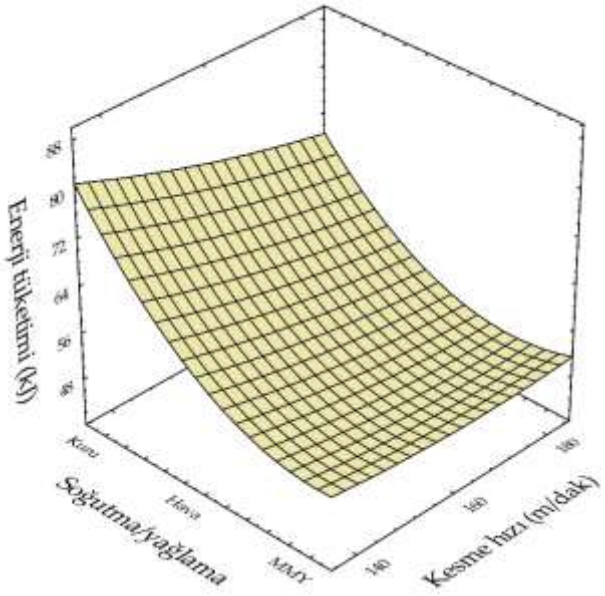
Şekil 1. Deneysel şema

III. BULGULAR TARTIŞMA

A. *Enerji Tüketimi analizi*

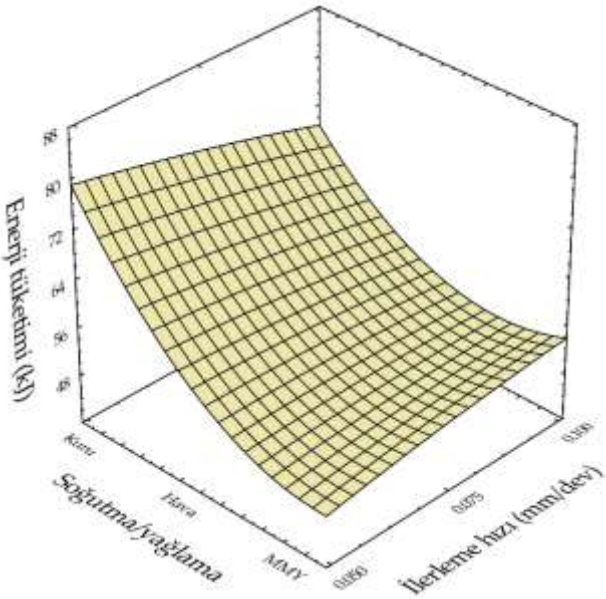
İşleme süreçlerinde enerji tüketimi, üretim verimliliği ve sürdürülebilirlik açısından büyük bir öneme sahiptir. İşleme süreçleri, hammaddelerin istenilen şekil, boyut ve yüzey kalitesine getirilmesi amacıyla çeşitli makine ve ekipmanların kullanıldığı operasyonları içerir. Bu süreçlerde enerji, makinelerin çalıştırılması, kesme işlemleri, soğutma sistemleri ve yardımcı ekipmanların işletilmesi için gereklidir [7]. Yüksek enerji tüketimi, üretim maliyetlerini artırırken, aynı zamanda çevresel etkilere de neden olur. Özellikle enerji maliyetlerinin yükseldiği ve enerji kaynaklarının sınırlı olduğu günümüzde, enerji verimliliği daha da kritik hale gelmiştir. Enerji tüketiminin azaltılması, işletmelerin rekabet gücünü artırırken, karbon ayak izini azaltarak çevresel sürdürülebilirliğe de katkı sağlar. Bu amaçla, gelişmiş makine teknolojileri, optimize edilmiş kesme parametreleri ve verimli enerji yönetim sistemlerinin kullanımı, enerji tüketimini minimize etmek için önemlidir [8]. Aynı zamanda, enerji izleme ve yönetim sistemlerinin entegrasyonu, enerji kullanımının sürekli olarak izlenmesini ve optimize edilmesini sağlar [9]. İşleme süreçlerinde enerji tüketiminin etkin bir şekilde yönetilmesi, sadece maliyet tasarrufu sağlamakla kalmaz, aynı zamanda çevresel etkileri azaltarak daha sürdürülebilir bir üretim modeli oluşturur. Bu da, hem ekonomik hem de çevresel açıdan uzun vadeli yararlar sağlar [10]. Soğutma ve yağlama ortamları, işleme süreçlerinde enerji tüketimi üzerinde belirleyici bir rol oynamaktadır [11]. İşleme sırasında kesici takımlar ve iş parçaları arasında meydana gelen yüksek sıcaklık ve sürtünme, kesme işlemlerinin verimliliğini ve kalitesini olumsuz yönde etkileyebilir [12]. Soğutma ve yağlama ortamlarının kullanımı, bu sorunları minimize ederek, işleme sırasında oluşan ısıyı dağıtarak ve sürtünmeyi azaltarak enerji verimliliğini artırır [13]. Etkin soğutma ve yağlama, kesici takım ömrünü uzatır ve işleme hızını artırır, böylece makine verimliliğini ve üretim hızını yükseltir. Bu durum, enerji tüketimini doğrudan etkiler; çünkü daha verimli kesme işlemleri, aynı miktarda işin daha az enerji ile yapılmasını sağlar. Ayrıca, soğutma ve yağlama sıvılarının doğru seçimi ve kullanımı, makinelerin daha düşük enerji tüketimi ile optimal performans göstermesine olanak tanır [14]. Bunun yanı sıra, modern soğutma ve yağlama sistemleri, geri dönüşüm ve yeniden kullanım özellikleri sayesinde enerji tasarrufunu daha da artırır [15]. Örneğin, yüksek basınçlı soğutma sistemleri, soğutma sıvısının etkin kullanımını sağlayarak, toplam enerji tüketimini düşürür. Sonuç olarak, soğutma ve yağlama ortamlarının optimize edilmesi, sadece enerji tüketimini azaltmakla kalmaz, aynı zamanda üretim süreçlerinin genel

verimliliğini ve sürdürülebilirliğini de önemli ölçüde iyileştirir. Bu çalışmada kesme parametreleri ve soğutma/yağlama ortamlarının enerji tüketimi üzerindeki etkilerine odaklanılmıştır. Şekil 1'de kesme hızı ve soğutma/yağlama ortamlarının enerji tüketimi üzerindeki etkilerini temsil eden 3B grafik gösterilmektedir. Kesme hızı açısından değerlendirildiğinde, kesme hızının artmasıyla genel olarak enerji tüketiminin azaldığı görülmektedir. Soğutma/yağlama ortamı açısından değerlendirildiğinde ise kuru ortamdan MMY ortamına doğru gidildikçe enerji tüketiminin azaldığı tespit edilmiştir.



Şekil 2. Kesme hızı ve soğutma/yağlama ortamlarının enerji tüketimi üzerindeki etkileri

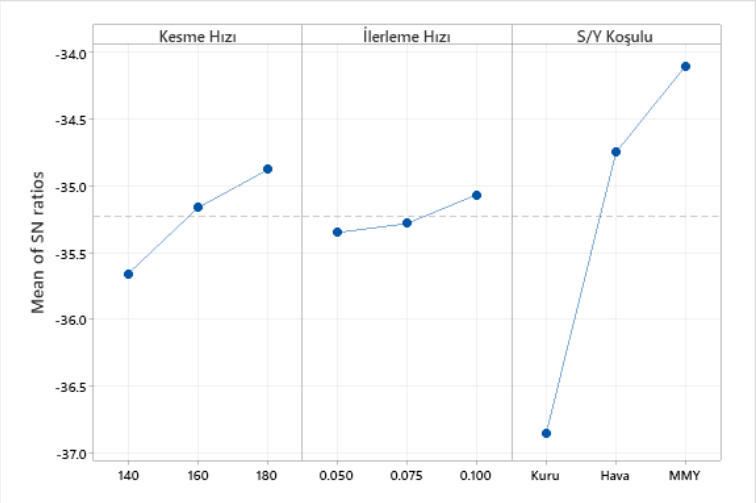
Şekil 3'te ilerleme hızı ve soğutma/yağlama ortamlarının enerji tüketimi üzerindeki etkilerini gösteren 3B grafiği verilmiştir. İlerleme hızı açısından değerlendirildiğinde, artan ilerleme hızları enerji tüketiminin azalmasına neden olmuştur. İlerleme hızı arttığında işleme için toplam süre azalacağı için dolaylı olarak enerji tüketimi de azalma eğiliminde olmaktadır. En düşük enerji tüketimi değeri (61 kJ) 140 m/dak kesme hızında, 0.100 mm/dev ilerleme hızında ve MMY ortamında kayıt altına alınmıştır.



Şekil 3. İlerleme hızı ve soğutma/yağlama ortamlarının enerji tüketimi üzerindeki etkileri

B. *İstatistiksel analiz*

Taguchi istatistiksel analizi, ürün ve süreç geliştirme faaliyetlerinde kaliteyi artırmak ve varyasyonu minimize etmek amacıyla kullanılan güçlü bir deney tasarım metodolojisidir. Japon mühendis ve istatistikçi Genichi Taguchi tarafından geliştirilen bu yöntem, özellikle imalat ve mühendislik alanlarında yaygın olarak uygulanmaktadır [16]. Taguchi yöntemi, deneylerin sistematik bir şekilde planlanmasını, faktörlerin ve etkileşimlerin etkilerinin analiz edilmesini ve optimal koşulların belirlenmesini sağlar. Bu metodoloji, deneylerin daha az sayıda koşul ve tekrar ile gerçekleştirilmesine olanak tanıyarak maliyet ve zaman tasarrufu sağlar [17]. Taguchi analizinde, ortogonal dizi adı verilen özel deney matrisi kullanılır. Bu matriks, faktörlerin farklı seviyelerinin kombinasyonlarını kapsayarak, ana etkilerin ve etkileşimlerin tahmin edilmesini kolaylaştırır. Sonuçlar, sinyal-gürültü oranı (S/N oranı) gibi istatistiksel ölçütlerle değerlendirilir, bu da kalite karakteristiklerinin istenen seviyede tutulmasını ve varyasyonun en aza indirilmesini hedefler. Ayrıca, Taguchi yöntemi, ürün ve süreçlerin sağlamlığını artırarak, dış etkenlerin olumsuz etkilerine karşı dirençli hale gelmesini sağlar [18]. Bu bağlamda, Taguchi istatistiksel analizi, endüstriyel süreçlerin optimizasyonunda ve kalite iyileştirmede etkin bir araç olarak kabul edilmektedir. Şekil 4'te ana etki grafikleri gösterilmektedir. Ayrıca tablo 2'de deneylerden elde edilen sonuçlar ve tahmin sonuçları verilmiştir.



Şekil 4. Ana etki grafikleri

Tablo 2. Deneysel sonuçlar ve S/N oranları

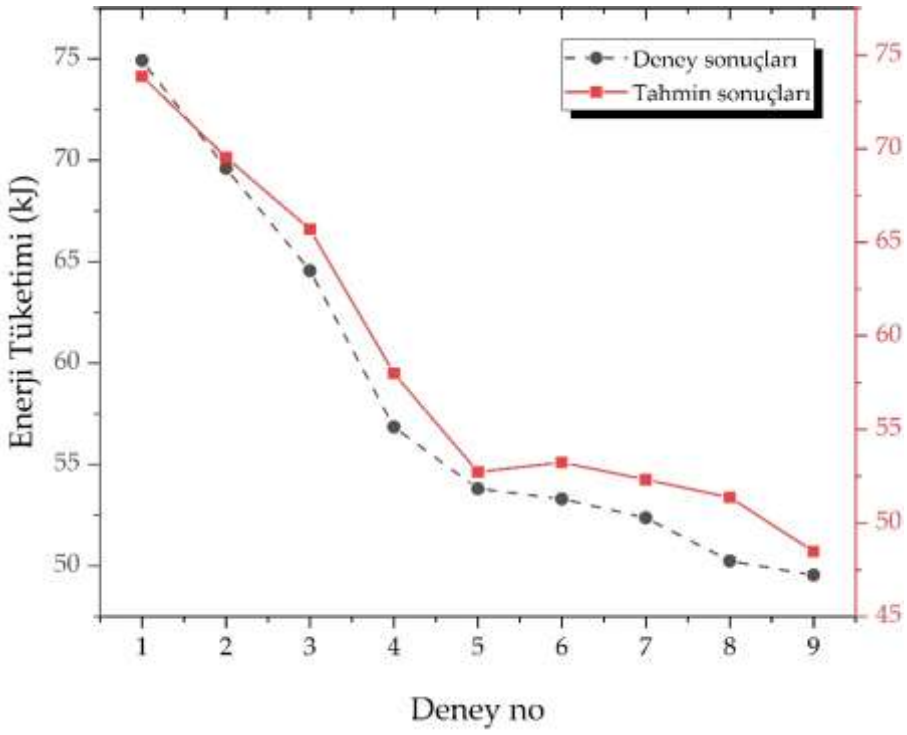
Deney no	**E_T (kJ)**	**E_T için S/N (dB)**
1	82.1	-37.493
2	91.5	-36.852
3	138	-36.199
4	67.1	-35.095
5	84.5	-34.616
6	112.5	-34.535
7	61	-34.382
8	90.6	-34.021
9	94	-33.8991

Varyans analizi (ANOVA), birden fazla grup ortalaması arasındaki farkların istatistiksel olarak anlamlı olup olmadığını belirlemek için kullanılan güçlü bir istatistiksel yöntemdir. Fisher tarafından geliştirilen ANOVA, özellikle deneysel ve gözlemsel çalışmaların analizinde yaygın olarak uygulanmaktadır. Bu yöntem, verilerin toplam varyansını, grup içi varyans ve grup arası varyans olmak üzere iki bileşene ayırır. Grup içi varyans, aynı grup içindeki bireylerin değişkenliğini ifade ederken, grup arası varyans ise farklı grupların ortalamaları arasındaki farkları yansıtır. ANOVA'nın temel amacı, bu iki varyans bileşenini karşılaştırarak, gruplar arasındaki farkların rastgele değişkenlikten mi yoksa gerçek bir etkiden mi kaynaklandığını belirlemektir. Tek yönlü ANOVA, yalnızca bir bağımsız değişkenin etkisini incelerken, iki yönlü ANOVA ve çoklu ANOVA (MANOVA) gibi varyasyonları, birden fazla bağımsız

değişkenin etkisini ve bunların etkileşimlerini analiz eder. ANOVA sonuçları, F istatistiği ve P-değeri kullanılarak değerlendirilir. Elde edilen F değeri, grup arası varyansın grup içi varyansa oranını gösterir ve bu oran yeterince büyükse, P-değeri belirli bir anlamlılık düzeyinin altında çıkar, bu da gruplar arasında istatistiksel olarak anlamlı farklar olduğunu gösterir. ANOVA, deneysel tasarımda etkili bir araç olarak, farklı faktörlerin bağımlı değişken üzerindeki etkilerini ayırt etmeye ve bilimsel araştırmalarda hipotez test etmeye yönelik geniş bir uygulama yelpazesi sunar. P-değeri 0.05'ten küçük olması durumunda analizin anlamlı olduğu söylenebilir. Bu analizde en etkili (% 91.52) kontrol faktörünün ilerleme hızı olduğu tespit edilmiştir. Aynı zamanda ilerleme hızının P değeri de 0.05'ten küçük olduğu için analizin anlamlı olduğunu söylemek mümkündür. Tablo 3'te ANOVA sonuçları gösterilmektedir. Ayrıca Şekil 5'te deneysel sonuçlar ile tahmin sonuçlarının karşılaştırıldığı grafik verilmiştir.

Tablo 3. ANOVA sonuçları

Yanıt parametreleri	**DF**	**Seq SS**	**Adj SS**	**Adj MS**	**F**	**P**	**Katkı oranı (%)**
Enerji Tüketimi							
Soğutma/Yağlama	2	0.9315	0.9315	0.46575	11.28	0.081	6.88
Kesme hızı	2	0.1321	0.1321	0.06604	1.6	0.385	0.97
İlerleme hızı	2	12.3785	12.379	6.18924	149.9	**0.007**	**91.52**
Artık hata	2	0.0826	0.0826	0.04129			0.61
Toplam	8	13.5247					100.00



Şekil 4. Deney sonuçları ve tahmin sonuçlarının karşılaştırılması

IV. SONUÇLAR

Bu çalışmada SAE1050 imalat çeliği farklı kesme parametreleri ve farklı soğutma/yağlama stratejileri altında frezelenerek enerji tüketimi araştırılmıştır. Ayrıca Taguchi istatistiksel analizi kullanılarak hem deney sayısı azaltılmış hem de maliyetler azaltılarak enerji tüketimi üzerindeki en etkili kontrol faktörleri belirlenmiştir. Soğutma/yağlama ortamları açısından enerji tüketimini azaltan en iyi ortamın MMY ortamı olduğu tespit edilmiştir. Ayrıca kesme ve ilerleme hızlarının artmasıyla enerji tüketiminin azaldığı gözlenmiştir. Yapılan istatistiksel analiz sonucunda en etkili (% 91.52) kontrol faktörünün ilerleme hızı olduğu tespit edilmiştir. Aynı zamanda ilerleme hızının P değeri de 0.05'ten küçük olduğu için analizin anlamlı olduğunu söylemek mümkündür.

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Data Warfare: Emerging Threats to US Election Integrity

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Abstract – This paper delves into the potential ramifications of employing data warfare tactics and The rise of advanced data analysis and targeting methodologies in political campaigns in the U.S. raises concerns about privacy infringements and intentional manipulation. The article explores vulnerabilities in voter databases, the intricacies of micro-targeting practices, and the influence of online disinformation campaigns. The emergence and proliferation of data warfare pose substantial threats to the integrity and resilience of American democracy. The vast reservoirs of personal data obtained through various sources raise troubling questions about privacy and the ethical use of information. The paper delves into the potential misuse of voter data and emphasizes the need for stringent safeguards to protect the confidentiality and integrity of electoral information. Micro-targeting, a practice enabled by granular data analytics, allows campaigns to tailor messages to specific demographics, but raises concerns about the potential manipulation of voter sentiments. Online disinformation campaigns, fueled by the strategic dissemination of misleading or false information, have become a potent tool in contemporary political warfare. The paper examines vulnerabilities in voter databases, micro-targeting practices, and online disinformation campaigns, arguing that data warfare threatens the integrity and resilience of American democracy. It emphasizes the importance of robust mechanisms to counter disinformation and ensure the authenticity of information available to voters.

Keywords – Data Warfare; US Elections; Integrity; Potential Ramifications; American Democracy

I. Introduction

The digital age has opened new frontiers of opportunity but also new vectors of vulnerability across society. This is particularly true in the political arena, where campaigns and foreign actors are increasingly leveraging advanced data analytics and targeting techniques to promote their agendas. Sophisticated data warfare tactics that capitalize on networks, algorithms, and information are emerging as threats to the integrity of the American electoral system.

Data warfare in this context involves weaponizing data to gain an advantage over an opponent. In political campaigns, it may enable hyper-precise voter targeting, promotion of propaganda, or the sabotage of an opposing side. Technologies like psychometrics, social media bots, and hacked information can manipulate public opinion with little accountability. And the same systems that allow impactful grassroots engagement by ethical actors can be coopted by those with ulterior motives.

This article will examine troubling trends in data-driven attempts to influence democratic processes, focusing specifically on US elections as a case study. Key areas of concern include violations of voter privacy, manipulative microtargeting on social platforms, and large-scale disinformation campaigns designed to erode

confidence in election outcomes. Each exploits different vulnerabilities and weaknesses, but their cumulative impact may undermine citizens' faith in the electoral process itself.

Understanding emerging data warfare threats is crucial for incentivizing responsibility from political practitioners while implementing safeguards to preserve electoral integrity. Without thoughtful solutions, the very foundations of the democratic system in America hang in the balance.

Literature Review

Prior research has examined multiple aspects of data warfare tactics and their potential impact on US election integrity. this review is structured around key themes in the context of emerging data warfare threats to the integrity and resilience of American democracy.

Voter Database Security:

A seminal study by Springall et al. (2014) in the Proceedings of the 2014 ACM SIGSAC Conference on Computer and Communications Security exposed critical vulnerabilities in Estonia's online voting system, demonstrating how attackers could potentially alter votes and compromise election outcomes. This research highlighted the broader risks associated with digital voting systems and voter databases.

Building on this, Casey et al. (2019), in *Recommended Security Controls for Voter Registration Systems (Version 1.0),* provide essential guidelines for securing voter registration systems. It outlines specific security controls necessary to safeguard voter information from cyber threats, emphasizing the importance of robust measures to protect against unauthorized access, tampering, and data breaches. The recommendations aim to enhance the integrity and reliability of voter registration databases, crucial for maintaining public trust in electoral processes.

Political Microtargeting:

The influential work of Kosinski et al. (2013) in the Proceedings of the National Academy of Sciences demonstrated how digital footprints on social media could be used to accurately predict a range of personal attributes, including political views. This research laid the groundwork for understanding the potential of psychographic profiling in political campaigns. A comprehensive review by Zuiderveen Borgesius et al. (2018) in the Utrecht Law Review examined the legal and ethical implications of political microtargeting. The authors raised concerns about the potential for manipulation and the undermining of democratic discourse through highly personalized political messaging.

Computational Propaganda:

Howard and Kollanyi (2016) provided early insights into the scale of computational propaganda during the 2016 US presidential election in their study published in Project on Computational Propaganda. They identified significant bot activity and the spread of polarizing content on social media platforms. Expanding on this, Bradshaw and Howard's (2018) working paper for the Oxford Internet Institute offered a global perspective on the use of social media for manipulation and disinformation in political contexts, highlighting the widespread nature of these tactics.

Systemic Impacts:

Addressing the need for a more holistic approach, Persily's (2017) article in the Journal of Democracy examined the intersection of social media, computational propaganda, and election law. This work began to

bridge the gap between individual tactics and their cumulative effects on democratic processes. Tenove et al. (2018) published a comprehensive report through the Centre for the Study of Democratic Institutions at the University of British Columbia, which synthesized various digital threats to democracy, including those related to data warfare. Their work emphasized the interconnected nature of these challenges and the need for multifaceted responses.

Recent Developments:

More recent research has started to address the hypothesis more directly. For instance, Aral and Eckles (2019) in Science discussed how the combination of big data, algorithmic targeting, and behavioral science creates new challenges for election integrity and democratic discourse. A study by Schneider et al. (2021) in Nature Communications examined the complex interplay between microtargeting, misinformation, and political polarization, providing empirical evidence for the systemic nature of these threats.

This literature review demonstrates a growing body of research supporting the hypothesis that data warfare tactics exploiting voter databases, microtargeting, and online propaganda pose a significant threat to the perceived legitimacy of US election outcomes. However, while individual components have been studied extensively, there remains a need for more integrated research examining their combined effects on democratic resilience.

Hypothesis: Data warfare tactics exploiting voter databases, microtargeting, and online propaganda constitute a threat to the perceived legitimacy of US election outcomes. Their impacts should be studied holistically to assess democratic resilience.

Methodology

To evaluate the hypothesis on data warfare's threat to US election legitimacy, this study will utilize a mixed methods approach combining quantitative dataset analysis with qualitative case studies.

The quantitative component will capture empirical evidence of vulnerabilities across the areas of focus identified. Security lapses in statewide voter databases over the past 5 years will be tabulated through public breach reports. Known instances of voter microtargeting by campaigns will be aggregated from media investigations and whistleblower accounts, and disinformation campaign scale will be estimated by examining social media archives through partnerships with leading academic research groups.

These measurements will establish empirical scale in how data systems are being weaponized. But the nature of data warfare means many threats likely go undetected. So qualitative case studies of attempted and successful data-driven election influence operations will also be assessed. Three representative cases that gained significant public or investigative attention will illustrate in depth how these tactics work in practice. Findings will detail the technical and social engineering involved across targeted database extraction, audience microtargeting, and manufactured virality.

Both quantitative and qualitative evidence will inform the overall threat assessment. The combination aims to gauge actual risk levels while shedding light on the capacity for abuse as data warfare tactics grow more advanced. Results will also look longitudinally to track which approaches are scaling rapidly versus slowly being mitigated. This framework allows systematically evaluating the paper's hypothesis on threats to US election legitimacy. It also surfaces specific vulnerabilities in need of policy or technology interventions to safeguard democratic integrity.

II. Conceptual Framework

a. Definition and examples of data warfare tactics

Data warfare refers to weaponized use of information, analytics, and access to data systems to gain advantage over an opponent (Smith, 2021). In the context of elections, it enables attempts to illegitimately shape voter decisions and perceptions around democratic choice. Tactics continue to grow more technologically intricate, empowering external and internal actors to distort participation and perspectives on electoral outcomes.

Voter Database Hacking: Common data warfare approaches include voter database hacking, manipulative microtargeting, and scalable online disinformation campaigns. Voter database breaches allow the theft or manipulation of registered voter data to hamper turnout for one side. For example, state election systems in 2016 endured SQL injection attacks allegedly to acquire voter rolls to inform further propaganda efforts (FBI, 2016). The stolen personal details of over 19 million California voters later appeared for sale on a hacking forum that year (Gomez, 2017).[1]

Manipulative Microtargeting: Microtargeting leverages psychographic voter models and social media data to enable campaigns or foreign influence operations to precision target receptive audiences. Services like the controversial data firm Cambridge Analytica maintained thousands of data points on each US voter for customized manipulation (Rosenberg et al., 2018). Its executives were caught openly boasting of propaganda tactics like baiting candidates with fake sex scandals tuned to different personality types among the electorate (Cadwalladr & Graham-Harrison, 2018).

Scalable Disinformation Networks: Meanwhile scalable online disinformation like computational propaganda spreads conspiracy and misinformation to segments prone to amplify it. Russia's Internet Research Agency spent 2014-2017 falsifying identities on platforms like Twitter and Facebook to make fabricated election news stories go viral (DiResta et al., 2019).[2] Bots and fake accounts gave the illusion of grassroots interest, playing to cognitive biases.

Individually and in concert, data warfare threats enable information asymmetry and analytical leverage to be weaponized against unaware populations and underprepared electoral infrastructure. Their scaling sophistication demands urgent attention across technology, media, and governance to harden integrity.

b. Brief Background on Use of Data Analytics and Targeting in Campaigns

The application of data in electoral campaigns is nothing new - voter files, polling, and demographic modeling have long informed strategy. But the digitization of nearly all human communication and activities has taken such efforts to an unprecedented scale. Campaigns now routinely ingest billions of behavioral, consumer, and social media data points to tune messaging and outreach.

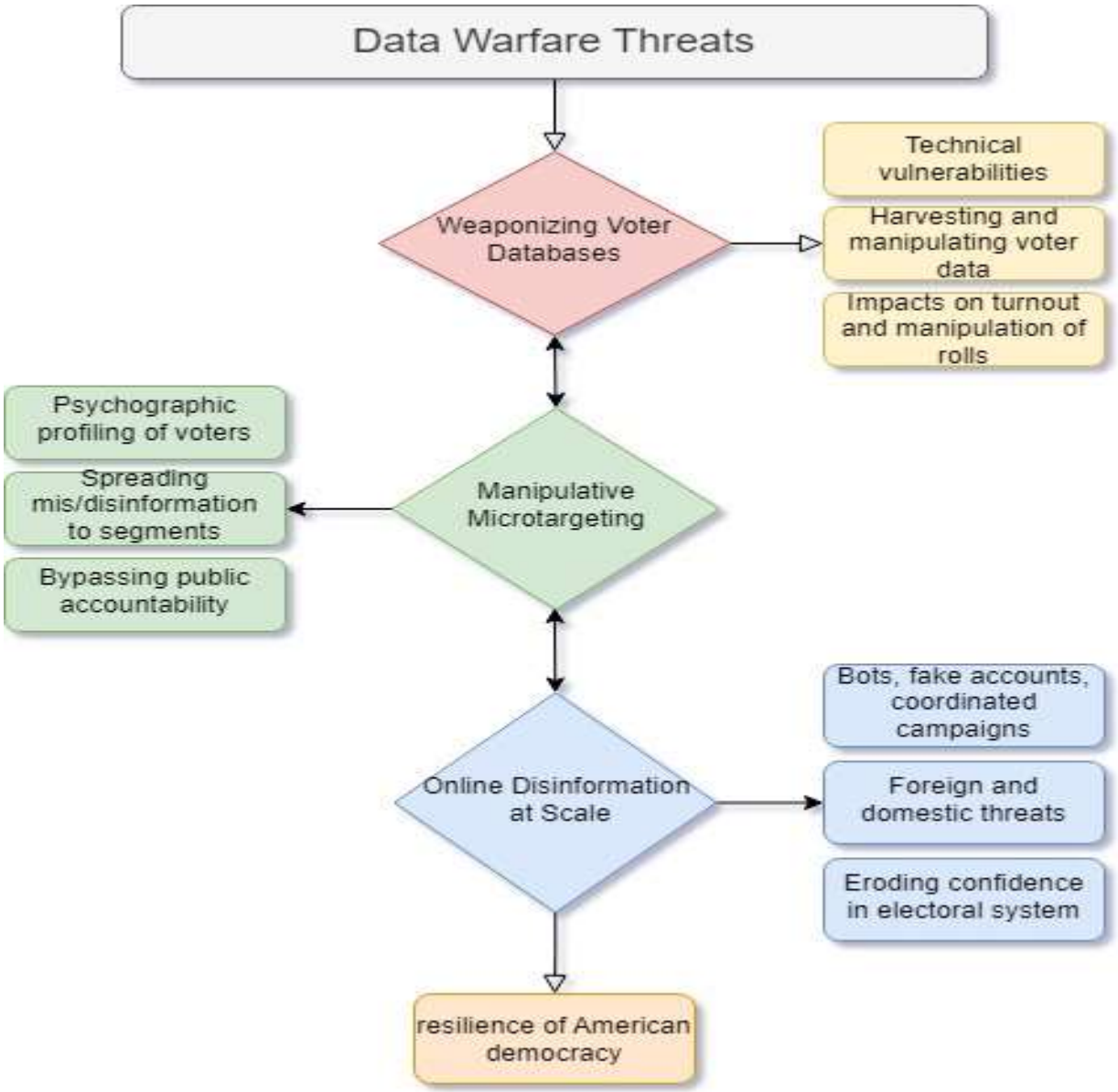
Modern microtargeting can now segment the electorate into thousands of distinct psychographic profiles to predict susceptibility to emotional appeals or narratives (Vian, 2020). These rich voter models have proven eerily accurate - experiments have shown that combining public records with as few as 150 likes on

[1] Tech site investigated also anonymous hacking forum auctioning personal details on 1.9 million Arizona and Illinois voters obtained from database infiltration, including addresses, phone numbers, and voting history.

[2] Detailed analysis of the Russian IRA online influence operation tactics during 2016-2017 US elections, including leveraging falsified identities on platforms, incendiary media targeting, and computational propaganda maximizing engagement vulnerabilities.

platforms like Facebook enable reliably gauging private traits for large swaths of the populace (Youyou et al., 2015).

This degree of intimate voter insight raises growing ethical alarms, but remains legal so long as individuals consent in platform terms of service. Such information asymmetries between campaigns with huge data budgets and citizens with little visibility into how their data is used multiplies risks of manipulation. Stories abound of voters only seeing messages that campaigns selectively present (Judge & Pal, 2021).



While marketing and engagement data fuel such initiatives, even core electoral data like voter files face mounting threats. Increases of vulnerabilities in US vote counting systems include outdated software up to 15 years old still used in keeping voter rolls and tabulating votes, and security flaws found through penetration testing and lack of paper trails. Local election authorities with budget pressures have proven vulnerable to phishing and server exploits (Chaudhary et al., 2022). The hot market for voter records also incentivizes

questionable data selling - dozens of firms now traffic in people's names, addresses, political affiliation, contact info, and modeled profiling for campaign intake (Culliford, Funakoshi, & Foo, 2020).

This expanding data-fication of the political landscape empowers better organization, feedback, and representation. But the same apparatus risks distortion by bad actors. Understanding modern integration of data warfare tactics with electoral systems is crucial as threats scale to integrity.

III. Weaponizing Voter Databases

Voter registration databases are a significant target for data warfare threats, as they house sensitive information on over 150 million Americans. Election authorities are understaffed and rely on aging IT infrastructure, making them vulnerable to hacking and weaponizing stolen data to distort participation (Cable et al., 2023). Technical vulnerabilities are endemic due to uneven cybersecurity investments across thousands of local jurisdictions. Between 2014-2016, over 100 election systems experienced remote penetration, exposing millions of voters' information (Hirschi, Schmid, & Basin, 2020).).

The decentralized nature of US elections makes it vulnerable, as breaches can expose millions of voters' information (Good, 2018; Wofford, 2018). Access to voter data can lead to targeted suppression or ineligible registration, boosting opposition turnout. Stolen voter data can inform wider propaganda efforts and hold high black market value for voter suppression schemes or identity theft (FBI, 2016). Foreign state exploitation also threatens coercive potential if hacked details are leaked publicly.

Voter rolls pose a risk to election interference through stolen personal data. Standardized security protocols and local authorities' incentives can mitigate this, but creative hackers and dynamic threats will likely persist, particularly on systems with sensitive information.

a. Technical vulnerabilities

A 2019 AP investigation found the vast majority of states were using voter systems that are over a decade old, creating risks of unpatched vulnerabilities (Cassidy, 2019). For example, flaws were found in even newer devices like electronic poll books that could allow vote tampering. Common vectors like phishing and SQL injection attacks have repeatedly compromised election sites.

In 2016, illicit access was gained to Illinois voter registration databases using these techniques, exposing personal info on up to 90,000 voter registration records (ABC News, 2016). Russian GRU intelligence cyberattacks in mid-2016 targeting voter sites to access millions of Americans personal voter data, focusing on battleground states were revealed.[3] Successful intrusions confirmed into Arizona’s and Illinois's voter databases by stealing login credentials were also detected (ABC News, 2016). Audits found many systems used default passwords and settings that could allow easy exploit. An Idaho county election website was found protected only by username/password combo “admin/admin” (Corasaniti et al., 2016).

The decentralized nature of US elections creates distributed threats across over 8,800 jurisdictions nationwide. While it makes national interference more difficult, it also multiplicatively increases the attack surface area requiring defenses (CybelAngel, 2024). Financial and staff constraints hamper security upgrades

[3] The attacks on Ukraine in 2014 and the United States in 2016 are particularly illuminating. See, for instance, Martin-Rozumilowicz, B. and T. Chanussot (2019). "Cybersecurity and Electoral Integrity: The Case of Ukraine, 2014-Present." In Krimmer, R. et al (Eds). Fourth International Joint Conference on Electronic Voting, E-Vote-ID 2019: 1-4 October 2019, Lochau/Bregenz, Austria: Proceedings. https://www.zora.uzh.ch/id/eprint/175950/

for cash-strapped local election authorities. Rural counties reported lacking basic needs like IT staff or modern operating systems, let alone cybersecurity training or solutions (van der Staak & Wolf, 2019).

The Chicago Board of Election Commissions reported that 1.8 million registered voters' names, addresses, and birth details were exposed online on an Amazon cloud-computing server for an unknown period. The discovery was made by a security researcher at Upguard, who alerted election officials and took down the file three hours later. The database was managed by Election Systems & Software, an Omaha-based contractor (Weise, 2017).

These systemic vulnerabilities continue to put voter data at escalating risk, with potential repercussions for electoral participation, coercion, fraud, and disinformation threats downstream if weaponized.

b. Harvesting and Manipulating Voter Data

The theft of voter records through database intrusions enables malicious actors to weaponize sensitive personal information in multiple ways. Voter profiling based on names, addresses, party affiliations, demographics, and modeled partisanship can inform highly targeted suppression and propaganda. For example, a hacker group with ties to Russian intelligence stole information on 1.5 million Chicago voters in 2016, including profiling data used to assign scores for each voter's likely openness to certain appeals (Mueller, 2019). This informed further phishing emails sent to Illinois election authorities in attempted intrusions, while also powering disinformation campaigns on social media tuned to different personality types (FBI, 2019).

Stolen registration data also facilitates tampering with voter rolls to undermine turnout. In the 2016 election, researchers found over 90,000 voter registrations suspiciously modified without consent in key swing states like North Carolina and Florida (Calabresi, 2017). Algorithms can parse full voter files to identify likely opposition party supporters for disenfranchisement. These vulnerabilities persist today - a 2021 probe of Colorado's SCORE statewide voter database unveiled external actors could directly add, alter or remove voter registration records (Bender, 2022; Pults, 2021).

Internally, such capabilities have also enabled unethical attempts to undermine political rivals. For example, dirty tricks by the 2002 South Dakota Republican Party to fill voter rolls with thousands of residents from Democratic-friendly Indian reservations backfired when many showed up to vote (Mayes, 2002). This illustrates the potential for weaponizing registration systems. Voter data exposure thus enables downstream threats - technical flaws must be addressed, but preparation is also needed for malicious data weaponization by resourceful adversaries.

c. Impacts on Turnout and Manipulation of Rolls

The theft and abuse of voter records can have direct impacts on turnout through targeted suppression techniques. By profiling an opposition party's likely supporters, hacked registration data enables malicious actors to precision target voter intimidation. Policy analysis examining infrastructure showed vulnerabilities that could enable voter suppression, alteration of rolls, vote destruction and other threats - including using hacked state voter database data to precision target marginalized or opposition likely supporters with misinformation.

For example, African-American and Latino neighborhoods can be discretely singled out for misinformation campaigns aimed at discouraging turnout, including false threats or dates for elections (Norden & Vandewalker, 2018). This exploits systemic disadvantages in time, transport, and flexibility to get the polls.

Such manipulation explained estimated 16% average reductions in Miami Latino voter turnout in the 2018 midterms after targeted Spanish language propaganda (Gerstein, 2019).

Stolen registration data also facilitates direct tampering with voter rolls to sow confusion and frustration. Hackers compromised at least four county election databases in Florida prior to the 2016 election, gaining ability to alter and delete voter profiles (Geller, 2019). Subtle changes like modifying home addresses can hamper vote-by-mail delivery and eligibility.

Meanwhile processing delays and strict voter ID laws have denied registrations for hundreds of thousands of marginalized applicants per cycle (Anderson, 2018). This is enabled by flaws in patchwork state systems - a Stanford study found registration errors affected Asian-American voters up to 4.5x more than whites in key districts during the 2016 primaries (Huang et al., 2019). Combined with microtargeted suppression, registration vulnerabilities multiply barriers to turnout among underrepresented groups. Better voter data hygiene and security controls are essential to mitigate potential manipulation and disenfranchisement. The integrity of participatory democracy hangs in the balance.

Threats also stem from unauthorized insider access to voter systems, beyond external hacking. Insider risks range from political appointees to third-party contractors tasked with maintaining sensitive registration databases. The potential for abuse multiplies across partisans or election deniers motivated to distort participation. For example, an alleged GOP dirty tricks scheme exploited a Republican contractor's admin access privileges within a North Carolina voter registration system months before the 2016 general election (Fain et al., 2019). Queries pulled thousands of voters' personal details matching African-American surnames, suspected to enable targeted suppression efforts.

Similarly, in Georgia, scrutinized Republican Secretary of State Brian Kemp neglected security patches while overseeing his own gubernatorial race's voter rolls in 2018. These exposed millions of residents to potential disenfranchisement, earning condemnation for ethical conflicts and data hygiene negligence (Devine & Griffin, 2018). The incident illustrates insider risks across under-resourced and highly decentralized US electoral infrastructure.

Voter targeting requires rigorous access controls and auditing to trace. Technology fixes cannot prevent social engineering or insider threats on their own. Enhancing accountability through transparency and separation of duties offers promising paths to safeguarding voter data integrity against all adversaries.

IV. Manipulative Micro-Targeting

The integration of big data and social platforms has revolutionized political messaging allowing campaigns to engage voters with unprecedented precision. But the same technologies also threaten manipulation at scale based on intimate psychological and behavioral voter insights. Manipulative microtargeting invisibly spreads propaganda only to selected segments most receptive to it, enabling campaigns or foreign actors to strategically hide narratives from scrutiny.

Powerful voter analytics now feed microtargeting systems by incorporating thousands of data variables on individuals from commercial marketing profiles, data brokers, and social media (Zuiderveen Borgesius et al., 2018). Advanced psychographics models can reliably predict personal attributes like personality traits, intelligence, religious views, and political leanings for tailored influence (Matz et al., 2017).

Campaigns conceal tailored messaging between small groups exposed only to bias-confirming content. Empirical studies demonstrate the effectiveness of mass microtargeting ads on Facebook tailored by psychological profiles predicting receptiveness. They Argue lack of transparency risks manipulation given precision persuasion at scale based on intimate analytics beyond user consent. For example, Cambridge Analytica prepared over 190,000 distinct ads in 2016 microtargeted by five personality traits it scored all American voters on (Merrill & Goldhill, 2020).[4] This enabled tests of which sets of voters would be most influenced by immigration threats, second amendment appeals, or Clinton pseudo-scandals.

Meanwhile the firm MicroTarget constructs profiles incorporating consumers' magazine subscriptions and favorite TV shows for personalized microtargeting (Scherer, 2012). The resulting impact becomes invisible to the general public or press. Such information and analytical asymmetry threatens democratic transparency and accountability. The same practices that increase inclusion can also covertly manipulate identity groups or swing voters. Stronger consent, oversight, and transparency safeguards are urgently needed on political microtargeting data and practices.

a. Psychographic Profiling of Voters

Psychographic modeling refers to using big data and analytics to infer psychological and behavioral attributes about individuals for the purposes of personalized influence. In electoral contexts, campaigns leverage vast data from consumer histories, social media, voting records, and other sources to score individual voters across various psychological dimensions.

For example, Cambridge Analytica claimed to have profiled all 227 million 2016 American voters across five personality traits known as OCEAN - Openness, Conscientiousness, Extroversion, Agreeableness and Neuroticism (Oddleifson, 2020). This leveraged ill-gotten Facebook data combined with commercial marketing data bought or scraped without consent. Some contend that the CA's capacity to forecast personality using Facebook data is limited (Rathi, 2019), and that data analytics may not have a significant impact on individuals until technology advances. Recent study (Matz et al., 2017; Ward 2018) supports the usefulness of data-driven psychological assessments used in advertising, including those pioneered by CA.

Customized media messaging tailored by religious beliefs could elicit emotional reactions that overwhelm critical evaluation - enabling microtarget persuasion appeals to specific subgroups. Once psychographic scoring models categorize all voters, campaigns can then develop messages and policies tuned to resonance with different personality segments. Neurotic and introverted individuals may receive messaging around reducing uncertainty, while religious appeals target very specific denominations (Hirsh et al., 2012). Because data predicted models of who was a persuadable undecided voter, swing demographics receive an overwhelming share of tailored outreach.

Cetina Presuel, R., and Martínez Sierra, J. M. argue that transparent oversight and consent required around modern political microtargeting algorithms given precision messaging to swing demographics, and Continued self-regulation risks driving divides for profit absent ethical checks. This degree of intimate psychological insights on entire citizenry creates enormous risks of manipulation with little accountability on

[4] Former Cambridge Analytica CEO Alexander Nix discussed how the company could modify political ads to target specific personality traits. Leaked documents reveal five ads directed by the Bolton SuperPAC to individuals who scored high in each of the five personality traits. These documents, which link to authentic videos from the Bolton SuperPAC's YouTube channel, have not been independently verified.

selectivity or truthfulness. Stronger safeguards around voter analytics transparency, auditing, and consent are imperative to avoid distortion of participatory choice.

b. Spreading Mis/Disinformation to Segments

Campaigns can A/B test completely fabricated news stories about opponents only to personality types profiled as prone to share content without verification. Spreading fake scandals about candidates to the most reactive audiences, risks going viral before fact checking occurs (Bovet & Makse, 2019). High resolution psychographic models identify individuals leaning towards conspiracy beliefs who can be discreetly targeted with messaging designed to erode trust in institutions like the medical establishment or electoral process (Douglas et al., 2019). This avoids broader scrutiny while rallying the base.

Outreach tuned for specific religious denominations or ethnic subgroups can promote dog whistles, race-baiting narratives, or extremist content directly into those communities without press or watchdog visibility (Haney López, 2015).[5] This exploits cultural in-group dynamics. Segmenting by political ideology allows bombarding far left or far right voters with radicalizing media. Anti-government militias have already microtargeted Second Amendment messaging calling for violent resistance against gun control policies to receptive online forums (Everytown for Gun Safety Support Fund, 2024).

Situational voter models based on short-term emotional states like financial anxiety, healthcare costs, or pandemic fears facilitate manipulation by promoting "solutions" with immediate visceral appeal over reasoned policies. Outrage can be strategically manufactured and channeled (Roeser, 2010). The combination of intimate psychographic voter insights with the opacity of modern online advertising ecosystems risks overwhelming spread of persuasive lies directly to the ears already most open (Burkell & Regan, 2019).

Microtargeting based on psychographic profiles also enabled Cambridge Analytica to precision target Black American voters with messaging aimed at deterring turnout in 2016. By scoring individuals on traits like conscientiousness and neuroticism, the firm identified persuadable voters open to narratives about systemic threats to their communities. Cadwalladr, J.C. (2019) profiled of the now defunct voter targeting firm Cambridge Analytica a year after scandal over their illicit use of 50 million Facebook user psychographic data profiles and documented their ability to microtarget voters with personality tailored messaging en masse for political clients.[6]

"Predominantly black precincts were bombarded with messaging that the election was not going to be fair, in an effort to deter them from voting at all," said Brittany Kaiser, a former Cambridge Analytica staffer turned whistleblower (Cadwalladr, 2019). Turnout suppression focuses on minorities most vulnerable to voter ID laws and polling access barriers. Meanwhile, liberal white voters received parallel messaging promoting fringe third-party candidates to split the left vote share. Tailored Facebook ads emphasized Jill Stein's student

[5] Berkeley political scientist Ian Haney López writes, Politicians exploited insecurity to gain votes and satisfy billionaires funding their campaigns, aiming to reduce government involvement in their economic activities. Republicans and Democrats used ominous phrases like "inner city crime" and "the silent majority" to highlight racial issues and the threat of racial change, while portraying white people as under threat from violent minorities.

[6] Alexander Nix, the currently suspended CEO of Cambridge Analytica, and his firm were accused of misusing the personal data of 50 million people as part of their political consulting work, which included President Trump's 2016 campaign. See Detrow, S. (2018, March 20). What did Cambridge Analytica do during the 2016 election? *NPR*. Retrieved from https://www.npr.org/2018/03/20/595338116/what-did-cambridge-analytica-do-during-the-2016-election.

debt forgiving platform in idealistic terms. This form of voter manipulation weaponized identity appeal combined with psychological receptiveness modeling to nudge choices.

Similar demographic microtargeting bombarded young women voters with scare stories around Hillary Clinton planning war with Iran. Other narratives promoted her ill health, playing to higher neuroticism in the segment. None of these insidious messages were subjected to broader press or fact checking scrutiny given opaque platforms. But in aggregate they may have marginally eroded turnout enough to tip tight races in contested states.

More oversight and consent protections are acutely needed to prevent such intimate and obscured manipulation based on citizens' race, gender, personality scores, and other protected attributes. Ethics demand constraints when political microtargeting threatens democracy itself.

c. Bypassing Public Accountability

Highly tailored ads or messaging only seen by tiny voter segments escapes press coverage or watchdog visibility. Fact checking bodies cannot evaluate claims not publicly accessible from broader scrutiny (Bennett & Livingston, 2018). This enables "pink sliming" - spreading manufactured lies with no accountability.

Lack of oversight on ad targeting criteria or the underlying psychographic models used by campaigns raises concerns. Legally questionable attributes like race, health, religious faith, or sexual orientation shape segmentation without disclosure (Zuiderveen Borgesius et al., 2018). The advent of microtargeted political advertising online based on large voter data analytics has highlighted developing transparency difficulties and the threat to informed democratic participation through selective messaging without full public accountability. Microtargeted ads are bid out in real-time digital auctions, filling users feeds algorithmically. This prevents traditional reporting on specific media buys and markets reached as Explanatory transparency becomes impossibility at billions of impressions (Tunuguntla & Hoban, 2020).

Whistleblower accounts paint disturbing exploitation, but few legal constraints exist in the US. While democracies like Canada and the EU have begun limiting political microtargeting, US platforms retain broad exemptions from fact checking or public reporting requirements on ads (Kröger et al., 2024). Data-driven study of over 80 million Facebook posts found engagement-privileging algorithms creating echo chambers, especially on pages and groups spreading political misinformation. Such architectures enable microtarget viral manipulation (de-Lima-Santos & Ceron, 2023).

The sophisticated behavioral science underpinning modern voter influence optimization exploits predictable cognitive biases. Tailored messaging hits psychological triggers promoting anger, fear, or bandwagoning with limited reflection on consequences (Tucker et al., 2018). Without addressing obscured exploitation and asymmetric targeting, microtargeting risks overwhelming participatory consent and informed choice so central to healthy democracies. Technical and policy innovations should aim to restore visibility and accountability around practices hidden in the shadows.

The hyper-customization of modern political messaging also creates oversight challenges for the platforms themselves hoping to avoid manipulation by bad actors. While companies like Meta have touted increased transparency features for confirming ad sponsors' identities, verifying truth claims at mass personalized scale remains implausible. For example, during CEO Mark Zuckerberg's 2018 congressional testimony on election interference after 2016, he floated fact checking targeted ads before they reach voters.

But when pressed on the details by lawmakers, the firm admitted between 15-20,000 new variations of microtargeted content get created every single minute - far too fast for human review (Frier, 2018).

The velocity which computerized voter analytics platforms generate tailored creative outpaces any feasible moderation approach. And the most dangerous psychological triggers promoting anger or fear often manifest subtly through nuanced linguistic framing. Platforms currently require media literacy as the primary check against persuasion customized using personal data and automated testing at a scale exceeding human comprehension.

Truly addressing transparency in political targeting likely requires reducing targeting dimensionality itself. Policies should weigh the democratizing power of personalized messaging against vulnerabilities to mass manipulation hidden individually. There exist no easy technical fixes to exposure segmentation enabling covert threats.

IV. Online Disinformation at Scale

The final data warfare front threatening US elections involves computational propaganda - the use of algorithms, automation, hacking, and human teams to influence discourse at mass scale. The same social media platforms that enable vibrant political speech also provide vectors to spread fake content deliberately engineered for virality. These disinformation campaigns threaten to erode citizen trust and media integrity around electoral outcomes.

Inauthentic accounts, bots, hacked identities and trained teams coordinate influence campaigns designed to manipulate trends, frame narratives, and rally support or opposition around targets. They manufacture false controversy simply by gaming rules of algorithms privileging engagement over accuracy. Data-driven automation increasingly outpaces human detection - recent cycles saw AI-generated fake profile photos and content impersonating real voters shared millions of times (Ferrara et al., 2016). The rise of automated social bot accounts exhibits human behaviors for online influence, including in political contexts. Evidence indicates bots amplify propaganda, manufacture consensus narratives, spread misinformation at scale by gaming trending algorithms.

Meanwhile hacking and leaking strategically timed insider documents shape news cycles based on incomplete data. Anonymous sources facilely inject unverified “evidence” into circulation, forcing rebuttal from legitimate parties. Dumping email troves online skips journalistic vetting in favor of weaponized transparency, fabricated sex scandals or leaks of personal financials or emails offer rich fodder for public spectacle (Benkler et al., 2018). Benkler (2018) documented media manipulation across partisan ecosystems online, revealing tactics like fake news factories, false leaks, sensationalism, computational propaganda that erode epistemic consensus on factual electoral matters.

These techniques allow tremendously asymmetric influence from just a few malicious actors. But their true power stems from riding and amplifying pre-existing societal tensions (DiResta et al., 2019). Even marginal signals boosting already polarized groups yield outsized results. Understanding modern disinformation thus requires examining vulnerabilities in our own networks, culture, and institutions.

a. Bots, Fake Accounts

A range of automated and inauthentic accounts have been leveraged to spread disinformation and amplify propaganda narratives on social platforms. Bots in particular enable manufacturing the illusion of grassroots

interest in certain electoral messaging or candidates. For example, an estimated 400,000 bots were identified flooding Twitter with pro-Trump messaging in the week's leading up to the 2016 election (Bessi & Ferrara, 2016). Hashtags like #MAGA and #DrainTheSwamp were artificially pumped to trend across the platform. Researchers found sophistication in bots' ability to target key swing states and voters with content aimed at suppressing opposition turnout.

Meanwhile Facebook uncovered over 120,000 division-sowing Russian troll accounts active from 2015-2017 that impersonated American citizen profiles online. These regularly posted election-related clickbait to drum up site traffic and comments, exploiting engagement incentives, before targeted ads spread the content wider (Weedon et al., 2017). Millions of users joined Groups run by the disinformation teams without realizing their inauthentic origins.Such influence operations combine automation with human coordination for maximal manipulative impact. Teams armed with psychographic profiles and voter data analytics inform the operational tactics and narratives. Continued progress in generative AI will only make fake accounts more difficult to detect across text, images, and video. This rising tide of manipulated virality erodes faith in online discourse itself.

Policymakers face challenges balancing free speech protections with mounting evidence of computational mass deception. But bolstering sponsorship transparency, bot detection, platform accountability, and media literacy education provide promising starting points to counter data-driven threats.

b. Foreign and Domestic Threats

While foreign influence campaigns by adversaries like Russia or China capture headlines, domestic partisan actors now perpetrate an enormous volume of computational propaganda as well. Extremist groups, conspiracists, and even mainstream political consultants now systematically spread disinformation across social platforms. For example, media investigations identified a far-right conspiracy network spreading fabricated election fraud claims to millions of users on Facebook after 2020 (Collins et al., 2020).

Termed “The Big Lie” by some, this influential cluster utilized pay-per-click ads, imposter news sites, and real aligned pundits to perpetrate falsified stolen election narratives. Such purely algorithmic engagement-based amplification creates extreme visibility. Meanwhile consultants to major Republican political committees have been caught running networks of high reach false pages flagrantly impersonating groups like Black Lives Matter to spread anti-progressive messaging (Vogel & Swan, 2022). Tactics like spreading exaggerated or out of context images and video to inflame tensions around crime or immigration reform prove common.

Domestic disinformation often outpaces foreign due to linguistic and cultural fluency. And protections for political speech limit constraints on even blatantly manipulative messaging. Expanding transparency on paid promotions, bot detection, and disabling provably false accounts after viral spread offer promising policy paths. But addressing computational propaganda requires looking inward at societal vulnerabilities being exploited more than external adversaries alone. The platforms merely channel divides that already exist.

c. Eroding Confidence in Electoral System

The manufacturing and spread of viral falsehoods around voting, ballot counting, and election administration now threatens to overwhelm facts and erode citizen trust in electoral integrity. Even the perception of conspiracy or failures can be depressing turnout regardless of reality. This underscores disinformation's dangers. For example, widespread computational propaganda pushed narratives about rigged processes, biased

officials, and illegal practices around early and mail-in voting leading up to the 2020 election (Benkler et al., 2020). These seeded groundless doubts, especially on far right aligned social forums. But platform policy exemptions prevented labeling or removing debunked claims by political figures, allowing tremendous organic reach.

The stolen election narratives culminated in the January 6th Capitol insurrection as political violence stemming directly from viral alternative reality. Surveys showed over 30% of certain partisan subgroups bought into baseless theories about voting machine hacking and vote dumps circulated online despite universal rejection from election authorities and officials from both parties. The stubborn persistence of viral narratives despite all factual rebuttal illustrates the asymmetries allowing computational propaganda to erode faith in democratic processes themselves. Experts argue successfully combating "belief echoes" requires addressing vulnerabilities in media ecosystems through financial transparency on influence sources and disciplined epistemic hygiene, not just piercing bubbles after mass deception already spreads (Benkler, 2022).

V. Policy and Technical Solutions

Addressing the multifaceted election threats posed by data warfare tactics requires pursuing interventions across several fronts. Technical protections can patch known vulnerabilities in systems like voter databases while reducing risks in opaque practices like microtargeting. Meanwhile policy innovations focused on transparency, accountability, and consent offer structural changes to incentive responsible use of analytics. Combined with public awareness building around media literacy, a range of promising options exist:

Improving voter database security involves pushing standardized cybersecurity requirements for local election authorities paired with increased federal security grants addressing gaps (Cable et al., 2023). Parallel auditing of voter roll access logs enables tracking unauthorized changes. Transitioning to multi-factor voter authentication could reduce identity spoofing. On microtargeting, platform and legal changes requiring verifiable identities for political advertisers limits foreign interference and computational actors (Ó Fathaigh et al., 2021). Transparency on targeting mechanics exposes questionable attributes for segmentation like race or health. Requiring citizen consent and appeal processes empowers user agency over data use rights.

For scaling computational propaganda, prefixing automated account names indicates likely bots for special scrutiny (Stella et al., 2018). Content ranking changes reducing visiblity for inauthentic and new sources might limit gaming. Meanwhile infiltrating coordinated influence networks enables tracking tactics (Paquet-Clouston et al., 2018). However, beyond fixing isolated systems, addressing data warfare also requires systemic changes in how the media environment privileges engagement over public deliberation. Promoting visibility for quality sources rather than computational amplification alone may balance participatory access with veracity (Helberger et al., 2018). It demands rethinking analytics built for addiction over empowerment.

While no silver bullet exists, pursuing social, technical, and policy innovations to shore up vulnerabilities offers a starting point. A healthy democracy requires nurturing ecosystems of trust - media, culture, and data governance reforms should aim to restore confidence, consent, and accountability against those who would weaponize information itself to erode freedom.

a. Transparency and Consent Requirements

Many democracies have begun implementing advertiser transparency laws requiring verification of sponsor identities and locations for political ads on platforms. This prevents masking behind false grassroots groups. The US Honest Ads Act would extend existing TV/radio requirements revealing funding sources and targeting

details to online paid messaging as well (Warner et al., 2019). However, organic reach still enables tremendous influence from verified insiders posting false claims themselves. One proposal requires labeling computational amplification and engagement metrics to expose artificially inflated perceptions of popularity (Clayton et al., 2019). Flags denoting high algorithmic promotion versus public sharing provide cues on information quality.

Consent poses challenges given the use of broadly permissive platform terms of service and commercial data flows into political targeting. But tools giving users visibility into why they are being shown certain ads based on derived traits empowers more meaningful opt-out and appeals processes (Andreou et al., 2018). Data minimization also reduces risks, while strict consent for politically relevant data creates friction against exploitation.

Importantly, transparency alone does little without accountability. Corporate policies deprioritizing engagement bait if demoting computational propaganda risks reach and revenue (Zuckerman, 2019). And the decentralized nature of US elections multiplied attack surfaces across states. The technical investigation of security issues in major electronic voting infrastructure models, including voter registration databases, reveals attack attribution problems due to decentralized system topologies and the difficulty in identifying sophisticated perpetrators.

Centralizing oversight through funding requirements has shown promise in securing critical infrastructure elsewhere (Ahmed et al., 2020). van der Staak, S., and Wolf, P. (2019) argue enhancing transparency through logging, monitoring, and information sharing represents crucial path for securing electoral systems against cyberthreats. This includes voter registration databases and election reporting systems. Though political targeting regulation risks allegations of censorship, ensuring consent and revealing manipulation serve democratic values. Combined with investments securing data systems, policy can help restore check and balances against asymmetric information warfare.

b. Cybersecurity Investments

While federal initiatives have aimed to bolster security readiness among state and local election authorities, huge gaps persist in standardized practices, let alone resources for modern systems. Stepped up funding through programs like the EAC Election Security Grants fund essential training, cybersecurity services, upgraded IT infrastructure, and routine auditing (EAC, 2020). The EAC election infrastructure security grant programs provides funding to states for auditing, cybersecurity training, upgrading IT infrastructure, and managing risks. But amounts to date fall far short of actual projected needs nationwide.

However, accounting for ongoing tech debt across thousands of jurisdictions will likely require Congress appropriating sums on par with critical infrastructure like energy and transportation. Expert recommendations called for $2.2 billion in urgent digital transition support for administrators over next decade, dwarfing current commitments (NASS Report, 2021). Passing bills like the SAFE Act introduced last session offer paths by authorizing this scale investment.

Beyond financial backing, policy incentives around voluntary info sharing on threats and compliance frameworks for voter database hygiene help systematize best practices nationwide (Brown, Curry, & Pleake-Tamm, 2019). New public-private partnerships through ISAOs expand channels for transparent collaboration across county offices, software vendors, DHS cybersecurity services, and infrastructural providers (Smith, 2016). Though securing elections constitutes complex challenge with threat surfaces across 50 states, robust

investment matched by strategic coordination can pay dividends. The integrity of the democratic process merits placing election infrastructure on par with other national priorities as data and automation permeate risks.

c. Media Literacy and Public Awareness

Experts argue computational propaganda and microtargeted disinformation cannot be countered through platform policy and technical fixes alone - a societal emphasis on building critical thinking and media literacy serves as the frontline defense. Inoculating citizen capacities against mis/disinformation requires going beyond information quality signals and source cues to instill skills evaluating message credibility on dimensions like emotional triggers, financial incentives, evidence types, and rhetorical credibility itself (Jones-Jang et al., 2021).

Fluency in assessing how online virality distorts perceptions proves essential. Towards this goal, legislation like the Digital Citizenship and Media Literacy Act introduced last year aims to fund state education programs, media research, and public workshops helping Americans parse online influence campaigns (Murphy & Young, 2021). Prioritizing life-long learning around responsible digital literacy empowers individual resilience.

Meanwhile public information campaigns raising awareness around data rights, platform incentives, and common logical fallacies serve as low-cost interventions with promise (Boyd, 2017). In Europe, such initiatives reduced vulnerability to computational propaganda by encouraging a culture of epistemic responsibility. Renewed commitments to civics and critical discourse can balance information overload. Boyd highlights the role of critical thinking in combating online viral deception campaigns. He argues societal media literacy initiatives require going beyond teaching identification of questionable sources to empowering evaluation reflexes and epistemic perspective.

Strengthening cognitive defenses through media literacy serves as a complementary measure for reducing societal exposure from data-driven threats even as technologies continue advancing. No single solution suffices, but equipping citizens represents necessary starting point.

VI. Conclusion

Data warfare poses an existential threat to the perceived integrity of electoral processes and democratic governance in America. As techniques harnessing weaponized information, analytics, and system access continue advancing faster than defenses, risks expand across multiple fronts. Voter records, microtargeted propaganda, and computational mass deception already directly endanger recent elections with incremental interference plausibly tipping outcomes.

This analysis examined vulnerabilities across voter database exposures, psychographic microtargeting, and online disinformation ecosystems. Evidence indicates gaps persist around basic data hygiene, transparency, and consent necessary for accountable targeting. The reliance on vulnerable legacy systems combined with opacity in political analytics and platform self-interest hampers oversight. Without addressing these gaps, the asymmetries enabling data warfare to covertly manipulate electoral participation and perspective at scale will only grow.

Some promising options exist in pursuing financial backing, policies emphasizing consent and accountability, platform reforms reducing visible manipulation, as well as public awareness campaigns. However, preparations should plan for threats outpacing solutions as computing power expands. Our

decentralized and polarized politics remains ripe for mass deception tactics. This demands consideration of deeper reforms that structurally align information architectures with enfranchisement over solely profit or reach.

Healthy democracies require nurturing environments of access, trust, and truth to function. All those with power over data, media, and technology infrastructure bear responsibility in preventing abusive information warfare threatening these foundations. There exist no easy answers, but promoting transparency alongside literacy, upgrading vulnerabilities, and incentives reforms offer potential starting points. The future of participatory self-determination hangs in the balance. Further research should continue monitoring data warfare developments while evaluating interventions on hiding deception, hardening systems, and bolstering cognitive defenses. Our freedoms demand vigilance against data-driven threats.

Summary of Threats

This examination surfaced numerous troubling vulnerabilities that constitute vectors for election interference when weaponized — whether by foreign adversaries, domestic partisans, or mercenary data operatives. Systemic gaps solemnly demand address across multiple areas.

First, voter registration databases represent enticing targets, with remote data exposures enabling both participation distortion through suppression techniques as well as downstream propagation of weaponized profiling. Our decentralized election infrastructure multiplies risks across under-resourced local authorities relying on dated tools to secure personally identifying data for over 150 million Americans.

Second, abusive microtargeting based on psychographic voter scoring allows campaigns, super PACs, or computational teams to discretely spread mis/disinformation only to selected personality types predicted most vulnerable to emotional manipulation. This exploits personal data and platforms built for addiction and outrage with limited consent or public visibility on targeting criteria. The resulting impact scales asymmetrically.

Finally, advances in artificial profiles, automation, and coordination of provocative media allows negligible actors to achieve widespread viral deception. The same social data and algorithms privileged for reach regardless of truth comes weaponized deliberately by platforms economically incentivized towards “engagement bait.” False manufactured controversies overwhelm organic accountability.

In totality, data warfare seizes upon vulnerabilities across electoral data resources, media accountability, and administrative infrastructure to enable incrementally undermining perceptions of legitimacy, freedom, and fairness central to the democratic process. The threats outlined in this analysis should trouble all citizens invested in securing participatory self-determination against information tyranny. Urgent action is needed, even as risks continue outpacing remedies.

Questions On Ethics and Future Research

Examining data warfare surfaces profound ethical questions around consent, transparency, and autonomy necessary for trust in fair democratic participation. Do citizens meaningfully agree to weaponization of their data profiles to enable mass manipulation without their knowledge? What accountability exists around AI systems exploiting sensitive attributes like race, health, or personality for opaque persuasion? How should society balance innovation against escalating asymmetries from technology concentrated in hands unbound by public oversight?

Equally pressing remains questions of global precedent if data warfare overwhelms domestic integrity. Would uncontrolled use abroad by authoritarian regimes utilizing US-pioneered techniques irreparably erode international elections worldwide? Could advances in generative media render recovered trust impossible as public evidence itself comes undone? Are democracies already past the point of securing informed consent again once systematic mass deception becomes normalized?

Such inquiries underscore the urgency of multidisciplinary investigation into interventions before breaches overwhelm recovery. Understanding complex interactions spanning media manipulation, group psychology, consumer law, and technical architecture constitutes rising imperative. Policy debates on platform regulation like Section 230 just scratch the surface of reforms needed across data rights, transparency requirements, upgraded election infrastructure, cybersecurity frameworks, and more.

Future research directions could include developing comprehensive models of data warfare impacts on elections, conducting longitudinal studies of voter trust and behavior in response to these tactics, and exploring potential technological and policy solutions to mitigate these threats while preserving democratic values. Meanwhile expanding media literacy and societal antibodies against viral lies cannot wait on institutions alone. Public consciousness around the very real vulnerabilities in information quality represents first line of resilience. In partnership across public, private and civic realms lies potential to weather this era of disruption without forfeiting liberty.

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NH_4SCN Additive Assisted Vertically Aligned Efficient 1,5-Diamino Naphthalene Based Two-Dimensional Dion Jacobson Phase Perovskite Solar Cells

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Abstract – Dion-Jacobson (D–J) phase two-dimensional (2D) perovskites have emerged as a preeminent class of layered perovskite materials owing to their superior ambient stability and structural tunability. Amid superb improvements in stability, the power conversion efficiencies (PCEs) of D–J phase perovskite solar cells (PSCs) are limited due to the parallel alignment of inorganic octahedral layers further creating anisotropy in the mobility of charge carriers. In 2D perovskites, additive engineering is one of the efficient process to enhance the out of plane crystallinity and modulate the phase distribution that further leads to the improved carrier transport and also beneficial in upscaling the device performance. In this work, a new member of D–J phase 2D perovskites based on 1,5-diamino naphthalene spacer is fabricated and further NH_4SCN additive treatment is employed to facilitate the growth of preferred out of plane orientation of perovskite crystals. For the optimized amount of NH_4SCN additive, the PCE of $NDA(MA)_3(Pb)_4(I)_{13}$ perovskite device is improved significantly from 6.4% to 9.5%. Moreover, the additive engineered $NDA(MA)_3(Pb)_4(I)_{13}$ perovskite device is shown the preferred orientation, higher crystallinity, lower defect-states and superb stability. The additive engineered unsealed perovskite device retains 59% of its initial efficiency after 1000 h of continuous storage under 60% of relative humidity.

Keywords – D–J phase 2D perovskite, bifunctional spacers, additive engineering, 1,5-diamino naphthalene,

I. INTRODUCTION

Two-dimensional (2D) halide perovskites are currently considered as promising semiconducting materials for the fabrication of photovoltaic devices due to their superior ambient stability and structural diversity [1-6]. The power conversion efficiency (PCE) of the 2D perovskites is increasing significantly and reached up to 20% [7-9]. Larger organic spacer cations used to cleave the conventional 3D perovskites into crystallographically oriented planar 2D perovskites has a great influence on its crystal structure [10-11]. On the basis of the choice of organic spacer, 2D perovskite can crystallize into three different structures: - 1) Ruddlesden Popper (RP) phase, 2) Dion-Jacobson (D–J) phase, and 3) Alternating cation interface phase perovskites. Notably, the RP phase structure comprises of monovalent organic cations that are electrostatically bound to the inorganic lead halide framework on one end only, resulting in a double layer of organic spacers creating a van der Waals gap between the adjacent inorganic interlayers [9], [12-13]. This gap in RP phase perovskite structure not only became the reason for moisture penetration but also creates hindrance for charge transport. In principle, D–J phase 2D perovskite structures having general formula $(A')(A)_{n-1}(Pb)_n(X)_{3n+1}$ use divalent organic amine A' ($H_3N–R–NH_3$) as the spacer molecule and has the potential to eliminate the van der Waals gap [14-16]. Here the two amine groups attached at

both ends of the diamine molecule has the ability of the formation of hydrogen bonds with the inorganic perovskite slabs without creating any gap into the perovskite structure. The advancement of low-dimensional D–J phase perovskites has lately attracted considerable attention in view of their appealing stability against harsh environmental conditions as well as their competitive performance in optoelectronic applications.

Several divalent amines as ethylenediamine, 1-4 butyl diamine (BDA), 1-4 phenylene-dimethanammonium (PDMA) etc [17-20]. have been utilized to synthesize D–J phase 2D perovskites, however, these initial methods based on D-J phase perovskites have demonstrated comparatively low efficiencies. The inferior device performance in D–J phase perovskites is mainly generated due to poor charge transport attributed to the random crystal orientations and poor film morphology. Recently, chemical doping or additive engineering has been adopted as an efficient approach to improve the out of plane crystallinity as well as the device efficiency in D–J phase perovskites and recent investigations have revealed that they are capable of achieving high PCEs up to 20% [21-22]. Hitherto, different additives such as MACl, NH_4Cl, MASCN, and NH_4SCN have been utilized for this purpose [23-24]. Recently, Wu et al. used the methylammonium thiocyanate (MASCN) additive to achieve the preferred vertical orientation from 3-(aminomethyl)piperidinium (AMP) spacer-based D–J phase $(3AMP)(MA_{0.75}FA_{0.25})_3(Pb)_4(I)_{13}$ films. The optimized device not only attained higher crystallinity and preferred vertical orientation but also possess the PCE of 16.25% as well as 35 days of ambient stability with retaining 80% of its PCE [25]. Similarly, Yuan and co-workers dramatically elevated the PCE of p-Xylylene diamine (PXD) spacer based $(PXD)(MA)_2(Pb)_3(I)_9$ D–J phase PSCs to 15.6% from 1.2% with the assistance of methyl ammonium chloride (MACl) and achieved 29 days of ambient stability [26]. On the other hand, Xu et al. prepared trans-1,4-cyclohexanediamine spacer based self-aligned vertically oriented $(CHDA)(FA)_3(Pb)_4(I)_{13}$ D–J phase PSCs with 15% efficiency with 96.5% of thermal stability under 60 ^oC for 68 h [27]. Also, Jen et al. demonstrated the efficient tuning of random crystal orientation of $(BDA)(MA)_4(Pb)_5(I)_{16}$ quasi 2D perovskites into vertical crystal growth with a narrowed intermediate phase distribution. Here the improved crystal orientation and phase purity ultimately lead to the high PCE of 14.53% with a J_{SC} of 16.07 $mAcm^{-2}$ in corresponding D–J phase PSCs [28]. Similarly, Chen and co-workers formulated propane-1,3 diammonium (PDA) based $(PDA)(FA)_3(Pb)_4(I)_{13}$ based 2D perovskite devices having remarkable PCE of 13.8%. They utilized formamidinium chloride (FACl) as an additive during the film fabrication and investigated the role of Cl^- ion in the formation of vertically oriented $\{(FA)_nPb_nI_{3n+1}\}^{-2}$ inorganic quantum wells in the perovskite film. Here FACl addition led to $(PDA)(FA)_3(Pb)_4(I)_{13}$ thin films with compact morphologies, vertical-oriented crystal grains, proper energy- bandgap alignments and enhanced photovoltaic performance (PCE ~14%) with decent moisture stability, as 85% of original PCE of device retained after 540 h under 30-40% humidity exposure[29]. Hence additive engineering seemed to be an effective approach to obtain high crystallinity vertically oriented D–J phase 2D perovskite films with improved carrier transport.

In the present work, we have reported the first example of fabrication of n-4 layered D–J phase quasi 2D perovskite films having general formula $(NDA)(MA)_3(Pb)_4(I)_{13}$ that comprise of 1,5-Diamino naphthalene organic spacer cation. Further, we have demonstrated that NH_4SCN additive can enhance the crystallinity of $(NDA)(MA)_3(Pb)_4(I)_{13}$ 2D perovskite films and can induce the favorable out of orientation of inorganic 2D perovskite quantum wells, as evidenced by XRD and SEM. Moreover, we have also explored the photovoltaic performance of $(NDA)(MA)_3(Pb)_4(I)_{13}$ with and without NH_4SCN additive. Here the vertically oriented champion perovskite device fabricated with optimized amount of additive (2 mol NH_4SCN) has exhibited a preferred orientation, high crystallinity, decreased defects, and delivered the improved PCE of 9.5%. Moreover, the unsealed $(NDA)(MA)_3(Pb)_4(I)_{13}$ device with optimized NH_4SCN concentration has demonstrated very good ambient stability by retaining 59% of its PCE under 60% relative humidity along with a decent thermal stability.

II. MATERIALS AND METHOD

1,5 Diamino naphthalene ($n - C_4H_9NH_2$) was purchased from TCI, methylammonium bromide (MAI, Greatcell). Lead Iodide (PbI_2), Anhydrous ethanol (99.9%), chlorobenzene (95%), anhydrous N, N-dimethylformamide (DMF, 99.8%), acetonitrile (99.8%), dimethyl sulfoxide (DMSO, 99.9%), Hydrochloric acid (HCl, AR, 35-37%), titanium (IV) isopropoxide (99.9%), 2,2',7,7'-Tetrakis[N,N-di(4-methoxyphenyl)amino]-9,9'-spirobifluorene (spiro-OMeTAD), 4-tertbutylpyridine (tBP), lithium bis-(trifluoromethylsulphonyl) imide (Li-TFSI), and cobalt salt Co[t-BuPyPz]$_3$[TFSI]$_3$ (FK209) are received from Sigma-Aldrich. The SnO_2 solution was purchased from Alfa Aesar (tin (IV)oxide, 15 wt% in H_2O colloidal dispersion).

Absorption spectra were recorded with an Agilent Cary 100 UV-Vis spectrophotometer equipped with an integrating sphere to account for reflected and transmitted light. The room temperature photoluminescence spectra were taken by a SHIMADZU RF-6000 Spectro Fluorophotometer. The scanning electron microscopic images of the films were taken using a field-emission scanning electron microscope. An electron beam accelerated to 3 kV was used with an in-lens detector. The time correlated single photon counting (TCSPC) experiments for average lifetime measurement of perovskite films were performed using Horiba Jobin Yvon, Florocube with Excitation Sources: Nano LEDs with a wavelength of 400nm. For structural characteristics measurement X-ray diffraction pattern measurement of perovskite films were taken by using a Rigaku X-ray advanced diffractometer with Cu Kα 1,2 radiation (λ=1.541°). X- ray spectrum was collected within an angular range of $5° < 2\theta < 50°$.

Quasi 2D perovskite film fabrication

The 2D perovskite precursor solutions were prepared in a DMF: DMSO (4:1 v/v) solvents. Typically, for the fabrication of precursor solution (40 wt%) of n = 4 layered films 230.50 mg of PbI_2, 59.61 mg of MAI, and 19.77 mg of NDA were added to 550 mL of DMF:DMSO solution. Then solutions were stirred at 60 °C for 12 h. The precursor solution was spin-coated onto the substrate at 1000 rpm for 10 sec and continuously at 6000 rpm for 30 sec. Before end of the second step at 20 sec, 200 mL of chlorobenzene was poured on the films and followed by thermal annealing at 100 °C for 60 min. For the fabrication of additive incorporated n = 4 layered films, 1 mol (9 mg) and 2 mol (19 mg) NH_4SCN and were added into the precursor solution[30].

Device Fabrication

Fluorine-doped tin oxide (FTO) (8 Ω cm^2) substrate was etched with zinc powder and 2 M aqueous HCl. The etched FTO was cleaned in a soap solution, deionized water, acetone, and isopropanol, each step accompanied by sonication for 10 mins and followed by drying in a nitrogen air. Prior to c-TiO_2 deposition, FTO was treated with UV-Ozone for 15 mins. Then, c-TiO_2 film (20 nm) was deposited by spin-coating from a sol-gel precursor solution consisting of titanium isopropoxide (TTIP) in anhydrous isopropanol. The substrate was annealed at 150 °C for 15 mins on a hot plate and subsequently annealed in air at 500 °C for 30 mins. The SnO_2 aqueous colloidal dispersion (15wt%) was diluted using deionized water to the concentration of 2.5 wt%. Then, SnO_2 layers were fabricated on TiO_2 layer by spin coating method at 4000 rpm for 30 s, (ramp 2000) using the diluted SnO_2 aqueous solution and annealed at 150 °C for 30 min. Then, immediately all the substrates were transferred to the nitrogen filled glovebox for the fabrication of 2D perovskite layer (above mentioned procedure). Next, spiro-OMeTAD solution was prepared by dissolving in chlorobenzene at 70 mM, where tBP, Li-TFSI in acetonitrile, and FK209 in acetonitrile (molar ratio of spiro: FK 209: Li-TFSI: TBP of 1 :0.03: 0.5: 3.3) are added as additives. The gold electrode was deposited by thermal evaporation of 80 nm gold in high vacuum conditions. A 0.09 cm^2 non-reflective mask was used to define the active area.

III. RESULT AND DISCUSSION

1,5 Diamino naphthalene based quasi-2D perovskite

The NDA based n-4 layered $(NDA)(MA)_3(Pb)_4(I)_{13}$ D–J phase 2D perovskite films were fabricated using single step spin coating method. Specifically, $(n-C_4H_9NH_2)$, MAI, PbI_2 and HI were dissolved in DMF/DMSO in the stoichiometric ratio according to the general formula $(A')(A)_{n-1}(M)_n(X)_{3n+1}$ of n phase D–J perovskite. The NDA molecule and corresponding quasi 2D perovskite (n=4) structure is schematically shown in Figure 1a. The absorption spectrum consists of a small excitonic absorption peak near 400 nm representing the lower n phases, a broad low intensity absorption band near 500 nm representing the intermediate n phases and a blue shifted absorption edge at 746 nm confirming the fabrication of n-4 layered 2D perovskite. The photoluminescence (PL) peak of $(NDA)(MA)_3(Pb)_4(I)_{13}$ film is located at 767 nm (FWHM~23 nm). No small wavelength emission peak in the PL spectrum can be explained by fast energy transfer from the low-n phase region to a high-n region, inducing the emergence of a large absorption peak [31-32]. The crystallinity of $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite film is investigated using X-Ray diffraction (XRD) method. The XRD patterns of $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite film exhibits low crystallinity diffraction peaks at 2θ = 14.2°, 24.8°, and 28.5° corresponds to the (110), (202), and (220) facets of 2D perovskite further indicating a random crystal orientation [33-34].

Additive engineering of n-4 composition quasi-2D perovskite

In 2D perovskites, additive engineering is one of the efficient process to enhance the out of plane crystallinity and modulate the phase distribution that further leads to the improved carrier transport and also beneficial in up-scaling the device performance[35]. Till date, different additives such as MACl, NH_4Cl, MASCN, and NH_4SCN have been used for this purpose [36-37]. Here in this work, we have investigated the effect of NH_4SCN additive on the crystallinity and device performance of $(NDA)(MA)_3(Pb)_4(I)_{13}$ D–J phase 2D perovskite films. The additive incorporated $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite composition was prepared by adding different amount of NH_4SCN in the precursor solution according to the most recent reported article (detailed procedure can be found in the experimental section) [38].

First, to study the impact of NH_4SCN additive on the composition of 2D perovskites UV-vis spectrum was conducted for $(NDA)(MA)_3(Pb)_4(I)_{13}$ alone and in the presence of additive. Figure 1b shows that UV-vis spectrum of pristine perovskite consists of a high intensity absorption peak around 400 nm reportedly representing the lower n states, a broad and misty absorption hump near 500 nm representing the intermediate n states (i.e., n~3 or 4) and a blue shifted sharp absorption edge near 750 nm confirming the fabrication of a quasi 2D perovskite structure. After NH_4SCN addition, the absorption spectrum appeared to be similar, representing the similar n phase distribution in the additive incorporated films. Also, the 2mol NH4SCN based films show the 750 nm absorption edge blue shifted to 740 nm that further represents that additive incorporation reduces the presence of higher n states in n-4 perovskite films and plays a vital role in achieving the narrowed intermediate phase distribution.

Figure 1c represents the XRD pattern of pristine n-4 perovskite films after the addition of NH_4SCN additive. The low crystallinity broad peaks observed at 2θ = 14.1° and 28° corresponds to the (110) and (202) facets of 2D perovskite. After the addition of 1 mol NH_4SCN, the intensity of both the diffraction peaks enhanced moderately accompanied with a small decrease in the full width at half-maximum (FWHM). After the addition of 2 mol $NH4_SCN$, these two diffraction peaks have shown considerable enhancement in their intensity. Also, the FWHM of (110) and (220) peaks decreased from 0.136° and 0.164° (no additive) to 0.087° and 0.089° (with 2 mol NH_4SCN), respectively (Figure 1d and 1e). Therefore, superior crystallinity and narrower FWHM has been observed for 2 mol NH_4SCN additive films. Also, the intensity enhancement for the (110) and (220) diffraction peaks indicate the preferential out-of-plane growth of inorganic quasi-2D perovskite QWs. This structural finding is promising since vertically orientated quasi-2D perovskite films leads to improved charge carrier transport which is essential for better photovoltaic performance of the device [39]. Figure 1f represents the transient PL spectra of

$(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite films with and without additive. The fluorescence decay values were found to be following the bi-exponential decay kinetics. The TRPL decay parameters are listed in Table S1 (supporting information). The average lifetime of these perovskite films is calculated through $\tau_{avg.} = \frac{\sum_{i=1}^{2}(a_i\tau_i^2)}{\sum_{i=1}^{2} a_i\tau_i}$ equation, where a_i is the amplitude of i[th] lifetime component and τ_i is the respective lifetime value [40]. The pristine perovskite films without NH_4SCN shows two lifetime components of 94 ns-slow and 15 ns-fast decay, whereas 178 ns-slow and 36 ns- fast decay lifetime components are observed for 2 mol NH_4SCN additive films. Both lifetime components of the film having 2 mol NH_4SCN as additive are significantly longer in comparison to the pristine perovskite film. Also, the average decay lifetime of films after NH_4SCN addition is significantly increased to 106 ns (2mol NH_4SCN) and 80 ns (1mol NH_4SCN) in comparison to pristine n-4 perovskite films (55 ns). The longer lifetimes suggest the reduced nonradiative recombination with a lower defect density, which will further facilitate carrier transport and hence contribute to a higher V_{OC} value [41].

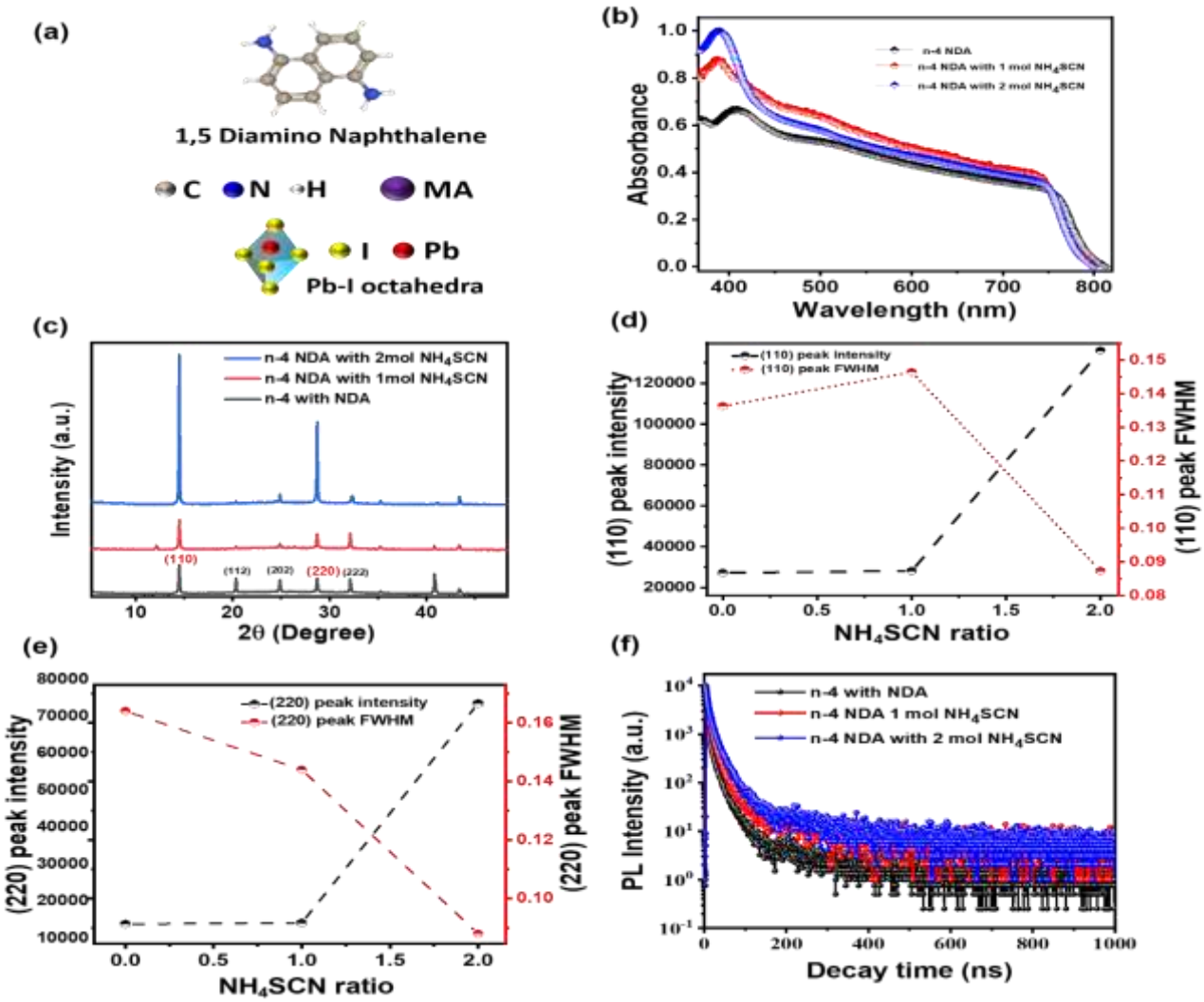

Figure 1. (a) Schematic illustration of the 1,5- Diamino naphthalene molecule. (b) Absorbance spectrum of $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite films prepared with different concentration of NH_4SCN additive. (c) XRD pattern of $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite films loaded with various amounts of NH_4SCN additive. (d), (e) the variation in peak intensity and FWHM of the corresponding (110) and (220) diffraction peak respectively, with different concentration of NH_4SCN additive. (f) TRPL decay graphs of $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite films with/without NH_4SCN addition.

Scanning electron microscopy (SEM) analysis was performed to analyse the effect of additive on the morphology of native $(NDA)(MA)_3(Pb)_4(I)_{13}$ films. The pristine perovskite films show the homogeneous and smooth layered film structure without distinguishable boundaries. On the addition of 1

mol NH_4SCN, the perovskite film became dense and exhibit the emergence of granular structure with smaller grain sizes, but for 2 mol NH_4SCN films, clear grain boundaries with comparatively larger grain sizes are observed. Hence 2 mol NH_4SCN additive based films confirmed the highest crystallinity as consistent with the XRD results. The average grain size calculated for 1 mol NH_4SCN films and 2 mol NH_4SCN films are 535 nm and 1.05 μm, respectively as shown in Figure 2. Combining the SEM images, it has been concluded that NH_4SCN can significantly improve the course of crystallization and has a great impact on the film morphology [42].

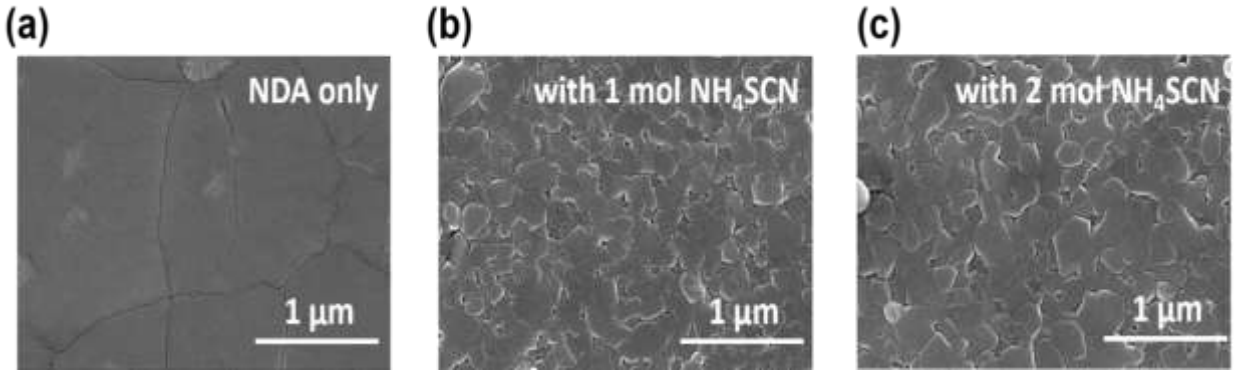

Figure 2. SEM images of the (a) $(NDA)(MA)_3(Pb)_4(I)_{13}$ quasi 2D-perovskite films. (b) after 1 mol NH_4SCN addition. (c) after 2 mol NH_4SCN addition.

Device Performance

To evaluate the influence of NH_4SCN addition on the photovoltaic performance of pristine D–J phase $(NDA)(MA)_3(Pb)_4(I)_{13}$ devices, we have fabricated the photovoltaic devices with FTO/c-TiO_2/SnO_2/2D Perovskite/spiro-OMeTAD/Au configuration (with an active device area of 0.09 cm^2) having different amount of NH_4SCN as presented in Figure 3a. The calculated photovoltaic performance parameters are summarized in Table 1. The pristine D–J phase devices bearing $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite film without the NH_4SCN additive has shown the PCE of 6.4% with the short circuit current density (J_{SC}) of 17.15 mA/cm^2, an open circuit voltage (V_{OC}) of 0.92 V and the fill factor (FF) of 40.52%. We further inspected the performance of NH_4SCN additive loaded PV devices. For 1 mol NH_4SCN addition the J_{SC} value increased to 17.58 mA/cm^2 whereas V_{OC} value increased by 0.95 V, FF enhanced up to 49.44% and the overall PCE reached to 8.3%. Further the device with optimized additive concentration of 2 mol NH_4SCN has the maximum PCE of 9.5% with J_{SC} of 18.46 mA/cm^2, V_{OC} of 0.99 V and the FF of 52.25%. As expected, the 2 mol NH_4SCN based D–J phase PV device shown the highest PCE value. Here the significantly increased J_{SC}, V_{OC} and FF values contributed to the enhanced device efficiency. The enhanced J_{SC} and FF implied that the higher crystallinity vertically oriented inorganic layers promoted the superior charge transport and collection in the additive based PV solar cells [43]. While the increased V_{OC} value suggests the reduced nonradiative recombination at perovskite/CTL interfaces [44]. The external quantum efficiency (EQE) spectrum and the corresponding integrated photocurrent curve for pristine $(NDA)(MA)_3(Pb)_4(I)_{13}$ and with different amount of additive is shown in Figure 3c. The value of integrated photocurrent for $(NDA)(MA)_3(Pb)_4(I)_{13}$ device without and with 2 mol NH_4SCN additive is 16.94 mA/cm^2 and 17.24 mA/cm^2 respectively, which almost resembles to the experimental J_{SC} values. The stabilized power output of $(NDA)(MA)_3(Pb)_4(I)_{13}$ with 2 mol NH_4SCN PV devices was scanned at maximum power input of 0.99 V, providing the stabilized PCE of 9.2% under 1 sun illumination for 100 sec (Figure 3d) confirming the best reliability of additive based high performance device. The comparison of PCE distribution of pristine $(NDA)(MA)_3(Pb)_4(I)_{13}$ devices with different amount of NH_4SCN additive is shown in Figure 3e. The performance trend is consistent with the earlier experimental findings as 2 mol NH_4SCN additive devices shown the maximum PCE.

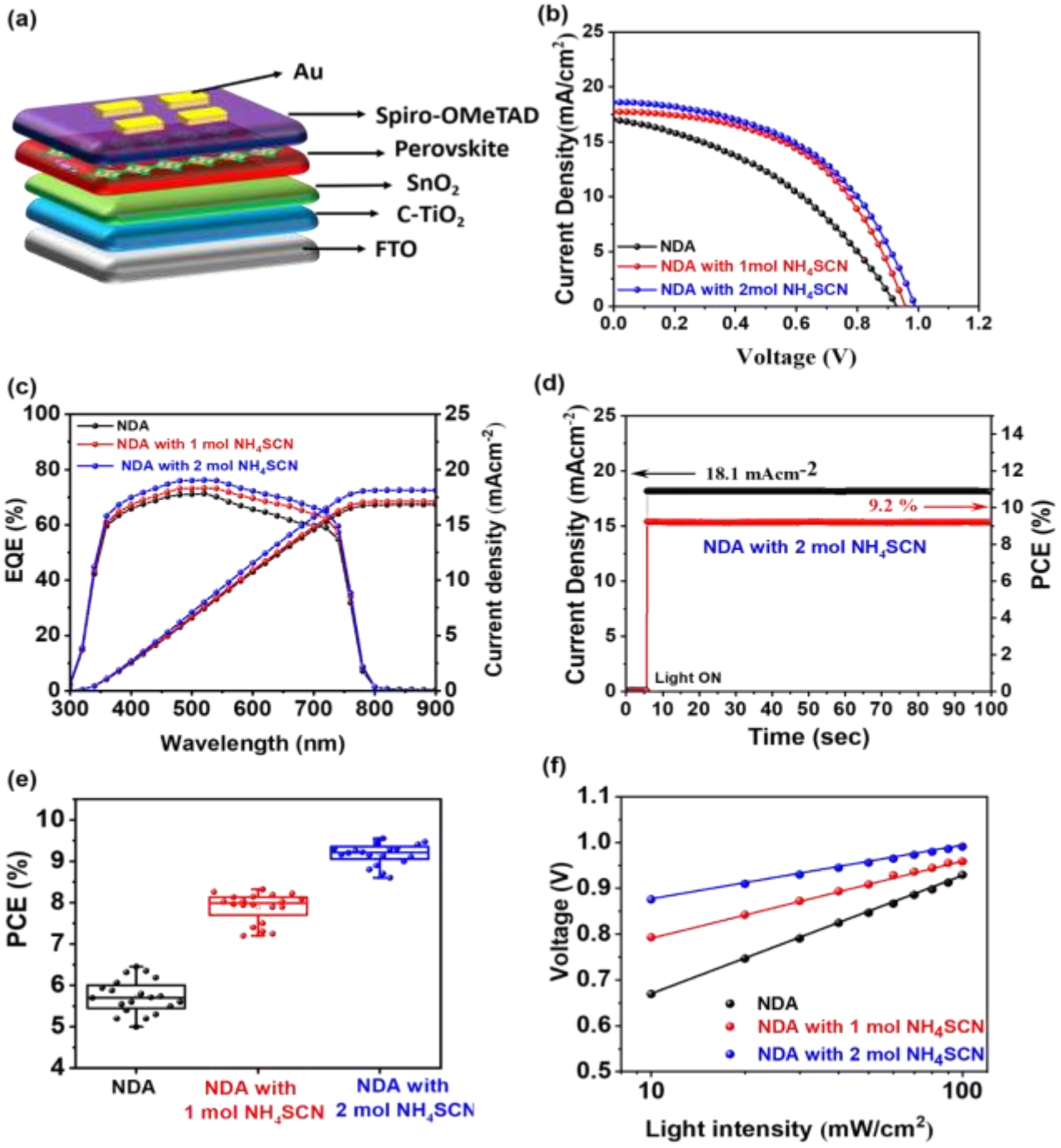

Figure 3. (a) Schematics of the device structure - FTO/c-TiO_2/SnO_2/2D Perovskite/Spiro-OMeTAD/Au. (b) Current density vs voltage characteristics curve of the devices based on the $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite films with different amount of NH_4SCN. (c) EQE curves and integrated photocurrent spectrum for the $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite devices with various amount of NH_4SCN additive. (d) Stabilized current density and PCE of the $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite devices with optimized amount of NH_4SCN additive. (e) The statistics of PCE of the $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite devices with different amount of NH_4SCN additive. (f) V_{OC} of the $(NDA)(MA)_3(Pb)_4(I)_{13}$ devices with different amount of NH_4SCN additive.

Table 1: Summary of the photovoltaic parameters of the $(NDA)(MA)_3(Pb)_4(I)_{13}$ photovoltaic devices having different amount of NH_4SCN additive.

Perovskite	V_{OC} (V)	J_{SC} (mAcm^{-2})	FF (%)	PCE (%)
NDA	0.9296	17.15	40.52	6.45
NDA with 1 mol NH_4SCN	0.9584	17.58	49.44	8.32
NDA with 2 mol NH_4SCN	0.9909	18.46	52.25	9.55

We further explored the recombination kinetics of the devices by measuring the light intensity dependence of their corresponding *J–V* characteristics. Here the V_{OC} values for $(NDA)(MA)_3(Pb)_4(I)_{13}$ devices with different amount of NH_4SCN additive is plotted against different light intensities as shown in Figure 3f. From the corresponding graph, the diode ideality factor can be determined using the equation:

Resilience of additive incorporated D–J phase PV devices to moisture and heat

Finally, the resilience of photovoltaic performance of this new class of D–J phase 2D PV devices to ambient air and moisture before and after additive incorporation was scrutinized, as shown in Figure 4, by assessing their hydrophobicity and the stability under heat and humid air conditions. In order to investigate the hydrophobic character of $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite films before and after NH_4SCN addition, we measured the contact angle of the corresponding films using a water droplet. The greater contact angle of 79° for 2 mol NH_4SCN additive incorporated film suggested the increased hydrophobicity compared to pristine 2D perovskite film (contact angle ~62°). The shelf life and resilience to ambient air of these perovskite films before and after NH_4SCN addition was also evaluated. The stability test was conducted by the measurement of PCE of the devices under relative humidity of $60\pm5\%$ without encapsulation. As shown in Figure 4d, when devices are stored in ambient atmosphere at relative humidity of 60 %, the device with 2 mol NH_4SCN has shown the optimum stability and retained 59% of its initial efficiency after 1000 h of continuous storage. On the other hand, at similar atmospheric conditions the efficiency of pristine $(NDA)(MA)_3(Pb)_4(I)_{13}$ devices dropped far more quickly and it was degraded completely within 600 h of storage. Also, the thermal stability test of $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite devices were conducted under constant temperature of 85 °C. The device with 2 mol NH_4SCN retained 54% of its original PCE after 200 h of storage while pristine $(NDA)(MA)_3(Pb)_4(I)_{13}$ devices were collapsed entirely after 55 h of storage. These results suggested that NH_4SCN addition in pristine D–J phase $(NDA)(MA)_3(Pb)_4(I)_{13}$ devices lead to better moisture and thermal stability. This research presents a new approach towards additive engineered novel D–J phase PSCs having high PCE with reasonable stability.

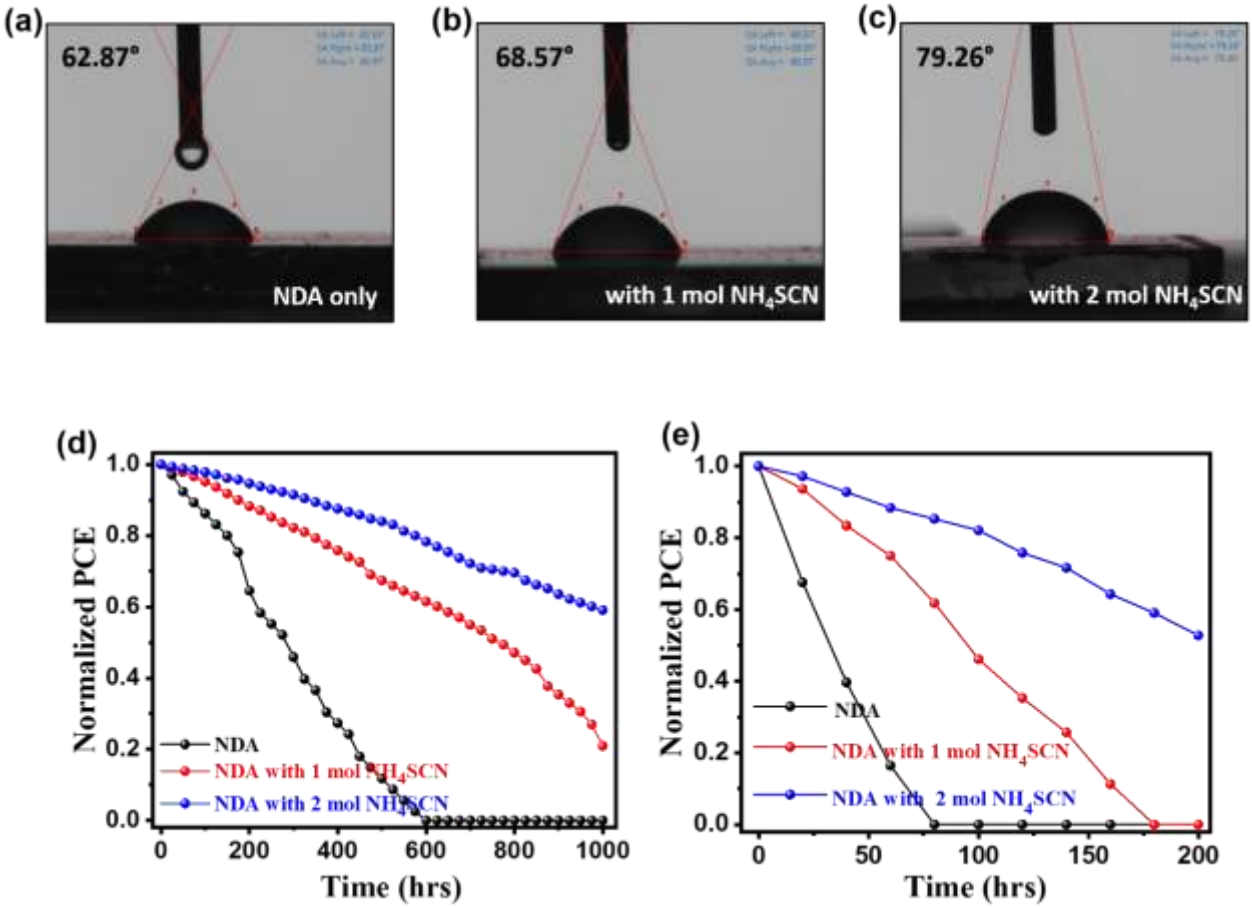

Figure 4. Measurement of contact angle of water droplet on (a) pristine n=4 layered $(NDA)(MA)_3(Pb)_4(I)_{13}$ 2D perovskites films (b) $(NDA)(MA)_3(Pb)_4(I)_{13}$ films with 1 mol NH_4SCN additive. (c) $(NDA)(MA)_3(Pb)_4(I)_{13}$ films with 2 mol NH_4SCN additive. (d) Moisture stability test (under RH 60%) of $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite device with and without NH_4SCN additive. (e) Thermal stability test under 85°C heating for $(NDA)(MA)_3(Pb)_4(I)_{13}$ perovskite device with and without NH_4SCN additive treatment.

IV. CONCLUSION

The main conclusions of the study should be summarized in a short Conclusions section. In conclusion, we presented the first example of D–J phase n-4 layered $(NDA)(MA)_3(Pb)_4(I)_{13}$ 2D perovskites with 1,5-Diamino naphthalene bifunctional organic spacer group. We further demonstrated the successful vertical alignment of their crystal orientation using NH_4SCN additive. The evolution of film crystallite orientation with different amounts of NH_4SCN has been revealed by XRD and SEM measurements. The champion $(NDA)(MA)_3(Pb)_4(I)_{13}$ device with optimized NH_4SCN concentration gave remarkable photoconversion efficiency of 9.5%, complemented with excellent ambient stability, by retaining % of its original efficiency after 1000 h under 0% humidity. In view of their excellent photovoltaic performance, NDA based D–J phase 2D perovskites holds promise to be a viable source of high efficiency optoelectronic devices with rational long term ambient stability. Furthermore, additional improvement of the materials and devices is now being investigated.

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Denial of Nationality: A Form of French Racial Discrimination Against Algerian Muslims in Colonial Algeria (1830-1962)

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Abstract – During the period of French colonial rule in Algeria (1830-1962), the Muslim population of Algeria faced systematic repression that affected all aspects of their lives. Among these practices, the phenomenon of "denial of nationality" emerged as a key tool of marginalization. France regarded Algerian Muslims merely as "subjects" — neither Algerian citizens by virtue of their land nor French citizens by virtue of their submission to the colonial state. France aimed to deprive Algerian Muslims of their basic rights. In this article, we seek to explore this phenomenon by uncovering its roots and motivations and highlighting its devastating effects on Algerian society.

We will begin by explaining the concept of "denial of nationality" and its consequences for individuals and society as a whole. We will then move on to the historical context in which this phenomenon emerged in Algeria, analyzing the colonial policies and laws that contributed to its entrenchment. Subsequently, we will delve into studying the manifestations of racial discrimination that characterized the denial of nationality and reveal the methods used to target Algerian Muslims specifically. Finally, we will assess the long-term impacts of this phenomenon on Algerians.

Understanding "denial of nationality" as a colonial tool of oppression is essential for comprehending contemporary Algerian history under colonial domination and for recognizing the depth of the challenges faced by Algerians in their struggle for freedom and dignity. With each story of denied nationality, a poignant human story is told, revealing the determination of the Algerian people to preserve their identity and dignity in the face of injustice and oppression.

Keywords – Denial of Nationality, Marginalization, Colonial Policies, Racial Discrimination, Colonial Algeria

I. INTRODUCTION

Amidst the chapters of French colonialism in Algeria (1830-1962), the Algerian people, especially Muslims, faced a series of horrors and systematic oppression that encompassed all aspects of their lives.

Nationality was not spared from these practices, as Algerians suffered from the phenomenon of "denial of nationality" which represented a quintessential tool of oppression, aimed at marginalizing them and stripping them of their basic rights.

In this article, we strive to delve into the depths of this phenomenon, uncover its roots and motivations, and shed light on its devastating effects on Algerian society. We will begin our journey by

explaining the concept of "denial of nationality" and its consequences for individuals and society as a whole. Then, we will address the historical context in which this phenomenon emerged in Algeria, and we will analyze the colonial policies and laws that contributed to its entrenchment. After that, we will delve into studying the manifestations of racial discrimination that characterized the denial of nationality, and we will reveal the methods used to target Algerian Muslims in particular. Finally, we will assess the long-term impact of this phenomenon on Algerian society, and we will discuss the efforts made to address its wounds and consequences.

Understanding "denial of nationality" as a colonial tool of oppression is essential to understanding modern Algerian history and to realizing the depth of the challenges faced by the Algerian people in their struggle for freedom and dignity. For with every story of denial of nationality, a moving human story is told, and the Algerian people's determination to preserve their identity and dignity in the face of injustice and oppression is revealed.

1. What do we mean by legal discrimination and denial of nationality?

Legal discrimination refers to the unequal treatment of individuals or groups based on characteristics such as race, gender, religion, or nationality, which is enshrined in and enforced by laws or legal systems. This kind of discrimination is sanctioned and perpetuated by the state through legislation, regulations, and policies.[1] Examples include:

- Apartheid laws in South Africa, which enforced racial segregation and unequal rights for different racial groups.

- Jim Crow laws in the United States, which mandated racial segregation and disenfranchised African Americans.

- Gender laws that restrict women's rights in some countries, such as laws limiting women's ability to own property, travel independently, or access certain jobs.

In the context of Algeria's colonial history, legal discrimination refers to the differential treatment of the various groups that made up the population of Algeria during the colonial period by the French. While settlers and Jews were granted French nationality and allowed to enjoy all the rights that this status entailed, the indigenous Algerians were left without a clear legal status. This had numerous consequences, forcing them to live harsh lives and occupy the bottom rung of the social ladder throughout the period in question.Denial of nationality refers to the practice of depriving individuals or groups of their citizenship or legal nationality. This can happen through explicit laws or administrative practices and can result in statelessness, where individuals are not considered nationals by any state. The consequences are severe, as stateless individuals often lack basic rights and access to services. Denial of nationality can occur for various reasons, including:

-Ethnic or religious discrimination: Targeting specific ethnic or religious groups to exclude them from citizenship.

-Political reasons: Revoking citizenship of political opponents or dissidents.

-Historical contexts: Colonization, decolonization, or the dissolution of states can lead to complex citizenship issues and statelessness.[2]

Denial of nationality often leads to significant human rights violations, including the inability to access education, healthcare, employment, and legal protection. It is a critical issue addressed by international human rights organizations and bodies advocating for the right to nationality and the prevention of statelessness.

2. What are the consequences of denial of nationality?

The legal discrimination faced by indigenous Algerians resulted in significant disadvantages, including disqualification from holding many civil and military positions. This exclusion extended to promotions within civil service roles, preventing equitable advancement opportunities. Additionally, indigenous individuals were barred from military promotions, further marginalizing their representation in state institutions. They were subjected to an exceptional judicial system, which often operated outside the norms applied to settlers. This punitive arsenal reinforced their subordinate status within the colonial framework, exacerbating social and political inequalities throughout the colonial period. Such systemic discrimination deeply affected their lives and prospects for upward mobility.[3]

3. Why was the denial of nationality to Algerian Muslims considered racial discrimination?

It is important to note that the denial of nationality was not the only form of discrimination faced by Algerian Muslims during the colonial period. They were also subjected to various forms of political, economic, social, and cultural discrimination. To understand the context of this discrimination, it is crucial to recognize the diverse population of Algeria during the colonial period:

- **Algerian Muslims:** They formed the vast majority of the population, indigenous to the land and adhering to Islam.
- **Algerian Jews:** While considered part of the indigenous population, they maintained a distinct religious and cultural identity.
- **European settlers:** Comprising French, German, Swiss, Spanish, Italian, and other nationalities, they arrived during the colonial era and were granted preferential treatment.
- **Foreign Muslims:** Primarily from neighboring Maghreb countries (Morocco, Tunisia), they migrated to Algeria for various reasons.[4]

Table 1: Population Growth in Algeria 1861-1954

Year	Settlers	Jews	Muslim Algerians	Total
1861	269,674	28,097	2,691,812	2,989,583
1881	376,772	35,663	2,842,497	3,254,932
1954	400,000	170,000	8,500,000	8,917,000

4- How did France distinguish between the inhabitants of Algeria? What were the manifestations of this distinction?

- **Granting French nationality to European settlers:**

- **Senatus-Consulte of July 14, 1865:** This law allowed foreigners (Europeans) to acquire French nationality and the associated rights and obligations.

- **Requirements:** Settlers only needed to prove three years of residence in Algeria and be 21 years of age to obtain French nationality. [5]
- **Impact:** French nationality made them French citizens ("citoyens français") with full rights.

➢ **Mass naturalization of Jews under the Crémieux Decree of October 24, 1870:**

- **Pre-1865:** The legal status of Jews was ambiguous, similar to Algerian Muslims. France considered them "indigenous Israelites" ("indigens israélites") during this period.
- **Senatus-Consulte of 1865:** This law classified them as French subjects ("sujets français").
- **Conditional citizenship:** They could obtain French citizenship and enjoy its rights if they requested it, but they would be subject to French law.
- **Mass naturalization:** Algerian Jews were collectively naturalized under the decree of October 24, 1870. They gained full rights and obligations as French citizens.[6]
- **Significance:** Jews were no longer considered "French subjects" and became French citizens, leaving Algerian Muslims as the only group with that status.[7]

➢ **Denial of nationality to Algerian Muslims:**

❖ **Ambiguous legal status until 1865:**

- France did not recognize Algerian Muslims as Algerian citizens.
- Despite debates, French authorities did not seriously discuss the issue.
- Their legal status was undefined, and they were referred to as "les indigenes musulmans" in legal texts.[8]

❖ **Senatus-Consulte of July 14, 1865: The First Attempt to Define the Legal Status of Algerian Muslims :**

The Senatus-Consulte of July 14, 1865, marked a significant turning point in French colonial policy towards Algeria. It was the first attempt to formally define the legal status of Algerian Muslims, who had been largely left in a state of legal limbo since the French conquest in 1830.[9]

Key Provisions of the Senatus-Consulte:

- **Algerian Muslims were classified as "French Muslim subjects" ("sujets français musulmans").** This designation implied a subordinate status within the French colonial hierarchy.
- **Retention of Islamic personal status:** Algerian Muslims were allowed to retain their Islamic personal status, governed by Sharia law. This was seen as a compromise to appease religious concerns.
- **Conditional access to French citizenship:** Algerian Muslims could, upon request, obtain French citizenship and enjoy the associated rights. However, the requirements for citizenship were complex and difficult for most Algerians to meet.
- **Military and civil service opportunities:** The Senatus-Consulte opened up the possibility for Algerian Muslims to be recruited into the French army and navy, and to hold certain civil service positions in Algeria.[10]

Outcomes and Consequences:

- **Low uptake of French citizenship:** Despite the potential benefits, Algerian Muslims were hesitant to pursue French citizenship. Statistics indicate that between 1865 and 1899, only 1,131 individuals acquired French citizenship, an average of 32 per year.[11]
- **Religious and cultural resistance:** Many Algerians viewed French citizenship as a betrayal of their faith and culture. They resisted the notion of abandoning their Islamic identity and legal traditions.
- **Continued marginalization:** The Senatus-Consulte failed to address the fundamental issue of Algerian self-determination. Algerians remained largely marginalized, lacking full political and economic rights.
- **Reinforcement of colonial hierarchy:** The law served as a tool of discrimination, distinguishing between French settlers and Algerian Muslims. Settlers had a relatively straightforward path to French citizenship, while Algerians faced numerous obstacles.[12]

➢ **Law of February 4, 1919: Cosmetic Reforms and the Persistence of Legal Marginalization for Algerian Muslims**

❖ **Context and Background:** The Law of February 4, 1919, was enacted in the aftermath of World War I, a period marked by rising nationalist sentiment among Algerian Muslims. The French colonial administration, seeking to appease these growing demands, introduced this law as a series of reforms aimed at improving the legal status of Algerian Muslims.[13]

❖ **Key Provisions of the Law:**

- **Conditional access to French citizenship:** Algerian Muslims could obtain French citizenship either through the Senatus-Consulte of July 14, 1865, or through the new provisions of the 1919 law.
- **Stringent requirements:** The conditions for acquiring French citizenship under the 1919 law remained as complex and difficult to meet as those under the 1865 Senatus-Consulte.[14]

❖ **Limited Impact and Continued Marginalization:**

- **Minimal uptake:** Despite the potential benefits, Algerian Muslims continued to be hesitant to pursue French citizenship. Between 1919 and 1930, only 1,204 Algerian Muslims naturalized, indicating a low level of acceptance.
- **Unchanged legal status:** The Law of February 4, 1919, failed to bring about any significant change in the legal status of Algerian Muslims. They remained classified as French subjects ("sujets français"), lacking full political and economic rights.
- **Denial of opportunities:** Their subordinate status continued to deprive them of access to various opportunities, including employment in many positions, military promotions, and political representation.[15]

➢ **March 1944 Ordinance:** This ordinance maintained the designation of Algerian Muslims as "French subjects" but granted them the theoretical right to hold all civil and military positions.[16]

- **1947 Algerian Basic Law:** While recognizing Algerian Muslims as French citizens, this law granted them limited political rights and obligations.[17]
- **General de Gaulle and the Status of Algerian Muslims:**
  - Upon assuming power in 1958, de Gaulle sought to achieve legal equality among the inhabitants of Algeria to quell popular unrest and isolate the population from the independence movement.[18]
  - **De Gaulle's Measures:** He introduced a series of measures, including speeches, decrees, and ordinances, aimed at granting Algerian Muslims French citizenship.[19]
  - **Resistance from the National Liberation Front (FLN):** The FLN rejected de Gaulle's proposals and continued to advocate for Algerian nationality, reflecting the deep-seated desire for self-determination.[20]

Conclusion:

Throughout the French colonial era in Algeria (1830-1962), the denial of nationality to Algerian Muslims served as a potent instrument of discrimination and marginalization. Rooted in racial and religious prejudice, this policy effectively excluded Algerian Muslims from full political, economic, and social rights, reinforcing their subordinate status within the colonial hierarchy.

The Senatus-Consulte of July 14, 1865, marked a turning point in the legal status of Algerian Muslims. While it granted them some limited opportunities, it also cemented their designation as "French subjects," a position that implied inferiority and denied them the full rights of French citizenship.

Subsequent measures, such as the Law of February 4, 1919, and the March 1944 Ordinance, failed to address the fundamental issue of Algerian self-determination. Algerian Muslims remained largely marginalized, facing restrictions on employment, political participation, and cultural expression.

The denial of nationality had a profound impact on Algerian society, exacerbating social divisions and fueling resentment. It served as a constant reminder of their subordinate status and the colonial administration's disregard for their aspirations.

The struggle for Algerian independence was inextricably linked to the demand for full citizenship and self-determination. Algerian Muslims, through various forms of resistance, challenged the colonial order and fought for recognition of their rights and identity.

The eventual end of French colonial rule in 1962 marked a watershed moment in Algerian history. The attainment of independence brought with it the restoration of Algerian nationality and the opportunity to establish a sovereign nation.

The legacy of the denial of nationality to Algerian Muslims serves as a stark reminder of the injustices and inequalities inherent in colonial systems. It underscores the importance of recognizing and addressing the root causes of discrimination and marginalization in the pursuit of a just and equitable society.

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[3] To review these texts, one can refer to the official publications of the General Government during the 19th century, which included specific laws concerning the Muslim population of Algeria. For an example of such laws, see:

-Loi, du 23 mars 1882, sur l'état des indigènes musulmans de l'Algérie, in : B.O.G.G.A, vingt-deuxième année 1882, imprimerie de l'association ouvrière, p. Fontana et c^{e} , 1883, Alger, pp.159-163.

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[5] Sénatus-consulte sur l'état des personnes et la naturalisation en Algérie, du 14 juillet 1865, in : B.O.G.G.A, année 1865, imprimerie Typographique et lithographie Bouyer, Alger, 1865, pp.365-366.

[6] Following the mass naturalization of Jews and the establishment of civil rule in Algeria in 1870, a major uprising erupted in eastern Algeria led by Mohamed El-Mokrani and Sheikh El-Haddad. For more details, see:
Louis Rinn : Histoire de l'insurrection de 1871 en Algérie, Librairie Adolphe Jourdan, Alger, 1891, 671pages.

[7] Girault Arthur : principes de colonisation et de législations coloniale, tome2, second édition, librairie de la société du recueil général des lois et des arrêts, paris, 1904.

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[18] Charles de Gaulle, Discours et messages avec le renouveau Mai, 1958-Juillet 1962, librairie Plon, 1970, p.17, et L'Echo l'Alger 05 Juin 1958.

[19] A.N.O.M., Aix-en-Provence, Boite 81F/1108, Ordonnance N°.58-1016 du 29 Octobre 1958 édictant des mesures destinées à favoriser l'accès des français musulmans d'Algérie aux emplois publics de l'état.

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Mesleki Eğitim Merkezlerindeki Öğrencilerin Yabancı Dil Eğitimine Yönelik Algıları

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Özet – Mesleki eğitim, Anadolu kültürünün bir parçası olan Ahilik Teşkilatı geleneğinin izlerini taşıyan ustalık-çıraklık eğitimlerinin devlet eliyle okullarında yerine getirildiği eğitimdir. Mesleki Eğitim Merkezlerindeki öğrencilerin yabancı dil eğitimine ve bu eğitimin kendi mesleklerine olan katkısına yükledikleri anlamlar nitel araştırma yöntemi ile saptanacaktır. Bu nitel araştırma deseninde olgu bilim deseninden yararlanılarak bir araştırma raporu oluşturulmuştur. Öğrencilerin yabancı dil eğitimindeki deneyimlerine ve düşüncelerine göre, yabancı dili nasıl algıladıkları saptanmaya çalışılmıştır. Öğrenciler Kdz.Ereğli Mesleki eğitim merkezi öğrencilerinden daha önce yabancı dil eğitimi almış olan öğrencilerden seçilmiştir. Bu araştırmada görüşme ve doküman analizi stratejileri kullanılmıştır. Öğrenci algıları araştırmaları için görüşme stratejisi öğrencilerle birebir etkileşim halinde hal, tavır durumlarının sorulara verdikleri cevaplarla paralel olup olmadığı ve sorulara hangi ruh halinde (neşeli, stresli, vb. duygularla) dönütler verileceğine imkân sağlamıştır. Ayrıca doküman analizi ile etkili ve verimli veri elde edilirken Mesleki eğitim merkezlerindeki yabancı dil eğitimi hakkındaki veriler toplanmış ve analiz edilmiştir. Bu çalışmada veri analiz yöntemlerinden olan içerik analizi yöntemi kullanılarak veri analizi yapılmıştır. Veriler kodlara dönüştürülerek temalar oluşturulmuş ve yorumlanmıştır. Öğrenciler genel olarak İngilizce derslerindeki ruh hallerini olumlu kelimelerle ifade etmiştir. Ayrıca İngilizce öğretin kendilerine fayda sağladığını sosyal ortamlarda prestij sağladığını ifade etmişlerdir.

Anahtar Kelimeler – Mesleki eğitim, öğrenci, yabancı dil öğretimi, İngilizce, nitel araştırma

I. GİRİŞ

Mesleki eğitim, Anadolu kültürünün bir parçası olan Ahilik Teşkilatı geleneğinin izlerini taşıyan ustalık-çıraklık eğitimlerinin devlet eliyle okullarında yerine getirildiği eğitimdir. Bu eğitim merkezlerinde öğrenciler ilgi ve yeteneklerine göre ilgili meslek alanlarına yönlendirilip mesleklerini hem pratik hem de teorik olarak gerçekleştirdikleri bölümlerde eğitimlerini almaktadır. Öğretim süresi normal eğitim yapan ortaöğretim kurumlarında olduğu gibi 4 sene olup teorik derslerin haftada bir pratik derslerin de haftanın diğer günlerinde ilgili işletmelerde yapılmasıyla farklılık göstermektedir. İşletmelerde mesleki eğitim ilk seneden son seneye kadar devam eder. Üçüncü yılın sonunda öğrenciler Kalfalık sınavına, dördüncü yılın sonunda ise Ustalık sınavına katılan öğrenciler başarılı olmaları takdirde Kalfalık/Ustalık belgeleri verilmektedir.

MESEM'lerde eğitim gören öğrenciler mezun oldukları takdirde lise diploması ile ustalık belgesini almaya hak kazanmaktadırlar. Çırak öğrenciler meslek hastalığı ve iş kazalarına karşı devlet tarafından sigortalanmaktadırlar. Pratik eğitim aldıkları işletmelerde öğrenciler Asgari ücretin en az %30'u olmak kaydıyla maaş alabilmektedirler. 4 senenin sonunda eğitimlerini tamamlayan öğrenciler ustalık belgelerini alıp KOSGEB'den 50.000 TL hibe ve 100.000 TL de faizsiz kredi desteği alarak kendi iş yerlerine açabilmektedirler (MESEM,2023).

Mesleki eğitim merkezlerindeki öğrenciler serbest piyasa koşullarının hâkim olduğu günümüzde bu rekabet sisteminin içerisinde kendilerine artı değerler katma zorunluluğu hissetmektedir. 10.Kalkınma planında da olduğu gibi iş piyasası ile eğitim sistemi arasında bir ahenk oluşturulup iş piyasasının ihtiyacı olan becerilerin öğrencilere verilmesi gerekmektedir (Horuz,2017, s.11). Yabancı dil bilmek bu becerilerin başında gelmektedir. Bu araştırmanın içerisinde ayrıntılı bir şekilde yabancı dil müfredatına sahip Mesleki eğitim merkezleri öncelikli olarak protokol kapsamına alınan okullardan oluşmaktadır. Protokol kapsamındaki okullar da yabancı dil bulunurken bu kapsamda olmayan okullarda proje kapsamında yabancı dil eğitimi verilmektedir.

Mesleki Eğitim Merkezlerindeki öğrencilerin yabancı dil eğitimine ve bu eğitimin kendi mesleklerine olan katkısına yükledikleri anlamlar nitel araştırma yöntemi ile saptanacaktır. Ayrıca daha önce bu alanda yapılmış bir çalışmanın olmayışı sebebiyle bu alanda yapılacak çalışmalara katkı sağlaması düşünülmektedir. Araştırmada yabancı dil olarak incelenen dil İngilizcedir. Veri akışı bu bağlamda sağlanmıştır.

Günümüzde Lingua Franca (Global ortak dil) olarak kabul edilen İngilizce her alanda etkisini hissettirirken onu öğrenmek hem mesleki hem de gündelik yaşantılarımız için bir yükümlülük halini almıştır. Mesleki eğitim merkezlerinde eğitim alan öğrencilerin yabancı dile olan ihtiyaç ve ilgilerinin tespiti, meslek hayatlarındaki verimlilik düzeylerini etkileyebileceği düşünülmektedir. Meslek eğitimi veren Mesleki eğitim merkezlerindeki öğrencilerin yabancı dil ve yabancı dil öğretimine olan algıları mesleki yetkinlik olarak yabancı dili nasıl gördükleri hakkında veri sağlayacaktır.

II. MATERYAL VE YÖNTEM

Bu nitel araştırma deseninde olgu bilim deseninden yararlanılarak bir araştırma raporu oluşturulmuştur. Öğrencilerin yabancı dil eğitimindeki deneyimlerine ve düşüncelerine göre, yabancı dili nasıl algıladıkları saptanmaya çalışılmıştır. Öğrenciler Kdz. Ereğli Mesleki eğitim merkezi öğrencilerinden daha önce yabancı dil eğitimi almış olan öğrencilerden seçilmiştir.

Bu araştırmada görüşme ve doküman analizi stratejileri kullanılmıştır. Öğrenci algıları araştırmaları için görüşme stratejisi öğrencilerle birebir etkileşim halinde hal, tavır durumlarının sorulara verdikleri cevaplarla paralel olup olmadığı ve sorulara hangi ruh halinde (neşeli, stresli, vb. duygularla) dönütler verileceğine imkân sağlamıştır. Ayrıca doküman analizi ile etkili ve verimli veri elde edilirken Mesleki eğitim merkezlerindeki yabancı dil eğitimi hakkındaki veriler toplanmış ve analiz edilmiştir.

Mesleki ve Teknik Eğitim Merkezindeki öğrenciler ile gerçekleştirilen görüşmeler, okul ders saatleri içerisinde okulun müdür yardımcısının izni ile öğrencilerle birebir araştırmacı ile görüşmecinin karşılıklı soru cevap şeklinde görüşmesi ile yapılmıştır. Görüşme katılımcının onayı alınarak kayıt altına alınmıştır. Öğrencinin kendini rahat hissetmesi için uygun ortam sağlanmaya çalışılmış olup araştırmacı öğrencinin rahatsız hissedebileceği durumlarda kaydı duraklatarak görüşmeyi sürdürmüştür. İlk görüşmede ses kaydına alınan süre 12 dakika olup toplam görüşme yaklaşık 40 dakika sürmüştür. Ayrıca doküman analizi için başvurulan öğretim programları MEB'in internet sayfalarından alınmıştır.

Bu çalışmada veri analiz yöntemlerinden olan içerik analizi yöntemi kullanılarak veri analizi yapılmıştır. Veriler kodlara dönüştürülerek temalar oluşturulmuş ve yorumlanmıştır. Bu araştırmada araştırmacının rolü, Mesleki Eğitim Merkezlerinde eğitim gören öğrencilerin yabancı eğitime olan algılarını araştırmaya uygun veri teknik ve uygulamalar kullanarak araştırma problemine uygun veri akışını sağlamaktır.

Geçerlilik araştırma verilerinin doğruluğu veya problem çözme yetisi konularını kapsamaktadır. Nitel araştırmalarda geçerliliğin sağlanabilmesi için araştırmacının problem durumunu mümkün olduğunca tarafsız olarak aktarması önem arz etmektedir. Ayrıca elde edilen verilerin araştırmaya konu olan durumu gerçekte olduğu gibi aktarması önemlidir (Baltacı,2019, s.380). Bu araştırmada yapılan görüşmelerde sorulan soruların görüşmeci tarafından anlaşılıp anlaşılmadığı teyit soruları ile saptanmaya çalışılmıştır. Araştırmalarda güvenilirlik, araştırma sonucunda elde edilen verilerin aynı araştırma konusunun bir başka zaman veya araştırmacı tarafından yapıldığında aynı sonuçları verip vermediği ile ilişkilidir. Mesleki eğitim merkezlerindeki öğrencilerin yabancı dil eğitimine olan algıları, araştırma konusu yapılan literatür

taramasında bir benzeri olmadığı için bu tür bir güvenilirlikten bahsetmek mümkün değildir. Fakat araştırmada kullanılan kaynakların açık ve şeffaf bir şekilde paylaşımı yapılmıştır.

III. BULGULAR

Nitel verilerin analizi sonucunda görüşme verilerinden elde edilen sonuçlara göre 3 ana tema ve doküman analizi sonucunda da 3 ana temaya ulaşılmıştır.

Görüşme verileri analizi sonucunda;

1. Yabancı dilin faydalarına ilişkin veriler,
2. Yabancı dil öğretimine ilişkin veriler,
3. Öğrencinin derse karşı olan tutumuna karşı olan veriler saptanmıştır.

1.Görüşme Verileri Analizi Sonucunda Yabancı Dilin Faydalarına İlişkin Veriler

Çalışmaya katılan öğrenciler yabancı dilin faydalarından bahsederken tüm öğrenciler yabancı dil becerinden olan konuşmanın en önemli beceri olduğunu vurgulamış birinci öğrenci ;*İngilizce olunca her yerde anlaşılıyor çoğu ülke zaten ana dili olmasa bile İngilizce yoluyla anlaşa biliyorsun ,*cevabı ile İngilizceyi kullanmanın önemini vurgulamıştır ayrıca İngilizce eğitimi ile bir dil farkındalığı oluştuğu öğrencilerin yabancı dil eğitim aldıktan sonra İngilizce ile diğer dilleri ayrıştırabildiği saptanmıştır. Bir öğrenci Almanca ile İngilizceyi karşılaştırmış ve Almancanın İngilizceden daha zor olduğunu söylemiştir.

2. Görüşme Verileri Analizi Sonucunda Yabancı Dil Öğretimine İlişkin Veriler

Çalışmada yabancı dil öğretimine ilişkin öğrencilerin kullanılan metallerden bahsederken en çok görsel materyallerden etkilendikleri bilgisine ulaşılmıştır. Bir öğrenci "Yabancı ders eğitimin de en keyif aldığı unsurlar nelerdir?" sorusuna İngilizce dersinde izlediği bir içerikten bahsetmiş ve keyif aldığını belirtmiştir. Ayrıca bir başka öğrenci İngilizce dersinde yapılan etkinliklerden aklında kalan bir örnek istenmiş ve cevap olarak *resimler vardı insanlar bir şey yapıyor biz onu bulmaya çalışıyorduk İngilizcesini yazıyoruz günlük aktiviteleri onun yaptığı aktiviteleri sıralıyorduk* şeklinde cevap vermiştir. Öğrenciler yabancı dil öğretiminde yapılan uygulamalarla ilgili bire bir katılım gösterdikleri uygulamaları tercih ettikleri belirlenmiştir. Bir öğrencinin "İngilizce dersinde en çok keyif aldığınız unsurlar nelerdir?" sorusuna, *uygulama hani mesela tahtaya kalkıp bir şeyler falan yazıyorum yani onlar çok güzel oluyor daha çok öğrenmiş oluyoruz benim açımdan öyle ben kendimi böyle uygulama yaparak daha çok öğrenmiş gibi oluyorum çünkü böyle bir konuşarak bir kulağımızdan gelip bir kulağımızdan çıkıyor ama görseli böyle kafamızda canlandıra biliyorsun* şeklinde cevaplamıştır. Bir başka öğrencim aynı soruya, *ayağa kalkıp karşılıklı konuşma diyalog yaptım ödevlerimiz vardı güzeldi yani* şeklinde cevap vermiştir. Bu cevap ile öğrencinin dili kullanarak yaptığı etkinliklerden daha çok keyif aldığı söylenebilir.

3. Görüşme Verileri Analizi Sonucunda Öğrencinin Derse Karşı Olan Tutumuna İlişkin Veriler

Çalışmaya katılan öğrenciler derse karşı tutumları için içsel olarak dersi sevdiklerinden, derste iyi hissettiklerinden, heyecan ve dinginliği aynı anda tecrübe ettiklerinden bahsetmişlerdir. Bir öğrenci "İngilizce dersindeki ruh halinizi nasıl tamlıyorsunuz?" sorusuna, *mutlu şahsen ve daha bir enerjik oluyorum sanki bilesiniz derslere biraz daha enerjik oluyorum* şeklinde cevap vermiştir. Ayrıca "İngilizce derslerinde ki ruh halinizi bir hava durumuna benzetseydiniz hangi hava durumu olurdu?" sorusuna, *güneşli çok güneşli* şeklinde cevap vermiştir. Bu metafordan anlaşıldığı gibi öğrenci İngilizce derslerinde kendisini mutlu hissetmekte ve olumlu bir tutum sergilemektedir. Ayrıca bir diğer öğrencinin aynı soruya *böyle bir şeyler öğrendikçe insan heyecanlanıyor hani cevap derken heyecanlanıyor bilmiyorum mutluluk bence* şeklinde cevap vermiştir. İngilizce dersini bir hava durumu metafora benzetmesi istendiğinde *ben böyle hani ılık bir hava olur ya eser ama sıcak eser lodos gibi ama yıkıcı olmayan* şeklinde cevap vermiştir. Bu cevap ile öğrencinin İngilizce derslerinde olumlu bir tutuma sahip olduğu derslerde heyecanlansa da bu heyecanın olumlu bir duygu olduğu söylenebilir. Diğer öğrenci ise İngilizce dersindeki ruh halini *ya işten çıkınca yorucu oluyordum ama nasıl eğlenceliydi ya farklıydı işte işten çıkıp İngilizce dersine gelmek her gün değişik bir rutin oluşturmuştum* şeklinde cevap vermiş ruh halini hava

durumuna benzetmesini istendiğinde *parçalı bulutlu* olarak yanıtlamıştır. Bu öğrencinin staj yaptığı yerden yorgun olarak derse katılması onun İngilizce derslerindeki ruh halini nötr bir şekilde olmasını sağladığı düşünülebilir. Derslere yorgun katıldığı için yeterli enerjisinin bulunmadığı için derslerde kendini ne kötü ne de mutlu hissetmektedir.

Öğrencilerin derse karşı geliştirdikleri dışsal tutumlar; sosyal ortam, küresellik, bilinir olma, farklılık ve fayda sağlama anahtar kelimeleri ile belirlenmiştir. Bir öğrencinin "İngilizce dersi almadan önce ve aldıktan sonra dünyaya bakış açında ne gibi değişiklikler oldu?" sorusuna *yani böyle İngilizce bilmek biraz kendi şeyi gösteriyor yani biraz daha yüksek hissettiriyor diğer öğrencilerden gerçekten evet hem dış ülkeye gitmiş görmüş hem öyle hem de yani farklı yani* şeklinde belirtmiş İngilizce bilmenin kendisine sosyal bir ortamda artı bir değer kattığından bahsetmiştir. Bir diğer öğrenci ise aynı *soruya hani mesela bir oyun yüklersin falan İngilizce bana öyle kattı anlayabildim telefondaki uygulamaları alırken ne bileyim mesela hani İngilizce anlayabildim onları İngilizce biliyorsan oradan anlarsın* şeklinde cevap vermiş İngilizce bilmenin gerçek yaşamında fayda kattığını belirtmiştir.

Doküman analizi sonucunda;

1. Yabancı dilde eğitime ilişkin veriler,
2. Yabancı dil eğitiminde yöntem ve tekniklere ilişkin veriler,
3. Yabancı dil öğretiminde kullanılan araç-gereçlere ait veriler bulunmaktadır.

1)Doküman Analizi Sonucunda Yabancı Dilde Eğitime İlişkin Veriler

Bu çalışmada kullanılan doküman analizinde, yabancı dilde eğitim ana teması altında okuma, İngilizce yazılmış kelimeleri fark etme, yazma, sözcük bilgisi ve cümle kurma becerisi kazandırılması hedeflenen beceriler olarak karşımıza çıkmaktadır. Bir diğer alt tema olan kazanımlar için özellikle mesleki İngilizce dersinde mesleki eğitim merkezi öğrencilerinin yabancı dilde mutfak ekipmanlarını bilme, yemek hazırlama, hijyen kuralları gibi ifadeleri bilmesi ve kullanabilmesi hedeflenmektedir. Mesleki eğitim merkezi konaklama ve seyahat hizmetleri alanı çerçeve öğretim programında karşımıza çıkan öğrenme kazananları olarak *yabancı dil broşür ve rezervasyon işlemlerini yapar, yabancı dilde havalimanı işlemlerini yapar, yabancı dilde tur ve gezi işlemlerini yapar*, kazanımları dikkat çekmektedir yani kendi alanları dahilindeki işlevleri gerçekleştirebilmeleri için öğrencilerin yabancı dil öğrenmesi hedeflenmektedir.

2) Doküman Analizi Sonucunda Yabancı Dil Eğitiminde Yöntem ve Tekniklere İlişkin Veriler

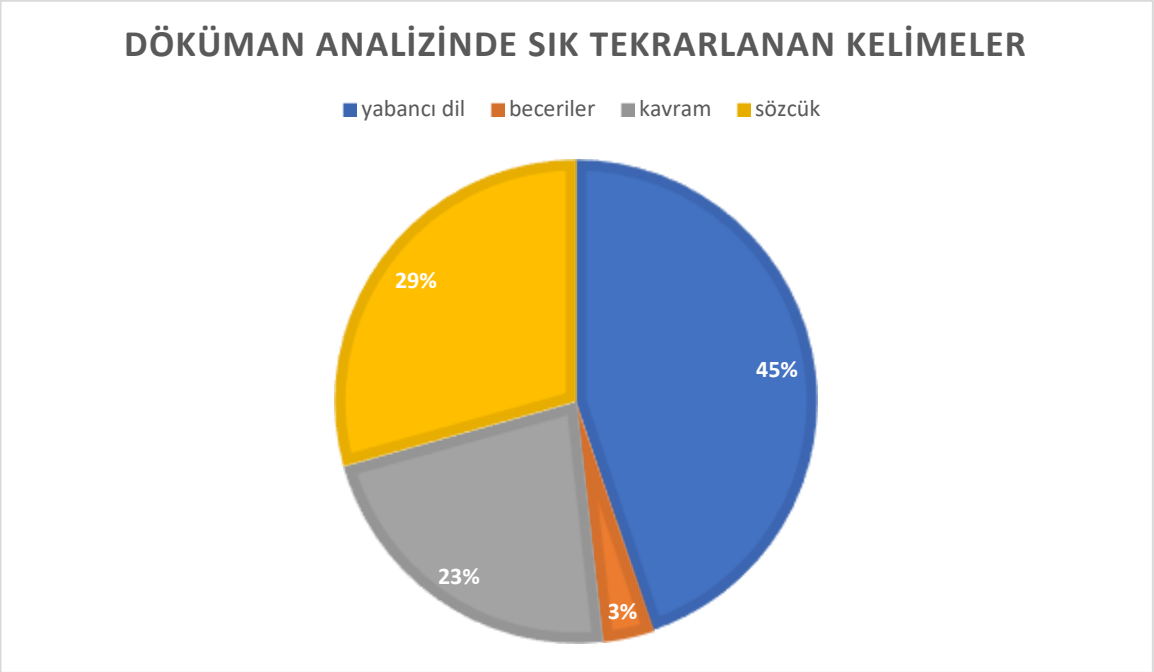
Bu çalışmada yabancı dil öğretiminde yöntem ve teknikler başlıkları , öğretmenler için anlatım ve gösteri tekniği bireysel bir yöntem olarak belirlenmiş hem öğretmenin hem de öğrencilerin beraber gerçekleştirilebileceği öğretim yöntem teknikleri olarak beyin fırtınası ,tartışma, soru-cevap ve grup çalışması kavramları öne çıkmaktadır .mesleki eğitim merkezlerinde gösterilen çerçeve programlarda yabancı dil öğretiminde kullanılan yöntem ve tekniklerden bahsedilmemiş olup örneklem grubumuzda bulunan öğrencilerin halk eğitim merkezi aracılığı ile aldıkları İngilizce A1 seviye kurs programında bahsedilmektedir..

3. Doküman Analizi Sonucunda Yabancı Dil Öğretiminde Kullanılan Araç-gereçler

Bu çalışmada kullanılan dokümanlarda yabancı dil öğretiminde araç gereçler ana teması altında modern araçlar ve klasik araçlar temaları belirlenmiş olup modern araçlar temasında *bilgisayar, televizyon, slaytlar ve videolardan* bahsedilmektedir. Klasik araçlar temasında ise *tahta, pano ve basılı metaller* yer almaktadır. Bir önceki ana tema iletildiği gibi mesleki eğitim merkezleri çerçeve programlarında araç gereçler özellikle belirtilmemiş olup öğrencilerin halk eğitim merkezlerinde aldıkları İngilizce ders programında yer almaktadır. Bu materyaller kullanılan yöntem ve tekniklere göre değişiklik göstermektedir. Örneğin; öğretmenlerin bireysel olarak gerçekleştirdiği anlatım tekniğinde tahta kullanımının daha fazla olduğu söylenebilir ya da öğretmen ve öğrencilerin beraber gerçekleştire bildikleri grup çalışmalarında basılı materyaller slaytlar ve bilgisayarlar kullanılmaktadır.

Şekil 1'de görüldüğü üzere doküman analizinde kullanılan yabancı dil, beceriler, kavram ve sözcük kelimeleri en sık tekrarlanan kelimeler olmuştur. En sık tekrarlanan kelime olan yabancı dil kelimesi %45'lik oranına sahiptir. İngilizce dersinin yabancı dil adı altında gösterilmesi bu sonucun

çıkmasını sağlamıştır. En az tekrarlanan kelime olan beceri kelimesi, kazandırılmak istenilen becerilerin sınırlı olduğu anlamına gelebilmektedir.



Şekil 1. SIk tekrarlanan kelimeler

IV. TARTIŞMA VE SONUÇLAR

Günümüzde küreselleşmenin de etkisi ile üretim küreselleşmiş bu üretimin gerçekleştirilebilmesi için nitelikli iş gücü ihtiyacı her zamankinden daha fazla olmaktadır. Bu kapsamda birçok ülke eşgüdümlü atılımlar gerçekleştirmektedir (Özer,2021.s.1). Nitelikli iş gücü ihtiyacının karşılanabilmesi için ülkelerde mesleki eğitime verilen önem gün gün artmaktadır. Bu farkındalık ile ülkeler rekabet edebilmek adına mesleki eğitimlerinin sürdürülebilir ve küresel standartlara uygun olarak şekillendirmemektedirler (Kınsız,2005, s.260). Bir dünya ortak dili olan İngilizce mesleki eğitim de önemli bir avantaj olarak karşımıza çıkmaktadır. Türkiye'de de mesleki eğitim merkezlerinde küresel boyutta rekabet edebilmek için öğrencilerin eğitim hayatları boyunca İngilizce dersi almaları bir avantaj olarak görülebilir.

Bu çalışmada elde edilen bulgular, görüşme ve doküman analizleri yapılarak bulunmuştur. Örneklem grubunda yer alan öğrencilerin yabancı dil eğitimine olan algıları belirlenmeye çalışılmıştır. Öğrenciler genel olarak İngilizce derslerindeki ruh hallerini olumlu kelimelerle ifade etmiştir. Ayrıca İngilizce öğretin kendilerine fayda sağladığını sosyal ortamlarda prestij sağladığını ifade etmişlerdir. Öğrenciler İngilizce derslerinin ileriki iş hayatlarında katkı sağlayacağı görüşünü de iletmişleridir. Öğrencilerin olumsuz olarak ifade ettikleri görüşler; İngilizce dersinin kendi ders müfredatlarında bulunmayışı, daha önce almış oldukları İngilizce ders saatlerinin yetersiz oluşu ve İngilizce derslerine staj yaptıkları yerlerden sonra katıldıkları için yorgun ve bitkin hissetmeleri bu sebeple derse adapte olamadıklarını ifade etmişlerdir. Ayrıca doküman analizinde bulgular elde edilirken mesleki eğitim merkezleri çerçeve programlarının çok kolay ulaşılabilir olmadığı saptanmıştır. Araştırma boyunca kaynak internet sitelerinin taşınması bu bilgilere ulaşmayı zorlaştırmıştır. Ulaşılan programlarında ayrıntılı ve kapsayıcı olmadığı saptanmıştır. Çerçeve programlar incelenirken içeriğinde öğrencilere kazandırılması gereken beceriler ve kazanımlar yer almış fakat bu eğitimin nasıl yapılması gerektiğinde bahsedilmemiştir. Öğrencilerin proje kapsamında aldıkları halk eğitim merkezi aracılığı ile yapılan İngilizce A1 kursu planında bu eksiklikler bulunmamaktadır. Mesleki eğitim merkezlerinin kökenin köklü bir geçmişi olmasına rağmen kurum olarak yeni bir yapılanma olması literatür taramasında derinlemesine bir araştırma yapılmamasına sebep olmuştur.

Yukardaki sonuçlar göstergesinde birkaç öneri sunulmuştur. Bunlar;

- Mesleki eğitim merkezlerinde ki öğrencilerin istek ve ihtiyaçlarına uygun olarak yabancı dil eğitim politikası oluşturulabilir.
- Bu alanda daha çok çalışma yapılabilmesi için araştırmacılar teşvik edilebilir.
- Mesleki eğitim merkezlerinde öğretimi yapılan çerçeve programların daha kolay erişilebilmesine olanak sağlanabilmelidir.

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Ortak Sınavlarda Açık Uçlu Soruların Kullanılmasına İlişkin Öğretmen Görüşleri

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Özet **–** 9 Eylül 2023 tarihinde Resmî Gazetede yayımlanan MEB Ölçme ve Değerlendirme Yönetmeliğinin amacı, Bakanlıkça yapılan merkezi sistem sınavları, ulusal Millî Eğitim Bakanlığı /uluslararası izleme araştırmaları, okul öncesi eğitim kurumları ve ilkokullarda akademik ve sosyal gelişimin takibi, ortaokul ve ortaöğretim kurumlarındaki ortak yazılı sınav faaliyetlerinin usul ve esasları ile ölçme değerlendirme merkezi müdürlüklerinin görev, yetki ve sorumluluklarını düzenlemektir. Araştırmanın amacı Eylül 2023' te uygulanmaya başlanan ve temel eğitim ile ortaöğretİm kademesindeki bütün sınıf düzeylerinde yönetmelik gereği ülke ve il/ ilçe ortak sınavları dışında okulda yapılan bütün sınavların açık uçlu sorularla hazırlanması gereğinden yola çıkarak bu konuda öğretmen görüşlerini tespit etmektir. Çalışmada nitel araştırma yöntemlerinden olan durum çalışması yöntemi kullanılmıştır. Milli Eğitim Bakanlığı' na bağlı devlet kurumunda çalışan Matematik öğretmeni örneklem olarak yer almıştır. Araştırmada veri toplama aracı olarak yarı yapılandırılmış görüşme formu kullanılmıştır. Veriler, içerik analizi yöntemi kullanılarak incelenmiştir. Görüşme neticesinde; açık uçlu soruların etkin, derin ve ayrıntılı öğrenmeyi sağladığını bu soru türünün öğrencilerin öğrenmelerini yapılandırması, zaman yönetimi ve ifade becerisi kazandırması yanında onları daha fazla çalışmaya sevkederek öğrenmelerini etkilediği belirlenmiştir

Anahtar Kelimeler – Ortak sınav, ölçme değerlendirme, öğretmen, merkezi sınav, öğrenci

I. GİRİŞ

MEB Ölçme ve Değerlendirme Yönetmeliği üçüncü bölüm 5. Maddesi bendine ''İlçe, il veya ülke genelinde ortak yazılı sınavlar yapılabilir. Bu sınavların uygulanmasına ilişkin iş ve işlemler millî eğitim müdürlüklerince yürütülür'' d bendinde ise '' Uygulamalı sınavlar hariç, öğretmenlerin ortak değerlendirme yapabilmelerine imkân vermek üzere birden fazla şubede okutulan derslerin sınavlarının ortak yapılması esastır. Bu sınavların şube ve sınıflar bazında analizleri yapılır. Konu ve kazanım eksikliği görülen öğrencilerin durumları, ders öğretmeni ve eğitim kurumu sınıf/alan zümreleri tarafından yeniden değerlendirilir'' ibaresi yer almaktadır. Yönetmeliğin üçüncü bölüm 6. Maddesinin g bendinde 'Ülke ya da il/ilçe genelinde yapılacak ortak yazılı sınavlar hariç, okullarda yapılan tüm sınavlar cevaplarını öğrencilerin oluşturduğu ve farklı bilişsel düzeyde kazanımları ölçen maddelerden oluşan yazılı yoklama şeklinde yapılır' ifadesi yer almaktadır.

Eğitim sisteminin işlerliğini sağlamak adına, öğrencilerin istenilen davranışları kazanıp kazanmadığını belirlemek amacıyla eğitim-öğretim etkinliklerinin sonunda ölçme ve değerlendirme faaliyetleri zorunlu hale gelmiştir. Günümüzde, öğretmenler tarafından hazırlanan ölçme araçları kullanılarak elde edilen ölçümler, öğrencilerin başarı durumlarını değerlendirmek için temel alınmaktadır. Türkçe öğretimi özelinde, öğretimsel etkinliklerin hedeflere ulaşma derecesini belirlemek için doğru ölçme ve değerlendirme yöntemlerinin kullanılması gerekmektedir. Bu faaliyetler, programdaki amaçlara uygun olarak gerçekleştirilir ve öğrencilerin öğrenme düzeylerini tespit etmeye yöneliktir. Değerlendirme,

öğrencilere geri bildirim sağlayarak onları motive eder, öğretmenin kararlarını destekler ve öğretim etkinliğinin etkisini değerlendirmeye yardımcı olur. Sınavlardan elde edilen ölçümler, öğrenci başarısını yansıtmanın yanı sıra öğretimin etkililiğine dair bilgiler de sunar. Eğer öğrenciler istenilen davranışları kazanamazlarsa, bu durumun nedenleri araştırılmalı ve elde edilen bulgular çerçevesinde eğitim sistemi revize edilmelidir (Üstüner&Şengül,2004).

Okullarda uygulanacak ortak sınavların nasıl uygulanacağı konusunda yönetici ve öğretmenlerde çok sayıda soru işareti mevcuttur. 2023-2024 Eğitim Öğretim yılı itibariyle Ülke il/ilçe ortak sınavları dışında okulda yapılan bütün sınavlar açık uçlu veya açık uçlu ve kısa cevaplı maddelerden oluşmak zorunda ve birden fazla şubede okutulan bütün derslerin sınavı okulda ortak yapılmaktadır.(MEB, 2023).

Alan yazın incelendiğinde öğretmenlerin ortak sınavlarda açık uçlu soruların kullanılması hakkında öğretmen görüşlerine ilişkin daha önce yapılan bir çalışmanın olmaması, bu uygulamanın 2023-2024 yılında yayımlanan yönetmelik kapsamında zorunlu hale geldiği düşülürse doğal bir sonuçtur. Bu konuyla benzer nitelikte az sayıda araştırmanın olduğu (Bolat, Karamustafaoğlu& Korkmaz, 2022; Özen, 2020, Kahraman, 2024) görülmüştür. Türkiye'de açık uçlu soruları hazırlama konusunda öğretmen görüşlerinin belirlenmesini amaçlayan tezler incelendiğinde; konuya en yakın İnceçam, Demir &Demir, 2018, ''Ortaokul Öğretmenlerinin Sınıf İçi Ölçme ve Değerlendirmelerde Yazılı Yoklamalarda Kullandıkları Açık Uçlu Maddeleri Hazırlama Yeterlikleri'' makalesine ulaşılmıştır.

Araştırmanın amacı Eylül 2023' te uygulanmaya başlanan ve temel eğitim ile ortaöğretİm kademesindeki bütün sınıf düzeylerinde yönetmelik gereği ülke ve il/ ilçe ortak sınavları dışında okulda yapılan bütün sınavların açık uçlu sorularla hazırlanması gereğinden yola çıkarak bu konuda öğretmen görüşlerini tespit etmektir.

II. MATERYAL VE YÖNTEM

Çalışmada nitel araştırma yöntemlerinden olan durum çalışması yöntemi kullanılacaktır. Araştırma kapsamında öğretmen görüşlerini detaylı şeklide öğrenebilmek için nitel araştırma yöntemi kullanılır.

Durum çalışması, belirli bir sistemin detaylı bir şekilde incelenmesi ve anlaşılması için çoklu veri toplama yöntemlerinin kullanıldığı bir metodolojik yaklaşımdır Merriam (2013), durum çalışmasını sınırlı bir sistemin kapsamlı bir biçimde betimlenmesi ve incelenmesi olarak tanımlar. Creswell (2007) ise durum çalışmasını araştırmacının zaman içinde sınırlı sayıda durumu çoklu kaynaklardan (gözlemler, görüşmeler, dokümanlar, raporlar) derinlemesine incelediği, durumlar ve duruma özgü temaların belirlendiği nitel bir araştırma türüdür.

Milli Eğitim Bakanlığı' na bağlı devlet kurumunda çalışan Matematik öğretmeni örneklem olarak yer almıştır. Araştırmada veri toplama aracı olarak yarı yapılandırılmış görüşme formu kullanılmıştır. Veri toplama sürecinde yarı yapılandırılmış görüşme formu kullanılmış. Öğretmene 6 soru yöneltilmiş bu altı soru dışında alternetif sorulara da yer verilmiştir. Konu gündemde bir konu olduğundan öğretmenin ilgi ve aynı zamanda düşüncelerinin oldukça açık ifade ettiği karşılıklı söyleşi manasında akıcı iletişimle gerçekleşen bu görüşmede öğretmenin söyledikleri birebir yazı ile kaydedilmiştir. Yaklaşık 45 dakikalık bir görüşme yapılmıştır. Görüşme süreci oldukça verimli geçmiştir.

Veriler, içerik analizi yöntemi kullanılarak incelenmiştir. Veriler, içerik analizi yöntemi kullanılarak incelenmiştir. İçerik analizi, benzer verileri belirli kavramlar ve temalar altında toplamayı ve bunları okuyucunun anlayabileceği bir düzenleme ve yorumlama sürecini içerir (Yıldırım ve Şimşek, 2011, s.228). Analiz sürecinde dört aşama izlenmiştir: 1. Verilerin kodlanması, 2. Temaların belirlenmesi, 3. Kodların ve temaların düzenlenmesi, 4. Bulguların tanımlanması ve yorumlanması. Analiz sürecinde önce görüşme kayıtları düzenlenmiş ve sonra bilgisayar ortamına aktarılmıştır.

İçerik analizi veya içerik çözümlemesi, incelenen herhangi bir kaydedilmiş iletişim biçiminin içeriğine odaklanan bir yöntemdir. Bu kaydedilmiş iletişim biçimi, yazılı metinlerden kitap ve dergilere kadar çeşitli sözlü anlatım türlerine kadar geniş bir yelpazede bulunabilir. Ayrıca, görsel öğeleri de içerebilir, örneğin televizyon programları, reklamlar gibi. İçerik analizi, tanıklıklar, mevzuat, kamu belgeleri, vaka çalışmaları, raporlar, anket ve görüşme sorularının cevapları, haber bültenleri, web sayfaları, reklam panoları, posterler, grafiti, radyo programları, kataloglar, fotoğraflar, çizimler, videolar, filmler, müzikler,

gazeteler, kitaplar, dergi makaleleri, dini metinler, ders kitapları, nutuklar, romanlar ve mektuplar gibi birçok iletişim biçimini analiz etmek için kullanılabilir (Gül & Nizam, 2021, s.182).

III. BULGULAR

Açık Uçlu Soruların ortak sınavlarda uygulanmasıyla ilgili araştırmadan elde edilen bulgular öğretmen görüşlerine göre belli alt temalara ayrılmış, yapılan görüşmelerden doğrudan alıntılar yapılarak özetlenerek kodlar oluşturulmuştur.Görüşmede elde edilen verilerle tema "Açık Uçlu Soruların Öğretime Etkisi" olarak belirlenmiştir. Alt temalar ise sırasıyla; "öğrenmeye etkisi'', "düşünmeye etkisi", "ölçmeye etkisi", "öğretim programına etkisi", "öğretmene etkisi" adı altında beş başlıkta belirlenmiştir. Bu beş koda karşılık gelen görüşmede geçen öğretmen görüşlerinden alıntılar alınarak. tabloya eklenmiştir.

Tablo1. Açik Uçlu Sorularin Öğretim Sürecine Etkileri

	ALT TEMALAR	**KODLAR**	**KATILIMCI GÖRÜŞÜ**
TEMA: AÇIK UÇLU SORULARIN ÖĞRETİM SÜRECİNE ETKİLERİ	***Öğrenmeye Etkisi***	*Etkin öğrenme* *Derin öğrenme* *Ayrıntılı öğrenme* *Öğrenilenleri Yapılandırma* *Öğrenmek için daha fazla çaba* *Zaman yönetimi becerisi*	*"Yazmak, açıklama yapmak, kendi cevabını kendisi oluşturmak durumunda olduğunu biliyor öğrenci bu soru türünde.Onun için öğrenci daha çok çalışmaya gayret ediyor, ayrıntı ve aşamalara yer vermesi gerektiğini biliyor,daha iyi çalışması gerektiğini biliyor Cevabı kendisi yapılandırıyor, derin ve etkin öğrenmeye olanak sağlıyor.*." (ÖĞR).
	Düşünmeye Etkisi	Eleştirel düşünme Üst düzey düşünme becerileri Farklı bilşsel düzeyde cevaplar Yaratıcı fikirler Kendini ifade edebilme Düşünmeyi yapılandırma	".*Günümüzde öğrenciler cümle kurmakta zorlanıyorken mesela sözel derste yorum yazacak, zor tabi bu öğrenci için.Üst düzey düşünme becerisi gerektiriyor,eleştirel düşünme olanağı sağlıyor, sorular hakkıyla hazırlanırsa.Aslında sayısal derslerde durum pek böyle deği en fazla basamağına yaklaşır sınavla. Ben soru sayısının fazla olmamsı taraftarıyım daha önce belirttiğim gibi öğrenciye rahat rahat kendini ifade etme fırsatı yazma zamanı verilmeli. Yaratıcı fikirler çözümler üretsin, zamana fazlaca takılıp ifade etmesi kısıtlı olmasın.*" (ÖĞR).

	Ölçmeye Etkisi	Kazanım eksiklerinin aşamalı tespiti Üst düzey düşünme becerilerini ölçen sorular sorma imkanı Farklı bilişsel düzeyde sorular sorma imkanı Ayrıntılı ölçme Güvenilir ölçme Geçerli ölçme Zaman alıcı değerlendirme Uzman görüşü desteği Rubrik kullanma Düşük şans başarısı Ekonomik soru hazırlama süreci	"*Açık Uçlu Sorularda öğrencinin bilip bilmediğini, kazanımın ne derece öğrenci tarafından anlaşıldığını* *Nerede takıldığını anlayabiliyoruz. Açık uçlu sorulardan oluşan sınavlar bana göre diğer sınav türlerine* *göre çok daha güvenilirliği geçerliği yüksek sınavlar. Bunun yanında hazırlamak daha kolay bence* *seçenekleri oluşturmak da ustalık istiyor çoktanseçmeli olduğunda soru, burada soru hazırlarken* *daha çok istenilen davranışa odaklanarak soru üretiyoruz bu anlamda daha kolay.* *Daha az soru soruyoruz aslında bu daha net ölçüm yapmamızı sağlıyor.Aslında şans başarısının da* *neredeyse olmaması öğrencinin birbirinden rahat kopya çekememesi de ölçme değerlendirmeyi* *daha güvenilir ölçme sağlıyor. Aslında daha az soru daha az kazanımın ölçülmesi tabi bir yandan, ama* *öğrencinin neyi ne kadar öğrendiğini belirlemek bana göre bundan daha önemli. Açık uçlu sorular diğer* *sorulara kıyasla bize daha açık ayrıntılı durumu anlama analiz etme fırsatı veriyor* *.Bunun yanında bence bu sınavları okumak gerçekten zor ve zaman alıcı*." (ÖĞR)
	Öğretim Programının Düzenlenmesine Etkisi	*Hatalı ve eksik öğrenmelerin tespiti ve telafisi* *Kavram yanılgılarının saptanması* *Alt öğrenmelerin gözden geçirilmesi* *Öğrenmenin ayrıntılı analizi*	*'En önemlisi ön bilgilerdeki eksikliğin belirlenmesi aslında. Ben Matematik öğretmeniyim alanımdan* *örneklersem; trigonometri sorusu soruyorum örneğin fonksiyon bilmediğini anlıyorum verdiği cevaptan* *orayı anlayamamış ve bu nedenle bu aşamayı öğrenmekte zorlanıyor ya da rasyonel ve köklü sayıları* *yapamıyor temelinde o nedenle trigonometri sorusunda zorlanıyor gibi. Matematikte bir kazanımın* *öğrenilmesi için bir çok kazanımın öncesinde öğrenilmiş olması gerekiyor. Ön bilgilerdeki eksiklikleri* *tespit eebildiğimiz için süreçte telafi etme şansı veriyor veya öğrenci ve veliye* *doğru dönütler vermemizi sağlıyor.''(ÖĞR)*

	Öğretmene Etkisi	*Kazanıma dair dönütleri öğrenme* *Pratik soru hazırlama* *Aşamalı çözüm ve puanlama* *Süreci değerlendirme* *Analiz etme* *Hizmet içi eğitim* *Rubrik hazırlama eğitimi*	*"Soru çözümlerine baktığımda öğrenmiş diyebiliyorum, ayrıntılar var, veya öğrenemediği takıldığı yerleri görüyorum Sorun nerde, ön bilgi mi buna neden oluyor, öğrenmedeki hatalı öğrenme mi çocuk aslında temel matematik dört işlemde mi sorun yaşıyor vs. Ön bilgilerdeki eksiklikleri tespit eebildiğimiz için süreçte telafi etme şansı veriyor veya öğrenci ve veliye doğru dönütler vermemizi sağlıyor. Soru hazırlarken, kontrol ediyoruz zümre olarak uzman görüşü alıyoruz yani.. Tabi bu daha sağlıklı sonuç veriyor. Değerlendirme konusunda da soruların ortak olması sebebiyle rubriklerimiz ortak, bu da ortak Görüşlerle belirleniyor.Uzman görüşü bu süreçleri daha sağlıklı hale getiriyor her ne kadar çoğunluğumuz alanımızda zaten uzman olsak da ortak kararlar süreci daha objektif daha genel ve dah a temel sorulara dayandırıyor. Sınavlarımı değerlendirirken ayrıntılı dereceli puan anahtarı/ rubrik kullanıyorum. Rubrik hazırlama eğitimi almak yararlı olabilir diye düşünüyorum aslında. Değerlendirmelerimi anahtara göre yapsam da dikkatli olma gereği hissediyorum." (ÖĞR)*

IV. TARTIŞMA VE SONUÇLAR

"Ortak Sınavlarda Açık Uçlu Soruların Kullanılmasına İlişkin Öğretmen Görüşleri" isimli bu çalışma için bir öğretmenle ayrıntılı görüşme yapılmış; bu görüşme neticesinde kodlar yazılmış bu kodlara karşılık gelen alt temalar ve tema elde edilmiştir.Görüşme neticesinde ; açık uçlu soruların etkin, derin ve ayrıntılı öğrenmeyi sağladığını bu soru türünün öğrencilerin öğrenmelerini yapılandırması, zaman yönetimi ve ifade becerisi kazandırması yanında onları daha fazla çalışmaya sevkederek öğrenmelerini etkilediği belirlenmiştir.Bununla ilişkilendirilebilecek çalışmalar incelendiğinde, literatürde Temizkan ve Sallabaş (2011, s.217) çalışmalarında öğrencilerin okuduğunu anlama becerilerinin ölçülmesi açısından açık uçlu soruların bulunduğu testlerin çoktan seçmeli sorulardan oluşan testlere göre dezavantajlı olduğu bulguları da mevcuttur. Bunun temel sebebi olarak da yapılan çalışmada açık uçlu yazılı sınavlarda öğrencinin metni anladıktan sonra yazılı olarak ifade etmekte zorlanmasından kaynaklandığı ifade edilmiştir.

Ortak sınavlarda açık uçlu soruların kullanılmasına ilişkin öğretmen görüşlerine göre, bu soru türünün, öğrencilerin eleştirel düşünmelerini, üst düzey düşünme becerilerini, farklı bilşsel düzeyde cevaplar vermesini etkilediğini ayrıca öğrencilerin yaratıcı fikirler üretmelerini, kendilerini ifade edebilme ve bildiklerini yapılandırma yoluyla düşünmelerini etkilediğini ortaya koymuştur. Literatürdeki bir çok araştırmada açık uçlu sorunun etkileri olarak üst düzey düşünme becerilerini geliştirdiği konusunda veri, bulgu ve açıklamalar mrvcuttur. Karatay ve Dilekçi (2019, s.688) çalışmalarında; öğretmenlerin sadece basit bilgi hatırlatmalarından ziyade öğrencilerin üst düzey düşünme becerilerini geliştirmeye yönelik sorular kullanmalarının gerekliliğidir. Bu tür sorular, öğrencilerin eleştirel düşünme yeteneklerini

geliştirirken, üst düzey düşünebilme yeteneğinin de temelini oluşturduğu, ölçme araçlarında yer alacak soruların konu alanı ile ilgili olmanın yanı sıra bilişsel açıdan öğrencilerin eleştirel düşünme becerilerini alt düzeyden üst düzeye doğru geliştirecek şekilde olması gerektiği vurgulanmaktadır.

Ortak sınavlarda açık uçlu soruların kullanılmasına ilişkin öğretmen görüşlerine ilişkin yapılan araştırmada elde edilen Açık uçlu soruların öğretime etkisi temalı çalışmanın alt teması olarak belirlenen ölçmeye etkisi temasındaki kodlar incelendiğinde, öğretmenlerin; kazanım eksiklerinin aşamalı tespiti, üst düzey düşünme becerilerini ölçen sorulardan oluşması, farklı bilişsel düzeyde sorular sorma imkanı tanıması, ayrıntılı-güvenilir-geçerli ölçme, zaman alıcı-uzan görüşü ve rubrik gerektiren değerlendirme bu soru türünün ölçmeye etkisi olarak belirtildi. Literatür incelendiğinde, Birgün ve Gürbüz (2018, s.177) çalışmalarında, öğretmenlerin ölçme ve değerlendirme yaklaşımlarının ve öğrencilerin ölçme ve değerlendirmeye ilişkin algılarının, öğrencilerin öğrenme yaklaşımlarını ve çalışma biçimlerini önemli ölçüde etkilediği belirlenmiştir.

Ortak sınavlardaki açık uçlu sorular , öğrenci öğrenmeleri hakkında önemli dönütler vermesi açısından önemlidir. Öğretim programına etkisi, kavram yanılgılarının tespiti, eksik hatalı öğrenmelerin tespiti, ayrıntılı analiz imkanı sunması şeklinde öne çıkmaktadır.

Ortak sınavlarda açık uçlu soruların Kullanılmasındaki görüşlere ilişkin araştırmada yapılan görüşme sonucunda alt tema olan öğretmene etkisi incelendiğinde soruları hazırlık sürecinin kolay gelmesine rağmen değerlendirme sürecinin zorlayıcı olduğu görülmektedir. Bu konuda literatür taraması yapıldığında bir çok araştırma bu soru türünü hazırlamak konusunda hizmetiçi eğitim ihtiyacına işaret etmektedir. İnceçam, Demir ve Demir (2018) çalışması bağlamında açık uçlu soruları değerlendirirken öğretmenlerin objektif ve tutarlı olmayan puanlamalar yaptıkları bulgusunu destekler nitelikte açıklamalara yer vermektedir. Bulgulara göre öğretmenlerin; soru redaksiyonu yapılması, uzman görüşü alınması, soruların deneme uygulamasının gerçekleştirilmesi ve bu sonuçların değerlendirilmesi ölçütlerini bir maddenin hazır hale getirilene kadar yapılan uygulamalar bütünü olarak görmedikleri düşünülmektedir.

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Nükleer Tıp Merkezlerinde Oluşan Nükleer Malzemelerin Kullanımı ile Atıklarının Kontrolü ve Bertarafı

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Özet – Bu çalışma hastanelerdeki nükleer atıkların kontrolü ve bertarafı için etkili stratejiler belirlemeyi ve mevcut yönetim pratiğini iyileştirmeyi hedeflemektedir. Böylelikle hastanelerdeki nükleer atık yönetimi süreçlerindeki eksiklikleri, riskleri ve zorlukları ortaya koyacak ve geliştirilmesi gereken alanların araştırması hedeflenmiştir. Ayrıca, atık üretiminin azaltılması, doğru depolama yöntemlerinin benimsenmesi, güvenli taşıma prosedürlerinin uygulanması ve etkili bertaraf süreçlerinin oluşturulması için öneriler sunmaktadır.

Anahtar Kelimeler – Radyoaktif atık. Sağlık Radyolojisi, Güvenli taşıma, Depolama yöntemleri

I. GİRİŞ

Nükleer enerji teknolojileri, tıp alanında çeşitli uygulamalar için önemli bir rol oynamaktadır. Bu teknolojiler, tanı ve tedavi süreçlerinde kullanılan çeşitli nükleer tıp prosedürlerini mümkün kılar. Nükleer tıp, izotopların radyoaktif bozulması ve radyoaktif işaretlemeler gibi nükleer fenomenlerin kullanılmasıyla hastalıkların tanı ve tedavisinde değerli bilgiler sağlar. Bu alanda kullanılan teknikler arasında radyofarmasötiklerin kullanımı, radyoterapi ve görüntüleme yöntemleri bulunmaktadır.

Radyofarmasötikler, nükleer tıpta sıkça kullanılan önemli bir araçtır. Radyoaktif izotoplar, farmasötik bileşiklerle birleştirilerek hastaya enjekte edilir ve böylece vücutta hedeflenen bölgelerde izlenerek veya tedavi edilerek hastalıkların teşhis ve tedavisi gerçekleştirilir. Örneğin, radyofarmasötikler kullanılarak kanserli hücrelerin tespiti ve tümörlerin yerini belirleme amacıyla pozitron emisyon tomografisi (PET) yapılmaktadır. Bu yöntem, kanserin erken teşhisi ve tedaviye yanıtın değerlendirilmesi gibi önemli klinik bilgiler sağlar [1]

Radyoterapi, nükleer enerji teknolojilerinin bir diğer önemli uygulama alanıdır. Yüksek enerjili iyonlar veya röntgen ışınları gibi radyasyon kaynakları kullanılarak kanser hücreleri hedeflenerek yok edilir. Radyoterapi, kanser tedavisinde kullanılan etkili bir yöntemdir ve cerrahi müdahale gerektirmeden tümörlerin kontrol altına alınmasına yardımcı olur. Örneğin, lineer hızlandırıcılar (LINAC), kanser tedavisinde yaygın olarak kullanılan ve yüksek enerjili parçacıkların tümöre odaklanmasını sağlayan bir teknolojidir. Bu şekilde, tümör hücreleri öldürülürken normal hücrelere minimum zarar verme hedeflenir [2]. Nükleer enerji teknolojilerinin bir diğer önemli uygulama alanı, görüntüleme yöntemleridir. Manyetik

rezonans görüntüleme (MRG) ve bilgisayarlı tomografi (BT) gibi görüntüleme teknikleri, tıbbi teşhis ve hastalık izleme süreçlerinde önemli bir rol oynar [3].

Özellikle, pozitron emisyon tomografisi (PET) ve tek foton emisyon bilgisayarlı tomografi (SPECT) gibi nükleer tıp görüntüleme teknikleri, hastalıkların erken teşhisini sağlayarak tedavi sürecini iyileştirebilir. Bu teknikler, hastalıklı dokuların, organların veya fonksiyonel aktivitelerin görüntülenmesi için kullanılır ve doktorlara değerli bilgiler sağlar [4].

Sonuç olarak, nükleer enerji teknolojileri, tıp alanında önemli bir role sahiptir. Radyofarmasötiklerin kullanımıyla hastalıkların tanısı ve tedavisi kolaylaşırken, radyoterapi kanser tedavisinde etkili bir yöntem olarak kullanılır. Ayrıca, görüntüleme teknikleri sayesinde hastalıkların erken teşhisi ve izlenmesi mümkün olur. Bu nedenle, nükleer enerji teknolojileri tıp alanında önemli bir araçtır ve gelecekte daha da gelişeceği ve kullanımının artacağı öngörülmektedir.

II. HASTANE ATIKLARININ TANIMLANMASI VE AZALTILMASI

Modern sağlık hizmetleri hastanelerde ciddi miktarda atık üretmektedir. Bu atıklar hem çevre hem de insan sağlığı için potansiyel riskler taşır. Hastanelerde atık kaynaklarının tanımlanması ve azaltılması, sürdürülebilirlik ve çevresel koruma açısından önemlidir. Atık kaynaklarının tanımlanması, hastane faaliyetleri sırasında üretilen tıbbi atıklar, kesici ve delici atıklar, tehlikeli kimyasallar ve radyoaktif atıklar gibi farklı atık türlerinin belirlenmesini içerir. Her bir atık türü, ayrı bir işleme ve bertaraf süreci gerektirir.

Atık kaynaklarının azaltılması, doğal kaynakların korunmasına katkı sağlar ve atık yönetimi için harcanan kaynakların azaltılmasına yardımcı olur. Örneğin, yeniden kullanılabilir malzemeler tercih edilebilir ve enerji ile su tasarrufu sağlayan teknolojiler benimsenebilir. Araştırmalar, atık kaynaklarının tanımlanması ve azaltılması için farklı stratejilerin etkili olduğunu göstermektedir. Geri dönüşüm programlarının uygulanması, atıkların kaynağında ayrıştırılması ve geri dönüştürülebilir malzemelerin toplanması önemlidir. Ayrıca, personel eğitimi ve farkındalığı, atık yönetimi süreçlerinde önemli bir rol oynar. Eğitim programları, atık oluşumunu en aza indirme, atık ayrıştırma ve geri dönüşüm becerilerini içermelidir.

Sonuç olarak, hastanelerde atık kaynaklarının tanımlanması ve azaltılması, çevresel sürdürülebilirliği sağlamak ve insan sağlığını korumak için önemli bir adımdır. Geri dönüşüm programlarının uygulanması, yeniden kullanılabilir malzemelerin tercih edilmesi ve personel eğitiminin sağlanması gibi stratejiler, atık yönetiminde başarılı sonuçlar elde etmek için kullanılabilir

III. NÜKLEER ATIKLAR VE TANIMLANMASI

Nükleer enerji, enerji ihtiyacını karşılamada önemli bir rol oynamaktadır, ancak nükleer atıkların güvenli depolanması ve taşınması büyük önem taşır. Nükleer atıklar çevre ve insan sağlığı için ciddi riskler oluşturabilir. Nükleer atıkların depolanması, yayılma riskini en aza indirmek için özenle tasarlanmış yapılar gerektirir. Bu yapılar genellikle yer altında bulunur ve sızdırmaz kaplamalar, koruyucu kalkanlar ve izolasyon sistemleri içerir. Nükleer atık taşıma sürecinde ise sızıntı ve çarpma riskleri minimize

edilmelidir. Taşıma kapları darbe emici ve radyasyon emici özelliklere sahip olmalı ve sıkı güvenlik protokollerine uygun olarak kullanılmalıdır. Hastanelerde nükleer atık yönetimi, özellikle radyoterapi ve nükleer tıp uygulamalarında, sağlık çalışanları ve hastalar için kritik öneme sahiptir. Atıklar, sızdırmaz ve etiketli konteynerlerde toplanmalı, özel koruyucu giysilerle taşınmalı ve güvenlik sistemleriyle donatılmış depolama alanlarında saklanmalıdır. Risk değerlendirmesi, atıkların radyasyon seviyeleri, yarı ömürleri ve bileşimleri gibi faktörleri dikkate alarak yapılmalı ve uygun önlemler alınmalıdır. Ulusal ve uluslararası kuruluşlar, nükleer atık yönetimi ve güvenliği konusunda rehberlik sağlamaktadır.

Öbür taraftan, hastanelerdeki nükleer atıklarla ilgili yapılan çalışmalar önemli şu hususların üzerinde durmaktadır. Hastaneler, nükleer tıp ve radyoterapi gibi alanlarda nükleer atık üretir. Bu atıklar doğaya ve insan sağlığına zararlı olabileceği için güvenli bir şekilde bertaraf edilmeleri önemlidir. Nükleer atıklar özel depolama tesislerine taşınarak uzun vadeli depolanabilir veya geri kazanım yöntemiyle içlerindeki değerli radyoaktif materyaller ayrıştırılarak yeniden kullanılabilir. Yeni termal işlem teknikleri ve nanoteknoloji gibi teknolojiler, nükleer atıkların bertarafında umut vaat etmektedir. Uluslararası Atom Enerjisi Ajansı gibi kuruluşlar, bu süreçleri düzenler ve teşvik eder. Sonuç olarak, nükleer atıkların güvenli yönetimi ve bertarafı, çevre ve insan sağlığının korunması için kritik öneme sahiptir.

IV. HASTANELERDEKİ RADYOLOJİK VE NÜKLEER ATIKLARIN BERTARAF YÖNTEMLERİ

Hastahaneler, yoğun tıbbi tedavi ve teşhis faaliyetleri yürüten kuruluşlar olup, radyoaktif materyallerin kullanıldığı önemli tıbbi prosedürlerin gerçekleştirildiği yerlerdir. Bu prosedürler sonucunda ise nükleer atıklar ortaya çıkmaktadır. Nükleer atıkların etkin bir şekilde bertaraf edilmesi, çevresel etkilerin minimize edilmesi ve insan sağlığının korunması açısından büyük bir öneme sahiptir. Hastahanelerdeki nükleer atıkların bertarafı için çeşitli yöntemler ve teknikler bulunmaktadır. Bunlardan biri olan yüzey temizleme, radyoaktif materyallerin kullanıldığı alanlardaki kontaminasyonun giderilmesini amaçlamaktadır. Örneğin, kullanılmış radyoaktif iğnelerin veya tıbbi araçların üzerinde biriken atıkların özel temizleme prosedürleri ile temizlenmesi bu yönteme örnek olarak verilebilir. Bir diğer yöntem, nükleer atıkların uygun şekilde ambalajlanması ve depolanmasıdır. Bu yöntemde, radyoaktif atıklar özel kaplarda toplanır ve daha sonra güvenli bir şekilde saklanması için özel depolama tesislerine gönderilir. Bu depolama tesisleri, radyasyonu emme ve yayma kabiliyetine sahip özel malzemelerle donatılmıştır. Örnek olarak, radyoaktif ilaç kalıntılarının kurşun kaplı konteynerlere yerleştirilerek depolanması gösterilebilir.

Hastahanelerdeki nükleer atıkların bertarafı için bir başka yöntem ise radyoaktif atıkların yakılması veya parçalanmasıdır. Bu teknik, nükleer atıkların içerdikleri radyoaktif elementlerin zararsız hale getirilmesini hedefler. Örneğin, bazı radyoaktif ilaç kalıntılarının termal veya kimyasal işlemlerle ayrıştırılarak zararsız hale getirilmesi bu yönteme örnek olarak verilebilir. Nükleer atıkların bertarafı konusunda uluslararası düzeyde çeşitli kuruluşlar tarafından belirlenen standartlar ve yönergeler bulunmaktadır. Örneğin, Uluslararası Atom Enerjisi Ajansı (IAEA), nükleer atıkların güvenli bertarafı için çeşitli yönergeler ve protokoller yayınlamaktadır (Tablo 1). Hastahaneler, bu standartlara uygun şekilde nükleer atıkların bertarafını gerçekleştirmekle yükümlüdür.

Tablo 1. Ülkelerin Ulusal YSA Yönetim Politikaları [5].

Ülke	İzlenen Politika	Nihai Depolara Yönelik Tesisler ve İlerleme
Belçika	Yeniden işleme	- Dessel'de merkezi atık depolama yer almaktadır. - 1984 yılında Mol'de yeraltı laboratuvarı kurulmuştur. - Depo inşaatı yaklaşık 2035 yılında başlayacaktır.
Kanada	Doğrudan bertaraf	- 2002 yılında Nükleer Atık Yönetimi Kuruluşu kurulmuştur. - Atıkların geri alınabileceği derin jeolojik depolama politikası kabul edilmiştir. - 2009'da depolama sahasına yönelik çalışmalar başlamış, deponun 2025 yılında kullanımda olması beklenmektedir.
Çin	Yeniden işleme	- Lan Zhou'da kullanılmış yakıtlar için merkezi bir depo bulunmaktadır. - Depolama sahası 2020'ye kadar belirlenecektir. - 2020 itibarıyla yeraltı araştırma laboratuvarının çalışmaya, 2050 itibarıyla da bertarafın başlaması planlanmaktadır.
Finlandiya	Doğrudan bertaraf	- Program 1983'te başlatılmış olup, iki adet kullanılmış yakıt deposu mevcuttur. - Onkalo yeraltı araştırma laboratuvarı inşaat halindedir. - Olkiluoto yakınlarındaki depolama tesisinin 2023'te açılması planlanmaktadır.

Hastahanelerde nükleer atıkların bertaraf süreci, atığın kaydedilmesi ve izlenmesiyle başlar. Nükleer tıp birimlerinde kullanılan radyoaktif maddelerin türü, miktarı ve kullanım tarihi kaydedilir. Bu bilgiler, atıkların doğru bir şekilde bertaraf edilmesi ve izlenmesi için önemlidir. Ayrıca, atıkların güvenli bir şekilde taşınması ve depolanması için etiketleme ve izleme sistemleri kullanılır.

Smith'in [6] yaptığı bir çalışma, nükleer atıkların kaydedilmesi ve izlenmesinin, atıkların takibini sağlayarak güvenlik risklerini azalttığını göstermektedir. Tezde, atıkların doğru bir şekilde etiketlenmesi ve izlenmesiyle, atık miktarının azaltılması, kayıp veya hırsızlık gibi güvenlik sorunlarının önüne geçildiği belirtilmektedir. Nükleer atıkların bertaraf sürecindeki bir diğer önemli adım, atıkların geçici depolanmasıdır. Radyoaktif atıklar, özel olarak tasarlanmış kaplarda muhafaza edilir ve belirli bir süre boyunca geçici depolama alanlarında tutulur. Bu alanlar, atıkların güvenli bir şekilde saklanmasını sağlayan çeşitli güvenlik önlemleri içermektedir.

Johnson'ın [7], makalesine göre, geçici depolama alanlarında nükleer atıkların düzenli olarak kontrol edilmesi ve denetlenmesi gerekmektedir. Bu sayede, atıkların sızıntı veya dış etkenlere maruz kalma gibi risklere karşı korunduğu ve güvenlik standartlarına uygun şekilde saklandığı vurgulanmaktadır. Nükleer atıkların nihai bertarafı, güvenlik açısından en kritik adımdır. Bu süreçte, atıkların güvenli bir şekilde bertaraf edildiği ve çevreye zarar vermediği sağlanmalıdır. Farklı yöntemler kullanılarak atıkların geri dönüştürülmesi veya uzun vadeli depolanması mümkündür.

Garcia'nın [8] araştırması, nükleer atıkların nihai bertarafının güvenlik açısından önemli olduğunu vurgulamaktadır. Araştırmada, atıkların doğru bir şekilde işlenmesi ve depolanmasıyla, çevresel etkilerin minimize edildiği ve insan sağlığına olan risklerin azaltıldığı ifade edilmektedir. Hastahanelerde nükleer atıkların bertaraf süreci, çeşitli güvenlik önlemlerini içermektedir. Bu önlemler, atıkların kaydedilmesi ve izlenmesi, geçici depolama ve nihai bertaraf süreçlerinde uygulanmaktadır. Doğru kayıt tutma, izleme ve etiketleme sistemleri, atıkların takibini sağlayarak güvenlik risklerini azaltmaktadır. Geçici depolama alanlarında düzenli kontroller ve denetlemeler, atıkların güvenli bir şekilde saklanmasını sağlamaktadır. Nihai bertaraf sürecinde ise, atıkların çevreye zarar vermeden doğru bir şekilde bertaraf edildiği önemlidir.

V. SONUÇLAR

Nükleer tıp ve radyoterapi gibi tıbbi uygulamalar, hastahanelerde nükleer atık üretiminin artmasına yol açmaktadır. Bu atıkların doğru bir şekilde bertaraf edilmemesi ciddi çevresel ve sağlık riskler doğurabilir. Bu araştırma metni, hastahanelerde nükleer atıkların bertarafının sonuçlarını ve önerilerini incelemekte ve sağlık kuruluşlarının bu konuda alması gereken önlemleri vurgulamaktadır. Nükleer atıkların uygun olmayan bertarafı, çevresel etkilere ve insan sağlığına zararlı sonuçlara yol açabilir. Bu atıkların rastgele atılması veya düşük standartlara göre bertaraf edilmesi, toprak, su ve hava kirliliğine sebep olabilir. Radyoaktif maddelerin çevreye yayılması, biyolojik çeşitlilik üzerinde olumsuz etkilere neden olabilir ve uzun vadede kanser gibi hastalıkların artmasına yol açabilir.

Hastahanelerde nükleer atıkların uygun şekilde bertaraf edilmesi hem çevresel hem de insan sağlığı açısından önemlidir. Bu atıkların toplanması, depolanması ve imha edilmesi için özel prosedürler ve ekipmanlar gerekmektedir. Radyoaktif atıkların kontrollü bir şekilde bertaraf edilmesi, çevresel riskleri minimize edebilir ve personel ile halkın sağlığını koruyabilir.

Hastahanelerde nükleer atıkların bertarafı için bazı öneriler şunlardır:

1. Eğitim: Tüm sağlık personeli, nükleer atıkların doğru şekilde yönetimi konusunda eğitilmelidir. Bu eğitim, atıkların toplanması, depolanması ve bertarafı hakkında bilgi sağlamalıdır. Ayrıca, acil durumlar için gerekli önlemler hakkında da bilgilendirme yapılmalıdır.

2. İzleme: Hastahaneler, nükleer atıkların miktarını ve türünü izlemelidir. Bu izleme, atıkların doğru bir şekilde toplandığından ve depolandığından emin olmak için önemlidir. Radyoaktif atıkların düzenli olarak analiz edilmesi ve izlenmesi, herhangi bir kaçak veya kaza durumunda hızlı müdahale sağlayabilir.

3. İş birliği: Hastahaneler, nükleer atıkların bertarafı konusunda ilgili kurumlar ve yerel yönetimlerle iş birliği yapmalıdır. Bu, uygun bertaraf tesislerinin kullanılmasını ve atıkların taşınmasını sağlayabilir. Ayrıca, nükleer atıkların taşınması ve bertarafının yasal düzenlemelere uygun olduğundan emin olmak için yetkililerle iş birliği yapılmalıdır.

Hastahanelerde nükleer atıkların doğru bir şekilde bertaraf edilmesi, çevresel ve insan sağlığına yönelik riskleri azaltabilir. Uygun eğitim, izleme ve iş birliği önlemleri alarak, sağlık kuruluşları bu sorunun etkin bir şekilde yönetilmesine katkıda bulunabilir. Bu metin, hastahanelerde nükleer atıkların bertarafı konusunda farkındalığı artırmayı ve önlemlerin uygulanmasını teşvik etmeyi amaçlamaktadır.

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Neuromorphic Computing For Handwriting Pattern Recognition

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Abstract – These systems mimic the actions of neurons and synapses by using digital or analogue circuits that are optimised for parallel processing. Neuromorphic computing has the ability to outperform conventional computing architectures in some areas, especially pattern recognition, image processing, and artificial intelligence. This is because it makes use of the distributed processing and parallelism principles found in biological brains.

The goal of this third generation of AI computing is to mimic the intricate neuronal network seen in the human brain. AI is needed to compute and analyse unstructured data at a rate that can compete with the biological brain's exceptional energy efficiency. Spiking neural networks (SNN) are the artificial intelligence counterpart of our neural network of synapses. Artificial neurons are layered structures containing individual spiking neurons that may fire and interact with one another to initiate a cascade of changes in response to external inputs.

Keywords – Neurons, Circuits, Synapses, Spiking Neural Network, Image Processing, Pattern Recognition.

I. INTRODUCTION

One area of computer science called "neuromorphic computing" takes its cues from the architecture and operation of the neural networks found in the human brain. Its goal is to imitate biological neural networks' behaviour to build extremely effective and versatile computer systems. While neuromorphic computing aims to mimic the brain's parallel processing and learning capacities, traditional computing depends on digital processors that carry out computations sequentially. [2].

Hardware for neuromorphic computing systems is often made to mimic synapses and neurons, the fundamental components of neural networks found in the brain. These systems mimic the actions of neurons and synapses by using digital or analogue circuits that are optimised for parallel processing. Neuromorphic computing has the ability to outperform conventional computing architectures in some areas, especially pattern recognition, image processing, and artificial intelligence. This is because it makes use of the distributed processing and parallelism principles found in biological brains. [13].

IBM's TrueNorth chip, which has a large-scale neural network design with low-power, high-density synapse-like connections, is a well-known example of neuromorphic computing. Another illustration is the Loihi chip from Intel, which is designed to resemble the spiking neural networks seen in living brains. Numerous applications where real-time, energy-efficient computation is essential, such as improved robotics, autonomous vehicles, and sensory processing, are being investigated for these neuromorphic computing systems. [3].

The following are some salient features of neuromorphic computing:

• **Brain-inspired:** It seeks to imitate the brain's low-power functioning and pattern recognition capabilities.
• **Synapses and artificial neurons:** these components serve as the foundation for neuromorphic systems, mimicking the actions of their biological counterparts.

• **Possible advantages:** Applications needing real-time learning and adaptation, autonomous systems, and image and speech recognition are among the areas where neuromorphic computing shows promise.
• **Early stage:** Although there is a lot of research being done, neuromorphic computing is still a young subject with few practical uses.
All things considered, neuromorphic computing is a fresh take on computing that might transform a number of industries by providing an alternative information processing paradigm. [7].

This is a schematic representation of a simple neuromorphic system:

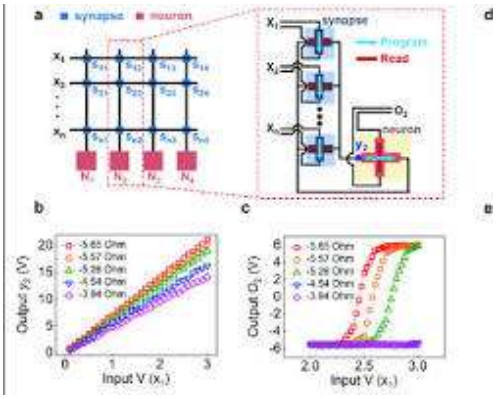

Fig 1A. A description of the diagram

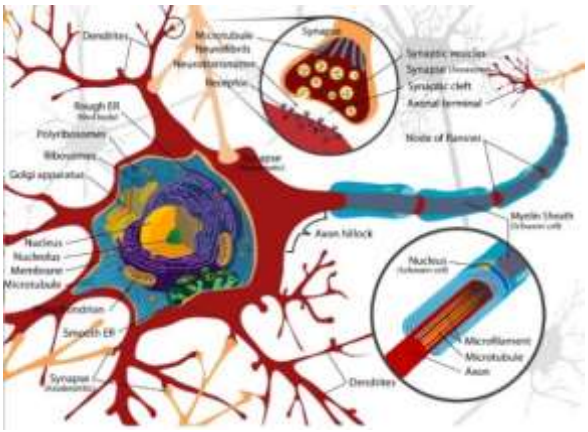

Fig 1B. A description of the diagram

• **Input layer**: Gathers information from the outside world in a manner akin to that of the brain's sensory organs.
• **Artificial neurons**: These are the brain-like structures that perform similarly to real neurons. They process information from other neurons, send out their output signal, and receive input from them.
• **Synapses**: Just as synapses in the brain regulate neuronal communication, these connections between neurons influence the intensity of the signal transmission. The system can learn and adapt by varying the strength of these links.
• **Output layer**: Generates the final product in a manner similar to how the brain produces other outputs, such motor commands.
It is crucial to remember that this is a simplified illustration and that real neuromorphic systems can have several layers of neurons and sophisticated connectivity patterns.

II. Spiking Neural Networks

Artificial neural networks (ANNs) using backpropagation and continuous values have historically been the foundation of deep learning. Even though they work well, ANNs have drawbacks, especially when it comes to energy usage and biological plausibility. Spiking neural networks (SNNs) provide a possible substitute that is modelled after how the brain functions in this situation.

SNNs communicate via discrete electrical pulses, or "spikes," as opposed to continuous values, imitating the spiking behaviour of organic neurons. [16]

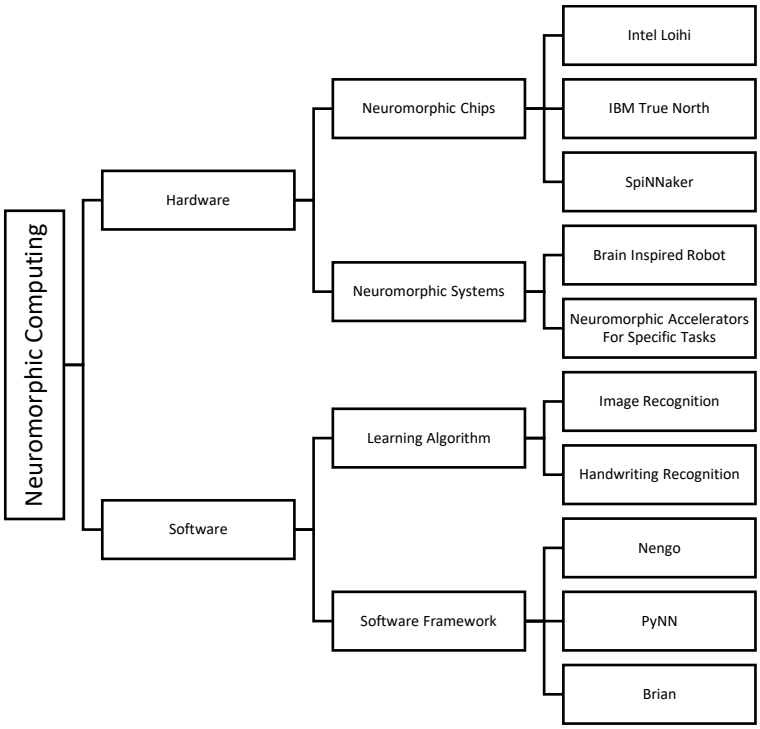

Fig 2. Anatomical Schematic for Neuromorphic Computing

III. PROGRAMMING LANGUAGES USED IN NEUROMORPHIC COMPUTING

Both software and hardware are involved in neuromorphic computing, and the platform and application-specific programming languages employed might change. Neuromorphic computing frequently uses the following programming languages: [10] [18]

1. **Python**: Because of its readability, ease of use, and abundance of libraries for scientific computing and machine learning, Python is a popular choice for creating software interfaces and applications in neuromorphic computing. Neural network models and simulations are frequently developed using Python frameworks like TensorFlow, PyTorch, and Keras.

2**. C/C++:** Programming the hardware of neuromorphic computing systems often involves low-level languages like C and C++. This includes designing and optimising analogue and digital circuits as well as putting device drivers and real-time control algorithms into practice.

3. **Hardware Description Languages, or HDLs**: Hardware Overview Field-programmable gate arrays (FPGAs) and application-specific integrated circuits (ASICs) are examples of neuromorphic computing hardware that can be designed and their behaviour described using languages like Verilog and VHDL.

4. **Languages Specific to Neuromorphisms**: To programme neuromorphic computer systems, several specialised programming languages have been created. Examples are PyNN (Python Neural Network), which is used to create and simulate spiking neural networks, and NESTML (NEural Simulation Tool Markup Language), which is used to describe neural network models in the NEST simulator.

5. **MATLAB**: Especially in disciplines like neuroscience and computational biology, MATLAB is extensively utilised in academic and research contexts for neuromorphic computing model and algorithm creation and simulation.

6. **Programming Frameworks and APIs Exclusive to Neuromorphic Computing**: A number of neuromorphic computing systems offer their own frameworks and APIs for creating applications. For instance, the Python-based BrainScaleS programming interface facilitates the creation and operation of spiking neural networks on its hardware.

The popular neural simulation tool, the Brian2 library, is used to create a spiking neural network (SNN) model for handwriting pattern recognition in the following simple Python code sample. In this example, integrate-and-fire neurons are used to create a simple SNN for pattern recognition. It should be noted that

while this code offers a foundation for creating SNN models, it does not directly target a neuromorphic computing platform such as Intel Loihi.
PSEUDO CODE

```
[56:27] Unexpected character: :
print("Output Spike Times:")
                          ^ here
[58:35] Unexpected character: :
    print(f"Neuron {neuron_index}: {spike_times}")
                                  ^ here
[62:26] Unexpected character: :
print(f"Recognized Digit: {recognized_digit}")
                         ^ here
[56:9] Expected ')' after arguments.
print("Output Spike Times:")
```

CODE EXPLANATION:

1. **Import libraries**: Brian is one of them for modelling neurons that fire.
2. **Definition of neuron model**: Leaky Integrate-and-Fire (LIF) model with particular parameters (voltage, time constant) is used in this example.
3. **Identify input neurons**: These stand in for the pattern's pixels.
4. **Describe synapses and connections**: This describes the type of connections between neurons as well as their strength.
5. **Identify learning rule**: Here, synaptic weights are modified by STDP in accordance with spike timing.
6. **Define input data**: Enter your real pattern data in lieu of the placeholder.
7. Start a simulation and give the network a certain amount of time to run.
8. **Examine output spikes**: Classify output neurons by examining their firing patterns.
9. **Training loop**: Use a training loop to modify weights in accordance with the intended results and learning principles.

Fig 3. Result Output

IV. WHAT IS THE PROCESS OF NEUROMORPHIC COMPUTING?

A technique in computer engineering known as "neuromorphic computing" models computer components after neural and brain systems in humans. The design of computer pieces, including software and hardware, is referred to by this word.
The goal of this third generation of AI computing is to mimic the intricate neuronal network seen in the human brain. AI is needed to compute and analyse unstructured data at a rate that can compete with the biological brain's exceptional energy efficiency. The human brain's exceptional energy efficiency is

demonstrated by the fact that it can function better than supercomputers with less than 20 watts of electricity. Spiking neural networks (SNN) are the artificial intelligence counterpart of our neural network of synapses. Artificial neurons are layered structures containing individual spiking neurons that may fire and interact with one another to initiate a cascade of changes in response to external inputs. [9] [11]

V. BASIC ALGORITHM AND PROCESSES OF NEUROMORPHIC COMPUTING

1. **Data preprocessing**:
- Get the MNIST dataset, which is made up of handwritten numbers 0 through 9.
- Divide the dataset into training and testing sets after normalising the pixel values.
- **Architecture Model**:
- Create the spiking neural network's architecture.
- Describe the output, hidden, and input layers.
- Figure out how many synapses and neurons there are in each layer.
- Decide between synaptic plasticity rules and the spiking neuron model (integrate-and-fire, for example).

3. **Training of the Model**:
- Apply the training algorithm on the Loihi chip (e.g., Spike-Timing-Dependent Plasticity, STDP).
- Give the SNN the training data, which consists of handwritten digits, and modify synaptic weights in response to spike timing.
- To optimise the network parameters, go through the training dataset several times.

4. **Model Evaluation**:
- Use a different testing dataset to evaluate the trained SNN model.
- Show the SNN handwritten digits, then watch the output neurons' spiking activity.
- Using the output spikes, ascertain the digit identification accuracy and compare it with conventional machine learning techniques.

5. **Performance Optimisation**:
- Enhance the SNN model's performance by modifying its many components, including its synapses, number of neurons, and network architecture.
- Adjust the synaptic weights to increase the precision of categorization.

6. **Intel Loihi Deployment**:
- Place the optimised SNN model on the neuromorphic Intel Loihi processor.
- Use the programming interface or software development kit (SDK) that is supplied to interface with the Loihi chip.
- Use the deployed model on the Loihi chip to do inference tasks for handwritten digit recognition in real time.

7. **Analysis and Reporting**:
- Examine the accuracy, energy economy, and computational speed of the SNN model running on an Intel Loihi.
- Examine the outcomes in comparison to machine learning techniques and conventional computer platforms.

Note: This is a simplified overview; extra stages, such as parameter tweaking, optimisation strategies, and hardware-specific considerations for deploying the model on Intel Loihi, may be necessary for the real implementation.

VI. WHY DO WE NEED NEUROMORPHIC COMPUTING?

Despite being based on how the brain functions, neuromorphic designs have the potential to learn a great deal about the brain by enabling us to see synaptic behaviour in action. Significant advancements in neurology and medicine may result from this. Even if the development of the neuromorphic processors that drive supercomputers is still progressing at an incredible rate, neuromorphic technology has not yet reached its full potential.

Even though SpiNNaker is a large-scale effort, it can only model a limited amount of the brain. Nevertheless, even with its current limitations, it has managed to replicate the Basal Ganglia, an area of the

brain that is known to be impacted by Parkinson's disease. With the use of machine learning, more research on the simulated activity may lead to scientific discoveries that clarify the causes and mechanisms of Parkinson's disease. [15]

VII. NEUROMORPHIC COMPUTING BENEFITS

When compared to conventional methods, neuromorphic computing offers several advantages, including energy economy, fast execution, resilience to local errors, and learning capabilities. [17]

1. **Enhanced Efficiency**:
   • Reduced Power Usage: Neuromorphic systems use power only during information processing, as opposed to conventional silicon-based computers that require an uninterrupted power supply. This can be especially helpful for applications where battery life is critical and resources are limited, such as edge computing devices.
   • Quicker Processing for Particular Tasks: Because of its innate architecture, which draws inspiration from the brain's capacity for parallel processing, neuromorphic systems perform very well in parallel processing tasks like pattern recognition and signal processing. For some particular jobs, this may result in processing speeds that are faster than those of regular computers.
2. **Better Learning and Adaptation**:
   • Real-time Learning: Neuromorphic systems, especially those that use Spiking Neural Networks (SNNs), have the ability to learn and adjust depending on incoming input in real-time. This is because, like the brain, they are able to dynamically alter synaptic connections.
   • Fault Tolerance: Neuromorphic systems may be able to continue operating even in the event of a partial hardware failure, drawing inspiration from the brain's natural fault tolerance. This is because, in contrast to traditional systems, information processing is spread over several linked neurons, making them less vulnerable to single point failures.
3. **Possibility of New Uses**:
   • Brain-inspired Robotics: By emulating how the human brain regulates movement and interacts with its surroundings, neuromorphic computing has the potential to create robots that are more capable of making decisions and adapting to their surroundings.
   • Advanced Pattern Recognition: The parallel processing and learning powers of neuromorphic systems may be able to increase the accuracy and efficiency of tasks like voice and picture recognition as well as anomaly detection.

VIII. NEUROMORPHIC COMPUTING LIMITATIONS

Neuromorphic computing has significant benefits, but a number of drawbacks prevent it from reaching its full potential and becoming widely used. [12]

1. **Hardware Challenges**:

• Limited Processing Power: Compared to high-performance CPUs and GPUs, contemporary neuromorphic systems often have lower overall processing power, despite being efficient for certain workloads. This restricts their capacity to be used for activities that require a lot of computation beyond their areas of expertise.
• Scalability and Integration: It is still difficult to scale neuromorphic systems to the complexity of large-scale neural networks used in deep learning techniques. Furthermore, work is still being done on effectively integrating them with conventional computer systems for hybrid solutions.
• Improvements in Power Efficiency: Although neuromorphic systems consume less power than conventional processors when performing active tasks, under some circumstances they may still need a large amount of standby power, which limits their maximum efficiency potential.

2. **Algorithm and Software Difficulties**:

• Limited Software Development Tools: The software development tools and libraries available for neuromorphic platforms are still in the early stages of development, in contrast to the extensive ecosystem of tools and libraries available for conventional computing. This may impede accessibility and development pace.

• Complexity of Algorithm Development: It is difficult for SNNs to be widely adopted and used since it takes specialised knowledge and experience to design and optimise algorithms for effective training and to take use of their distinctive characteristics.
• Limited Standardisation: The design and execution of neuromorphic systems are currently not standardised, which makes it challenging to compare various platforms and prevents the creation of industry-wide common tools and procedures.

3. **Additional Restrictions**:

• Expense: The development and production of neuromorphic hardware is now more costly than that of conventional computer hardware, which may restrict its early acceptance and accessibility.
• Maturity and Research Stage: Neuromorphic computing is still a developing subject with much research and development being done in it. This indicates that although progress is ongoing, it could take some time for the technology to realise its full potential and become widely applied.

It's critical to keep in mind that developers and academics are actively working to overcome these constraints. Hardware, software, and algorithm developments should help solve these issues and realise the full potential of neuromorphic computing as the field develops.

IX. THE POSSIBLE RISKS OF NEUROMORPHIC COMPUTING AND RECOMMENDATIONS

Because neuromorphic computing can emulate the flexibility and efficiency of the brain, it is very promising for many uses. Like any new technology, there are hazards and difficulties associated with it as well. The following are a few possible dangers of neuromorphic computing: [8]

1. **Ethical Concerns**: As neuromorphic computing develops, ethical questions about security, privacy, and possible abuse are brought up. Neuromorphic systems, for instance, may be employed in privacy-invading surveillance applications.
2. **Prejudice and Fairness**: Neuromorphic systems have the danger of prejudice and injustice, especially in situations where decisions are made. Unfair results may result from biases in training data or algorithms, particularly in vital fields like criminal justice or healthcare.
3. **Unforeseen effects**: Because neuromorphic systems are complex, unexpected behaviours or unforeseen effects are possible. This may be the consequence of interactions between various system components or emergent characteristics of neural networks.
4. **Security flaws**: Cyberattacks aimed at the software or hardware components might be one way that neuromorphic computing systems are vulnerable to security flaws. It will be essential to defend neuromorphic systems from malevolent actors in order to guarantee their dependability and security.
5. **Regulatory Challenge**s: As neuromorphic computing technologies grow, it can become more difficult to create the rules and guidelines needed to guarantee their responsible advancement and application. Regulatory frameworks will have to deal with matters like accountability, transparency, and safety.
6. **Requirements for Resources**: Neuromorphic computing systems may need a lot of resources to build and run, such as specialised hardware, software, and knowledge. For smaller research groups or organisations with less resources, this can provide access restrictions.
7. **Environmental Impact**: Although the energy efficiency of neuromorphic computing is frequently cited as an advantage, there may still be environmental effects from the manufacture and disposal of hardware components. Furthermore, if neuromorphic systems are not properly maintained, their energy consumption may become an issue as they grow more common.
8. **Labour Displacement**: By automating processes now done by people, neuromorphic computing has the potential to upend established labour markets, much like other kinds of automation and artificial intelligence. In particular industries, this can result in job displacement if suitable steps are not made to retrain employees.

To mitigate these risks and make sure that neuromorphic computing technologies are developed and applied responsibly, ethically, and in a way that benefits society as a whole, researchers, industry stakeholders, policymakers, and ethicists will need to work together.

X. CONCLUSION

Neuromorphic computing does, however, come with a number of difficulties and restrictions in addition to its intriguing potential. These include problems with scalability, restrictions on programming and software tools, challenges with energy efficiency, hardware limits, and the requirement for better learning and adaptation. Regulatory obstacles, security flaws, and ethical issues also need to be taken into account in order to guarantee the appropriate development and application of neuromorphic computing technology.

Notwithstanding these obstacles, continued study and development are propelling the area of neuromorphic computing forward. To overcome these obstacles and realise the full promise of neuromorphic computing in advancing artificial intelligence, deepening our understanding of the brain, and spurring innovation in a wide range of applications, cooperation between researchers, industry stakeholders, legislators, and ethicists is imperative.

In conclusion, the area of artificial intelligence and computing has a bright future ahead of it with neuromorphic computing. Neuromorphic computing is modelled after the architecture and physiology of the human brain with the goal of imitating the brain's flexibility, efficiency, and parallel processing power. Neuromorphic computing, which uses ideas from neurology to create hardware and software systems that mimic neural networks, has the potential to completely transform a number of industries, including pattern recognition, machine learning, robotics, and sensory processing.

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NÜKLEER GÜÇ SANTRALLERİNİN TEKNİK ÖZELLİKLERİ VE YAPISI: AKKUYU NGS ÖRNEĞİ

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Özet – Bu çalışma, Türkiye'nin ilk nükleer enerji santralı olan Akkuyu Nükleer Güç Santralı'nın teknik özelliklerini incelemektedir. Santral, Rus devlet şirketi ROSATOM tarafından geliştirilmekte olan bir projedir. İnşası, Türkiye ile Rusya arasında 2010 yılında imzalanan bir hükümetler arası anlaşma ile başlamıştır. Santral, dört üniteden oluşmaktadır ve toplamda 4.800 megavatlık bir kapasiteye sahiptir. Temel tasarımı çift devreli bir VVER (Su-Su-Enerji Reaktörü) olarak bilinmektedir.

Akkuyu NGS'de faaliyet gösteren reaktörler, VVER-1200 üçüncü nesil versiyonunu temel alarak basınçlı su reaktörü tipindedir. Her bir reaktörde 163 adet yakıt demeti bulunmakta olup, yakıt döngüsü süresi dört yıldır. Reaktör, çift kat koruma sistemi ile donatılmıştır ve dünyanın en güvenli reaktörlerinden biri olarak kabul edilmektedir.

Akkuyu NGS'nin ana ekipmanı arasında dört adet VVER1200 tipi su reaktörü, borik asit içeren soğutma ve moderatör suyu, dört adet buhar üreteci, dört ana dolaşım pompa seti ve bir türbin-jeneratör seti bulunmaktadır. Elektrik sistemleri, enerji üretimi, dağıtımı ve yardımcı güç kaynaklarını içermektedir. Santralin güvenlik sistemleri, iyonlaştırıcı radyasyon ve radyoaktif maddelerin çevreye salınımını engellemeye yönelik fiziksel bariyerlerden oluşmaktadır. Bu çalışma, Akkuyu Nükleer Güç Santralı'nın teknik özelliklerini detaylı bir şekilde açıklamakta ve nükleer enerji teknolojisine ilişkin kapsamlı bir bilgi sunmaktadır.

Anahtar Kelimeler – Nükleer, akkuyu, enerji, güvenlik, teknoloji

I. GİRİŞ

Enerji, modern toplumların temel ihtiyaçlarından biri olarak hayati önem taşımaktadır. Bu bağlamda, enerji arzının güvenli, sürdürülebilir ve çevre dostu bir şekilde sağlanması, küresel ölçekte stratejik bir öncelik haline gelmiştir. Günümüzde, enerji talebinin artmasıyla birlikte, çeşitli enerji kaynaklarına olan ihtiyaç da giderek artmaktadır [1]. Bu kapsamda, nükleer enerji, temiz ve karbon emisyonu olmayan bir enerji kaynağı olarak, enerji sektöründe önemli bir yer edinmektedir [2] - [4].

Nükleer enerji, atom çekirdeklerinin bölünmesi veya birleşmesi gibi nükleer reaksiyonlardan elde edilen termal enerjinin elektrik enerjisine dönüştürülmesi prensibine dayanır [5]. Bu teknoloji, yüksek verimlilik, düşük karbon emisyonu ve sürekli enerji üretimi gibi avantajlar sunmaktadır [6].

Türkiye'nin enerji talebinin artması ve enerji arz güvenliğinin sağlanması amacıyla, nükleer enerji teknolojilerine yönelik ilgi ve yatırımlar artmaktadır [6], [7]. Bu bağlamda, Türkiye'nin ilk nükleer güç santrali olan Akkuyu Nükleer Güç Santrali, ülkenin enerji portföyüne önemli bir katkı sağlamayı hedeflemektedir. Rusya'nın ROSATOM şirketi tarafından geliştirilen bu proje, Türk-Rus iş birliğinin bir ürünü olarak hayata geçirilmektedir. Akkuyu Nükleer Güç Santrali'nin teknik özellikleri ve işleyişi, Türkiye'nin enerji sektöründeki geleceği açısından büyük önem taşımaktadır [7], [8].

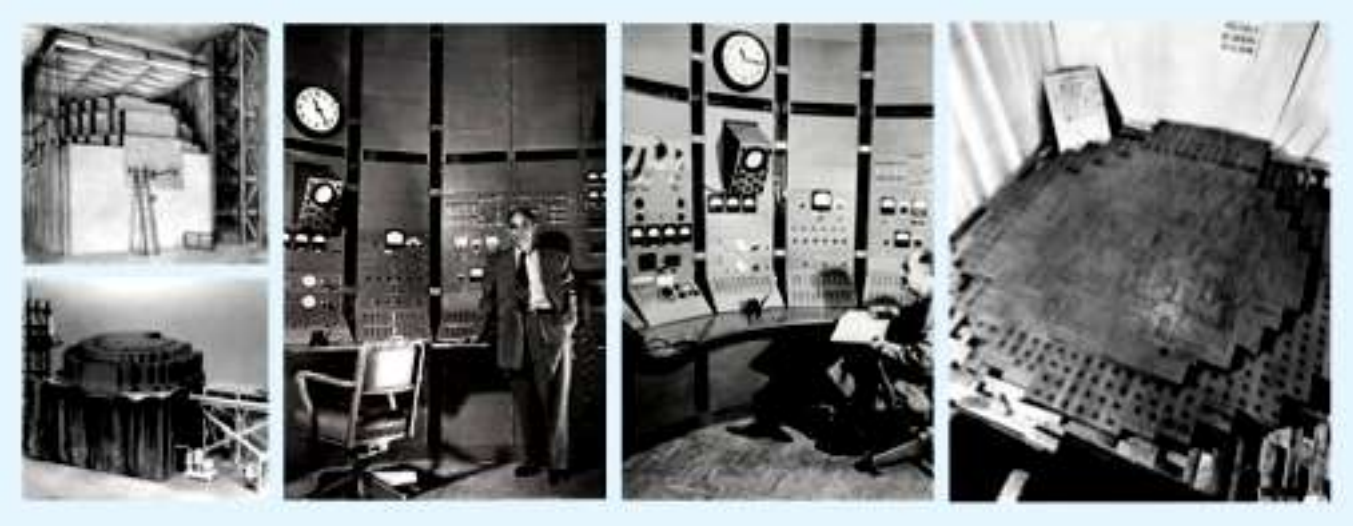
Bu çalışmada, nükleer enerji, nükleer güç santralleri, güç reaktörlerin tipleri, özellikleri ve nesilleri incelenerek, Akkuyu Nükleer Güç Santrali'nin teknik özellikleri detaylı bir şekilde ele alınacaktır.

II. NÜKLEER ENERJİ TEKNOLOJİSİ

Nükleer enerji, ağır atom çekirdeklerinin nötron yakalamaları sonucunda fisyon ve hafif atom çekirdeklerinin çok yüksek sıcaklıkta birleşmesiyle gerçekleşen füzyon tepkimeleriyle elde edilen büyük miktardaki enerjiyi ifade eder [9], [10].

1905 yılında Albert Einstein, fisyon sonucu ortaya çıkabilecek enerji potansiyeli hakkında bir öngörüde bulunmuştur [11] - [13]. Daha sonraki yıllarda, 1930'da bu öngörü Alman fizikçi Otto Hahn, Avusturya kökenli İsveçli fizikçi Lise Meitner ve diğer araştırmacılar tarafından deneysel olarak doğrulanmıştır. 1942'de Amerika Birleşik Devletleri'nin Chicago, Illinois kentinde insan yapımı ilk nükleer reaktör kurulmuştur. Bu proje, Enrico Fermi tarafından yönetilmiştir (Şekil 1) [13]. Ancak, dünyadaki ilk ortaya çıkan reaktör bu değildi. Afrika'da Gabon'daki Oklo'da, bir uranyum madeninde yeraltı sularının varlığı nedeniyle doğal bir nükleer reaktör oluştuğu ve binlerce yıl boyunca ısı ürettiği sonradan keşfedildi. Hem Amerika Birleşik Devletleri'nde Chicago, Illinois'de bulunan insan yapımı ilk nükleer reaktör hem de Afrika'daki Gabon'daki doğal nükleer reaktör, fisyonu kullanarak ısı üretti; ancak her ikisi de elektrik üretmedi [13].

Elektrik üreten ilk ticari nükleer güç santrali 1957'de işletmeye giren Shippingport, Pennsylvania'da (ABD) kuruldu. Fisyon kullanılarak üretilen ilk elektrik ise, Aralık 1951'de Arco, Idaho'daki deneysel üretken reaktörde elde edildi [13].



Şekil 1. Chicago Pile-1, 1942'de Enrico Fermi ve ekibi tarafından inşa edilen dünyanın ilk nükleer reaktörüdür [14] - [18].

Nükleer enerji, elektrik üretiminde nükleer reaksiyonların kullanılmasıyla sağlanan bir enerji kaynağıdır [19] - [21]. Bu enerji, nükleer fisyon, nükleer bozunma ve nükleer füzyon gibi reaksiyonlar yoluyla elde edilebilir. Günümüzde, nükleer enerjiden kaynaklanan elektriğin önemli bir kısmı, nükleer santrallerde uranyum ve plütonyumun nükleer fisyonu ile üretilmektedir [21].

Nükleer enerji, atom çekirdeğinden kaynaklanan bir enerji formudur ve Albert Einstein'ın ünlü $E = mc^2$ formülüyle açıklanan kütlenin enerjiye dönüşümü prensibiyle bağlantılıdır. Bu bağlamda, nükleer fisyon reaksiyonu ortaya çıkar. Bu reaksiyonda, genellikle uranyum izotoplarına maruz bırakılan atom çekirdekleri, nötron bombardımanı sonucunda kararsız hale gelirler. Bu kararsızlık, çekirdeklerin daha hafif atomlara bölünmesine yol açar, bu da enerji açığa çıkarır. Bu süreç, nükleer enerji üretiminin temelini oluşturur [22].

Atom çekirdeklerinin parçalanması, büyük miktarda enerji açığa çıkarmaktadır. Örneğin, uranyum gibi ağır atom çekirdeklerine nötronların çarpmasıyla bu çekirdeklerin parçalanması gerçekleştirilebilir; bu

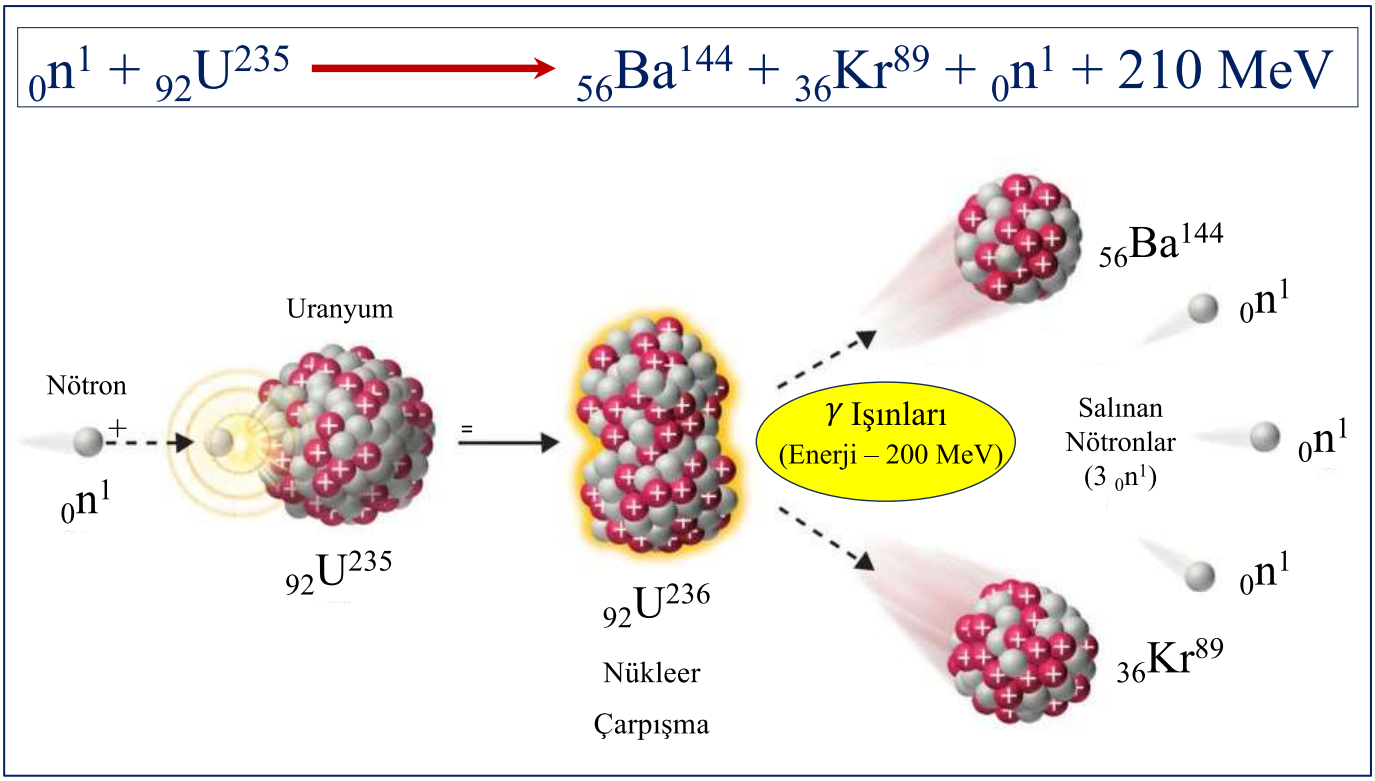
olaya "fisyon" adı verilir. Her bir parçalanma olayında, fisyon ürünleri, enerji ve birkaç nötron açığa çıkar [22].

Parçalanma reaksiyonunun sürekliliği uygun bir şekilde tasarlanmış bir sistemde sağlanabilir, çünkü bu reaksiyon sonucunda açığa çıkan nötronlar kullanılabilir (zincirleme reaksiyon). Bunun yanı sıra, hafif atom çekirdeklerinin birleşerek daha ağır atomları oluşturması da büyük bir enerji açığa çıkarmaktadır. Bu birleşme reaksiyonuna "füzyon" denir. Fisyon ve füzyon reaksiyonlarından elde edilen enerjiye "çekirdek enerjisi" veya "nükleer enerji" adı verilir [22].

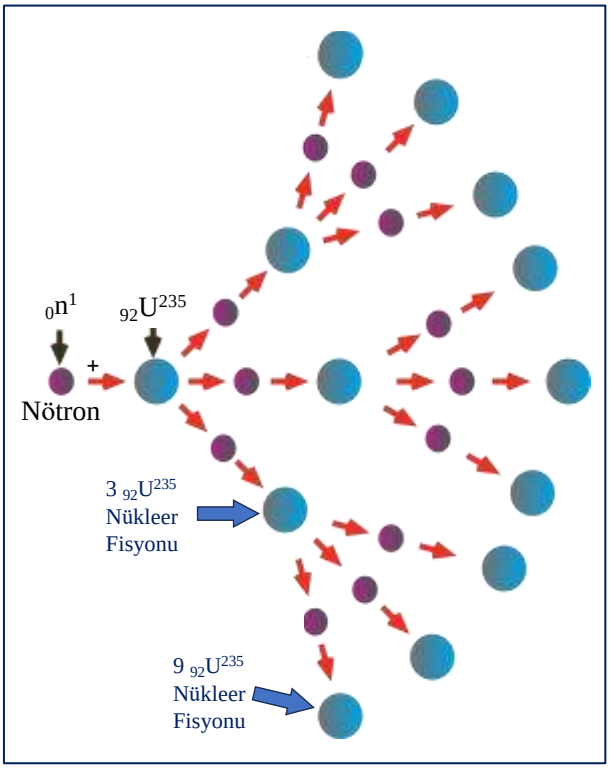
Fisyon, atom çekirdeğinin bölünmesi veya ağır çekirdeklerin ikiye ayrılması olayıdır ve bu süreçte büyük miktarda enerji, nötron ve gamma ışınları açığa çıkar. Ağır çekirdeklerin uyarılmasıyla gerçekleşen fisyon olayında oluşan çekirdekler fisyon ürünleri olarak adlandırılır ve genellikle nötronlar ve gamma ışınları aracılığıyla çekirdeklerin uyarılması gerçekleştirilir [23], [24]. Örneğin, $^{92}U_{235}$ çekirdeği düşük bir enerjiyle uyarıldığında $^{92}U_{236}$ birleşik çekirdeği oluşturur; bu süreçte çekirdek enerji alır ve uyarılmış hale gelir. Yeterli enerji elde edildiğinde ise çekirdek ikiye bölünür ve $^{56}Ba_{144}$ birinci fisyon ürünü, $^{36}Kr_{89}$ ise ikinci fisyon ürünü oluşur. Sonrasında her bir çekirdek, bölünmeden hemen sonra bir veya iki nötron yayınlar ve fazla enerji taşıyan çekirdekler gama ışınları yayarak enerji atarlar [25]. Nükleer santrallerde kullanılan tepkimeler, atom bombası teknolojisi fisyona örnektir [22]. Şekil 2'de, atom çekirdeğinin bölünme mekanizması ve reaksiyonu göstermektedir.

Fisyon reaksiyonlarının ilk çarpışmadan sonra ortaya çıkan fisyon ürünleri, etraflarındaki diğer atomlarla çarpışarak enerji transferine yol açarlar. Bu çarpışmalar sonucunda, atomlar arasındaki etkileşimler nedeniyle kinetik enerjinin büyük bir kısmı ısı enerjisine dönüşür. Oluşan ısı, genellikle bir soğutucu aracılığıyla alınarak, sonrasında bu ısı enerjisi elektrik enerjisi üretimi için kullanılır. Bu süreç, nükleer enerji santrallerinde elektrik üretiminin temelini oluşturur [22].

Fisyon olaylarında, her bir yutulan nötron için ortalama olarak 2-3 nötron oluşur ve bu nötronların enerjisi yaklaşık olarak ~2 MeV'dir. Bu oluşan nötronların bir kısmı dışarıya çıkarak fisyona yol açmazlar. Ancak, ortalama olarak her bir yutulan nötron için 2-3 nötronun oluşması, reaksiyonun kendi kendini sürdürebileceğini gösterir. Oluşan nötronlar yeni fisyon olaylarına neden olarak, oluşan reaksiyona "zincir reaksiyonu" denir [26]. Bu zincir reaksiyon mekanizması Şekil 3'te gösterilmiştir.

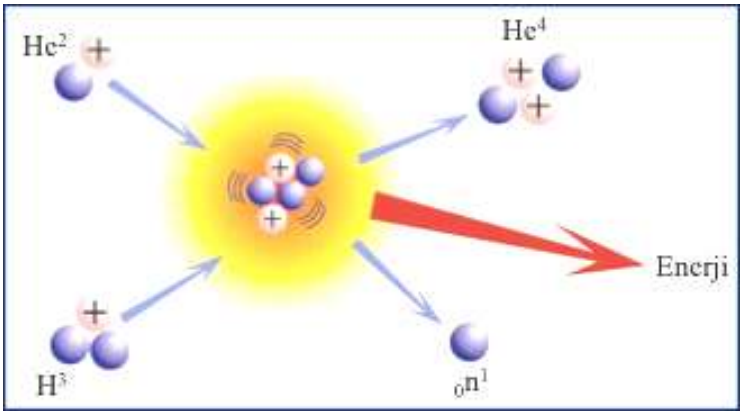


Şekil 2. Tipik bir fisyon reaksiyon mekanizması [27].



Şekil 3. Zincirleme reaksiyon mekanizması [28].

"Füzyon", iki hafif çekirdeğin bir araya getirilerek daha ağır bir çekirdek oluşturulması olayını ifade eder. Bu olay, fisyonun tam tersidir. Füzyon, yüksek enerji seviyelerine sahip atom çekirdeklerinin etkileşimini gerektiren bir süreçtir. Bu etkileşim, atom çekirdeklerinin yüksek sıcaklıklarda ısıtılmasıyla gerçekleşir. Örneğin, deuterium (H_2) ve tritium (H^3) füzyonu için $4 \times 10^8\ K°$ sıcaklık gereklidir. Atom çekirdeklerinin birleşmesinden sonra, başlangıçtaki çekirdeklerin kütlesi ile oluşan parçacıklar arasında büyük bir kütle farkı meydana gelir. Bu kütle farkı, enerji olarak açığa çıkar. Füzyon reaksiyonları sırasında açığa çıkan enerji, fisyon reaksiyonlarından çok daha büyük olabilir [29]. Şekil 4'te tipik bir füzyon reaksiyonu mekanizması göstermektedir.



Şekil 4. Tipik bir füzyon reaksiyonu mekanizması [30].

Nükleer fisyon, son derece yüksek enerji yoğunluğuna sahip olan ve birim yakıt kütlesi başına büyük miktarda enerji üreten bir yöntemdir. Kimyasal reaksiyonlarla enerji üretme sürecine kıyasla, fisyon reaksiyonu kullanıldığında, aynı enerji miktarını elde etmek için gereken malzeme miktarı oldukça azdır. Örneğin, tipik bir nükleer reaktörde 1 kg uranyumdan elde edilen fisyon enerjisi, 45000 kg odun, 15000 kg

petrol, 22000 kg kömür veya 14000 kg likit doğal gazın yanmasından elde edilebilecek enerji miktarına eşdeğerdir (Tablo 1) [22].

Kıyaslandığında, nükleer enerjinin güneş ve rüzgâr gibi yenilenebilir enerji kaynaklarıyla, aynı güç miktarını üretmek için daha küçük bir alan gerektirdiği gözlemlenmektedir. Örneğin, günümüz teknolojisiyle donatılmış bir 900 MWe kapasiteli nükleer enerji santrali bir yılda ürettiği elektriği sağlarken, bu miktarı elde etmek için verimlilik ve kullanılabilirlik faktörleri göz önünde bulundurulduğunda, yaklaşık 70 km^2'lik güneş panelleri ve binlerce rüzgâr türbini gerekmektedir [22].

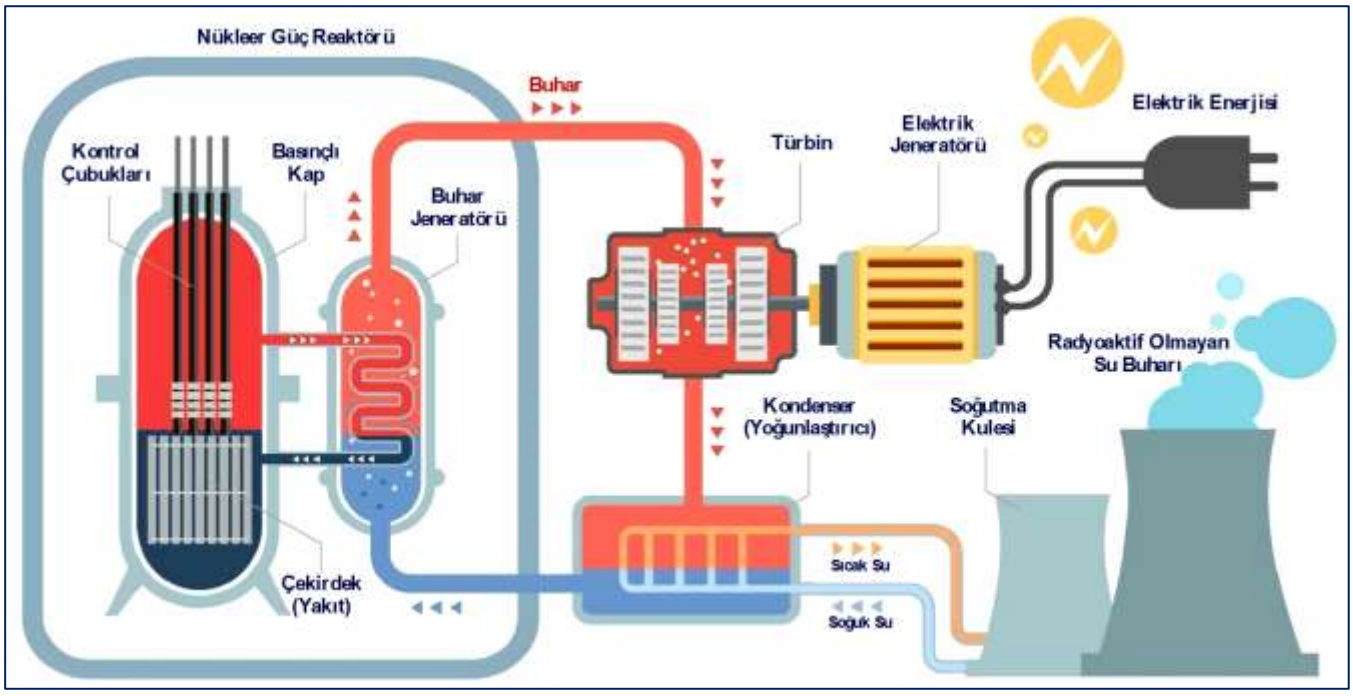
Tablo 1. Farklı yakıt türleri enerji içerikleri (ton/GJ) [22].

Yakıt Cinsi (ton)	Yaklaşık Enerji İçeriği (GJ)
Odun	14
Petrol	29
Kömür	42
Doğalgaz (Sıvılaştırılmış)	46
Uranyum (LWR, Tek geçişli)	630.000

III. NÜKLEER GÜÇ SANTRALLERİ

Nükleer enerji santrallerinde, reaktörün içerisinde ana yakıt olarak uranyum-235 atomu kullanılmaktadır. Uranyumun fisyon tepkimesiyle parçalanması sonucunda ortaya çıkan yüksek enerji miktarı elektrik enerjisine dönüştürülür. Bu büyük enerji, su buharını yüksek sıcaklıklara kadar ısıtarak, buharın türbin şaftını döndürmesini sağlar. Oluşan buhar, buhar türbinlerine iletilir ve bu mekanik hareket elektrik üretimi için alternatör aracılığıyla kullanılır. Jeneratörde üretilen elektrik, bir transformatör yardımıyla yüksek gerilime dönüştürülür ve enerji nakil hatları vasıtasıyla kullanılacağı yerlere iletilir [31], [32]. Şekil 5'te Nükleer enerji santralı çalışma prensipi göstermektedir.

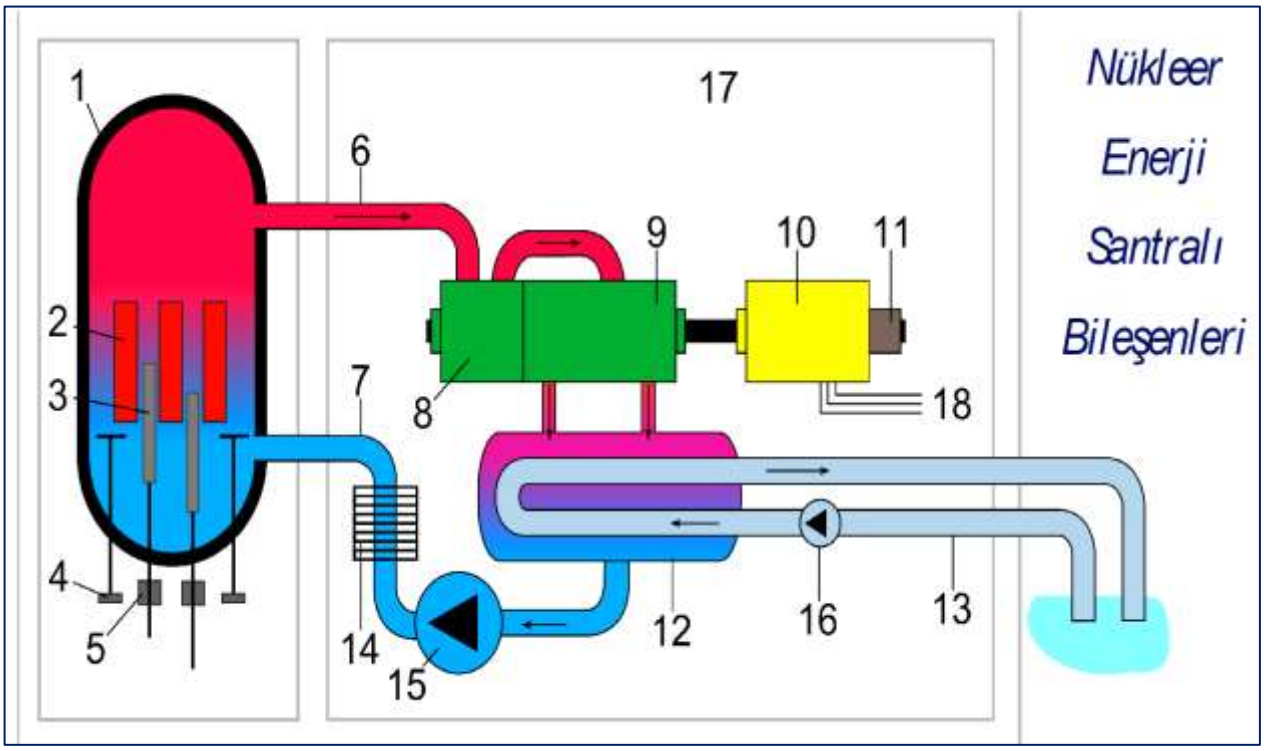
Türbinden çıkan ve basınç ile sıcaklığı düşmüş olan buhar, yoğuşturucuda (kondenser) tekrar sıvı hale dönüştürülür. Yoğuşturucu, bu faz değişimi için çevrede bulunan su kaynaklarını (örneğin deniz veya göl gibi), soğutucu olarak kullanır. Ardından, yoğuşturulan su tekrar reaktörün içine pompalanarak döngü tamamlanır. Bu sistemde su, termik santrallerde olduğu gibi sürekli bir döngü içinde kullanılarak enerji üretimi sürdürülür [31].



Şekil 5. Nükleer enerji santralı çalışma prensip şeması.

Nükleer santraller, kullanılan yakıt, soğutucu, moderatör ve nötron kaynaklarına bağlı olarak sınıflandırılabilir. Bu sınıflandırma, çeşitli alt gruplar içerebilecek şekilde yapılandırılabilir [33].

- Yakıta göre: Reaktörler, tabii ve zenginleştirilmiş yakıt kullanımına göre ayrılabilir.
- Moderatöre göre: Reaktörler, ağır sulu, hafif sulu ve grafik çubuk moderatörlerine sahip olabilir.
- Soğutucuya göre: Reaktörler, hafif sulu, ağır sulu, gaz soğutmalı ve sıvı metal soğutmalı olarak sınıflandırılabilir.
- Nötron kaynaklarına göre: Reaktörler, termal nötronlu ve hızlı nötronlu olarak gruplandırılabilir.
- Nükleer enerji santralı genel olarak bileşenlerini Şekil 6'da göstermektedir. Şekilde sunulan bileşenlerin açıklamaları ve görevleri aşağıda numaralara göre listelenmiştir:
    - Reaktör Kabı: Nükleer enerji santrallerinde, nükleer reaksiyonların gerçekleştiği ve nükleer yakıt çekirdeklerinin barındırıldığı birincil kalkanlı bir yapıdır. Reaktör kabının temel görevi, radyasyonun dış ortama sızmasını engellemek ve reaktör içindeki yüksek basınç ve sıcaklığı kontrol altında tutmaktır.
    - Yakıt Çekirdek Elemanı: Nükleer reaksiyonların gerçekleştiği bölümde bulunan ve nükleer yakıt elementlerini içeren yapısal birimlerdir. Bu elemanlar, reaktör içinde nötronların emilimini ve fisyon reaksiyonlarını destekler.
    - Kontrol Çubuğu Elemanı: Nükleer reaksiyon hızını kontrol etmek için kullanılan ve reaktör içine yerleştirilen malzemelerdir. Bu elemanlar, nötronların absorbe edilmesi yoluyla reaksiyon hızını düzenler ve reaktörün istenilen güç seviyesinde stabil bir şekilde çalışmasını sağlar.
    - Sirkülasyon Pompası: Soğutucu akışkanın (genellikle su) reaktör içinde dolaşımını sağlayan ve buhar üretimi için gerekli olan termal enerjinin transferini kolaylaştıran bir mekanik cihazdır.
    - Kontrol Çubuğu Motoru: Kontrol çubuklarını reaktör içinde hareket ettiren ve reaktörün güç çıkışını düzenleyen elektrikli bir motor sistemidir.
    - Buhar: Reaktörde oluşan termal enerjinin, suyun buharlaşması yoluyla mekanik enerjiye dönüştürüldüğü halidir. Buhar, türbinleri döndürerek elektrik enerjisi üretimi için kullanılır.
    - Girişli Sirkülasyon Suyu: Reaktör içindeki termal enerjinin transferini ve soğutma işlemini sağlamak için reaktöre beslenen soğutucu akışkanın başlangıç noktasıdır.
    - Yüksek Basınç Türbini: Buharı yüksek basınçta alan ve mekanik enerjiye dönüştüren bir türbin türüdür. Bu türbin, yüksek basınçlı buharı alarak elektrik jeneratörünü tahrik eder.
    - Alçak Basınç Türbini: Yüksek basınç türbininden çıkan düşük basınçlı buharı alan ve elektrik enerjisi üretimi için kullanılan ikinci bir türbindir. Alçak basınçlı buharın enerjisini kullanarak jeneratörü tahrik eder.
    - Elektrik Jeneratörü: Mekanik enerjiyi elektrik enerjisine dönüştüren elektromekanik bir cihazdır. Türbinler tarafından döndürülen jeneratör rotoru, manyetik alan içinde döndürülerek elektrik akımı üretilmesini sağlar.
    - Elektrik Jeneratörü Uyarıcısı: Elektrik jeneratörünün çıkış gerilimini ve frekansını kontrol eden ve istenilen elektrik enerjisi parametrelerini sağlayan bir regülasyon sistemidir.
    - Buhar Yoğunlaştırıcı: Kullanılmış buharın soğutularak sıvı haline dönüştürüldüğü bir cihazdır. Yoğunlaştırıcı, buharın dolaşım döngüsünün devamlılığını sağlamak için önemlidir.
    - Kondenser: Buharın yoğunlaştırıcıdan geçerek sıvı hale dönüştüğü birimdir. Kondenser, buharın ısısını çevre ortama aktararak tekrar su haline dönüşmesini sağlar.
    - Ön Isıtıcı Sistemi: Soğutma suyunun ısıtılmasını ve reaktör soğutma döngüsünün verimliliğini artırmayı amaçlayan bir sistemdir.
    - Su Sirkülasyon Pompası: Soğutma suyunun reaktör dolaşımını sağlayan ve soğutma işlemini optimize eden bir mekanik cihazdır.
    - Kondenserli Soğuk Su Pompası: Kondenserde yoğuşan buharın soğuk su ile temasını sağlayarak buharın yoğunlaşmasını ve tekrar su haline dönüşmesini kolaylaştıran bir pompadır.
    - Beton Odası: Nükleer reaktör ve diğer önemli tesisatı korumak için güçlendirilmiş beton yapıdır. Beton odası, çevresel etkilerden korunmayı ve olası kazalara karşı dayanıklılığı sağlar.
    - Elektrik Şebekesine Bağlantı: Üretilen elektrik enerjisinin şebekeye aktarıldığı noktadır. Bu bağlantı, nükleer enerji santralinin ürettiği elektriğin tüketiciye iletilmesini sağlar.



Şekil 6. Nükleer enerji santralı bileşenleri [31].

A. Nükleer Güç Reaktörleri

Nükleer reaktörler, fisyon nükleer zincir reaksiyonunu veya nükleer füzyon reaksiyonlarını başlatmak ve kontrol etmek amacıyla geliştirilmiş teknolojik cihazlardır. Bu reaktörler, genellikle nükleer santrallerde elektrik enerjisi üretimi ve nükleer deniz taşıtlarında güç kaynağı olarak kullanılmaktadır. Nükleer fisyon sürecinden elde edilen ısı, birincil soğutma akışkanı aracılığıyla (genellikle su veya gaz) ikincil bir döngüye aktarılır. Bu döngü, bir geminin pervanesini tahrik etmek veya elektrik jeneratörlerinin rotorlarını döndürmek gibi çeşitli amaçlar için kullanılır [34], [35].

Reaktör, işlevselliğini yakıtı basınçlı suyu ısıtarak sağlar. Bu ısıtma süreci, reaktörün çalışması için gerekli olan termal enerjinin üretilmesini sağlar. Ayrıca, kontrol çubukları reaktör içindeki nötron akışını kontrol eder. Bu çubuklar, gerektiğinde nötronların etkisini azaltarak fisyon reaksiyonunu kontrol edebilir veya tamamen durdurabilirler. Bu şekilde, reaktörün istenen güç çıkışını sağlamak veya güvenliğini sağlamak için kullanılırlar. Bu mekanizma, reaktörün istenilen performans seviyesini korumasını ve potansiyel tehlikeleri önlemesini sağlar [36].

Nükleer reaktörlerin çeşitliliği oldukça geniştir ve enerji güç santrallerde enerji üretiminde en yaygın olarak kullanılan 6 tür reaktör bulunmaktadır [22]. Bu reaktör türleri ve teknik özellikleri aşağıda açıklanmaktadır:

1. Basınçlı Su Reaktörü (Pressurized Water Reactor- PWR)

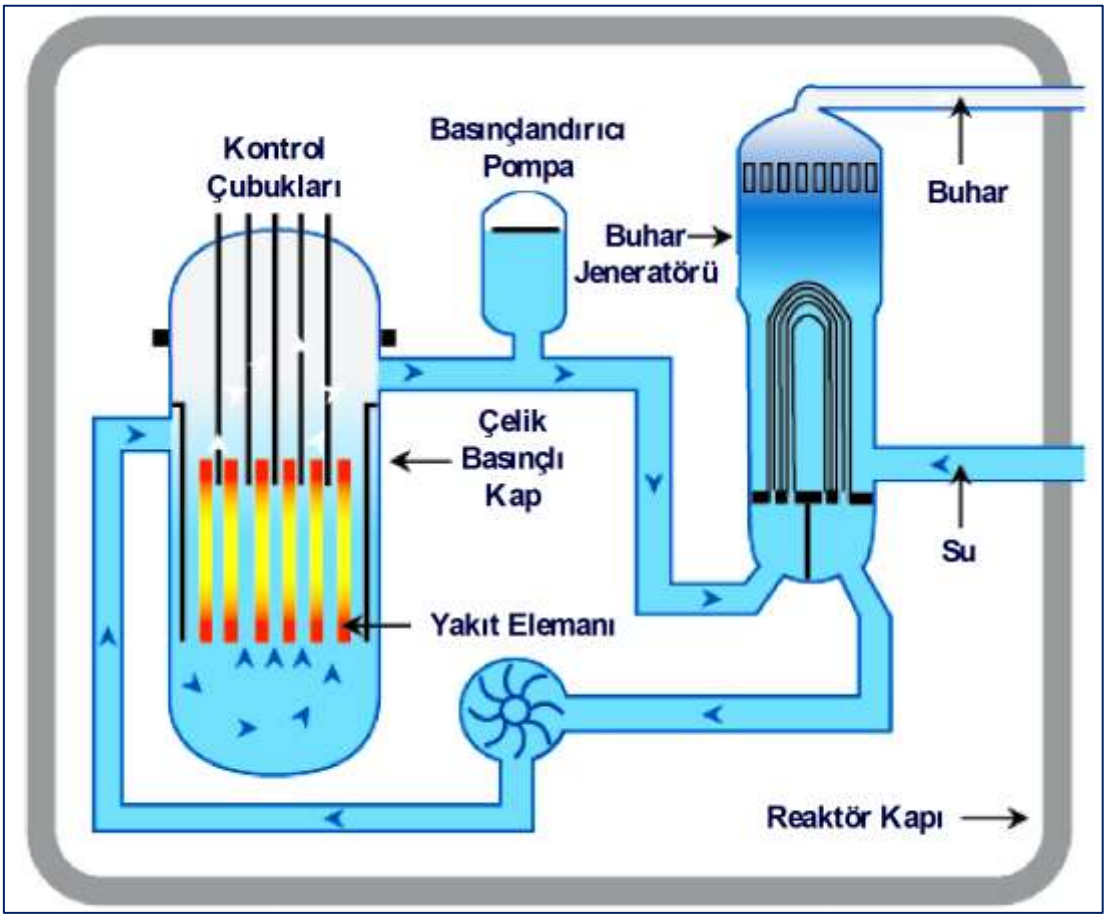
Basınçlı Su Reaktörleri (Pressurized Water Reactor- PWR), nükleer enerji üretiminde yaygın olarak kullanılan reaktörlerdir. Tipik bir PWR tasarımı, çekirdekteki yakıt montajlarının dikey düzenlemesiyle karakterizedir. Genellikle 200-300 çubuktan oluşan bu yakıt montajları, çekirdekte yer alır ve büyük bir reaktörde yaklaşık 150-250 montaj bulunabilir. Reaktör çekirdeğindeki su, yaklaşık 325°C sıcaklığa ulaşır ve 150 atmosfer basınç altında tutularak kaynama önlenebilir. PWR'lerde soğutucu ve yavaşlatıcı olarak normal su kullanılır ve soğutucu yüksek basınç altında tutularak sıvı halde kalması sağlanır. Birincil soğutma devresinde su, aynı zamanda yavaşlatıcı olarak da işlev görür ve buharlaşma, fisyon reaksiyonunu yavaşlatır, bu da güvenlik için önemlidir. İkincil devrede su buhar jeneratörleri olarak işlev görür ve elektrik üretmek için türbinleri tahrik eder. Son olarak, buhar birincil devreye geri döner ve ısı değiştiriciler aracılığıyla soğutulur [22], [36]. Şekil 7'de basınçlı su reaktörü şeması gösterilmektedir.

1. *Kaynar Su Reaktörü (Boiling Water Reactor- BWR)*

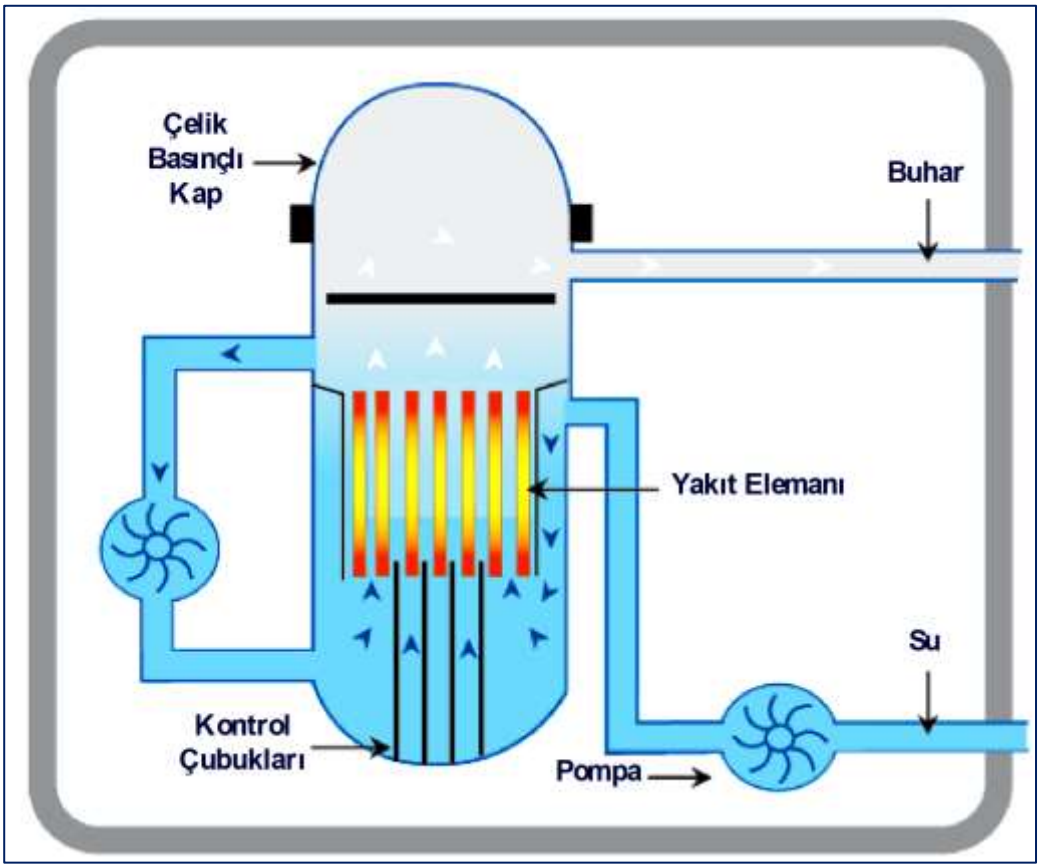
Kaynar Su Reaktörü (Boiling Water Reactor - BWR), düşük basınçta tek bir devre içinde suyun kaynadığı bir yapıya sahiptir. Reaktör, çekirdeğin üst kısmında buhar olarak bulunan suyun %12-15'ini kullanarak daha az soğutma etkisi ve dolayısıyla verimlilik sağlamak üzere tasarlanmıştır. BWR üniteleri, PWR'lere kıyasla daha kolay yük takibi yapabilirler ve buhar direkt olarak reaktör devresinin bir parçası olan türbinlere iletilir. Radyonüklidlerle kirlenmiş su nedeniyle türbin bakımı sırasında radyolojik koruma gereklidir. BWR yakıt montajı, genellikle 90-100 yakıt çubuğundan oluşur ve bir reaktör çekirdeğinde 750'ye kadar montaj bulunabilir, toplamda 140 ton uranyumu barındırabilir. İkincil kontrol sistemi, çekirdeğin içinden su akışını kısıtlayarak, üst kısımdaki daha fazla buharın yavaşlamayı azaltmasını sağlar [22], [36]. Şekil 8'de kaynar su reaktörü şeması gösterilmektedir.

2. *Basınçlı Ağır Su Reaktörü (Pressurized Heavy Water Reactor- PHWR)*

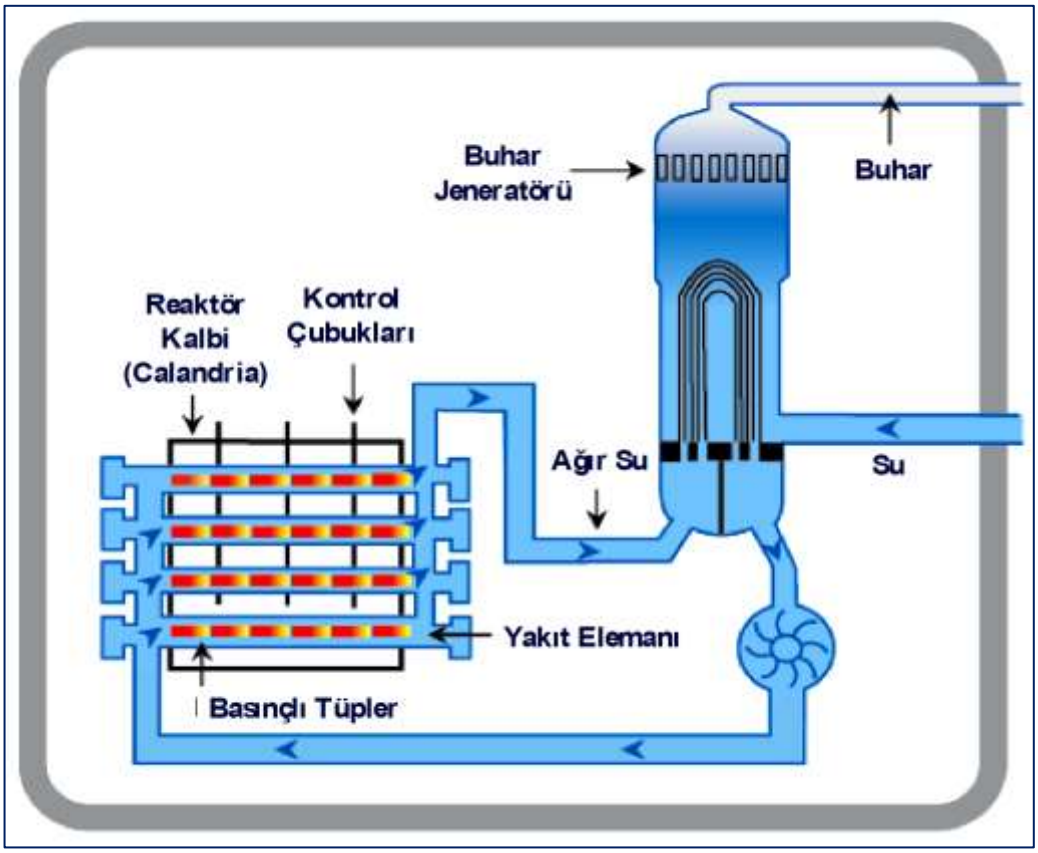
Basınçlı ağır su reaktörleri (PHWR'ler), nükleer reaktörlerin bir alt tipi olarak, soğutma ve nötron moderasyonu işlevlerini ağır su (deuterium oksit- D_2O) kullanarak gerçekleştiren sistemlerdir [37]. Bu reaktörler genellikle doğal uranyum yakıtını tercih etmekle birlikte, zaman zaman düşük oranda zenginleştirilmiş uranyum da kullanılmaktadır. Ağır su soğutucuları, basınç altında tutularak kaynamayı engeller ve bu şekilde, basınçlı su reaktörlerine benzer şekilde, daha yüksek sıcaklıklara (çoğu zaman) buhar kabarcıkları oluşturmadan ulaşılmasını sağlar. Ağır suyun genellikle hafif suya kıyasla izole edilmesi maliyetlidir; ancak, nötronların düşük emilimi sayesinde, zenginleştirilmiş yakıt kullanımı gereksinimini ortadan kaldırarak reaktörün nötron verimliliğini büyük ölçüde artırır. Ağır suyun yüksek maliyeti, doğal uranyum veya alternatif yakıt çevrimlerinin kullanımındaki düşük maliyetle dengelenmektedir [38].



Şekil 7. Basınçlı su reaktörü şeması [36].



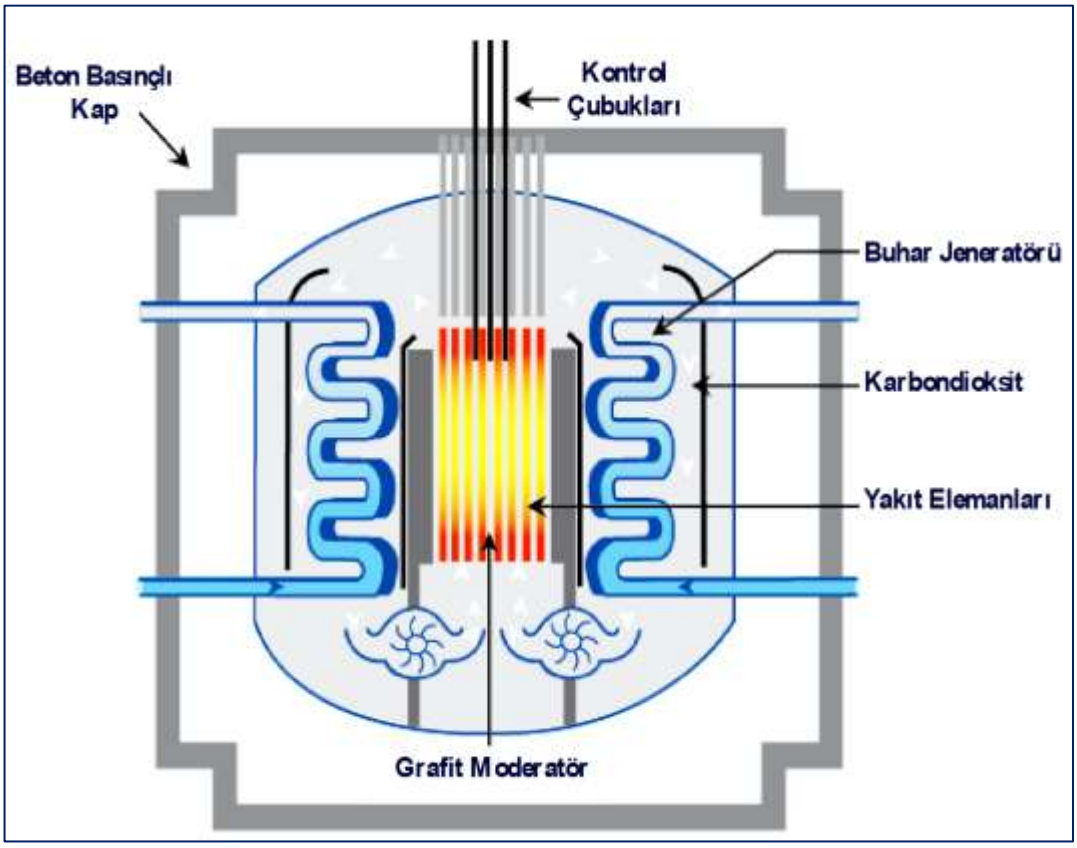
Şekil 8. Kaynar su reaktörü [36].



Şekil 9. Basınçlı döteryum reaktörü [36].

3. Gaz Soğutmalı Reaktör (Gas Cooled Reactor– GCR)

Gaz soğutmalı reaktörler, İngiliz gaz soğutmalı reaktörlerinin ikinci nesli olup birincil soğutucu olarak grafit moderatör ve karbondioksit kullanmaktadır. Bu reaktörlerde, yakıt olarak paslanmaz çelik tüpler içinde %2,5 - 3,5 oranında zenginleştirilmiş uranyum oksit topakları kullanılmaktadır. Karbon dioksit birincil devrede dolaşmakta olup 650°C'ye kadar ulaşmaktadır ve daha sonra dışarıdaki buhar jeneratörü tüplerini geçmektedir. Bununla birlikte, reaktör çekirdeği beton ve çelik basınçlı kabın içinde yer almaktadır, bu da ona 'integral' bir tasarım kazandırmaktadır. Kontrol çubukları moderatöre nüfuz ederken, ikincil kapatma sistemi soğutucuya nitrojen enjekte etmeyi içermektedir. Bu reaktör tasarımı yüksek sıcaklıkta çalışarak yüksek termal verim sağlamaktadır, yaklaşık olarak %41'e kadar [22], [36].



Şekil 10. Gaz soğutmalı reaktör şeması [36].

4. Kurşun-Sodyum Soğutmalı Reaktör (Liquid-Metal Fast-Breeder Reactor- LMFBR)

Kurşun-Sodyum Soğutmalı Reaktör (LMFBR), ışık suyu reaktörlerinden (termal reaktörlerin en yaygın türü) farklı bir prensibe dayanır. Işık suyu reaktörleri, moderasyon ve soğutma amaçları için normal su kullanırken, LMFBR'ler bu işlevleri genellikle kurşun ve sodyum içeren bir sıvı metal karışımıyla gerçekleştirir. Bu değişim, farklı işletme özellikleri ve avantajlar sağlar. Işık suyu reaktörlerinde, hafif hidrojen izotopunun varlığı hafif bir nötron zehiri olarak hareket eder ve bu da yapay olarak zenginleştirilmiş yakıtların kullanılmasını gerektirir. Bu zenginleştirme süreci, yakıt üretim sürecine karmaşıklık ve maliyet ekler. Ayrıca, nötronların ışık suyunda moderasyonu sıcaklık değişikliklerine duyarlıdır. Su sıcaklığı arttığında, yoğunluğu azalır ve daha az nötron yeterince yavaşlatılarak daha fazla tepkimeyi tetikler. Bu içsel negatif geri besleme mekanizması, reaksiyon hızını stabilize eder. Buna karşılık, grafit ve ağır su reaktörleri, ışık suyu reaktörlerine göre daha verimli termalizasyon elde ederler. Bu artırılmış termalizasyon, hafif hidrojen zehirleme etkilerinin olmamasıyla birleşince, bu reaktör tiplerinin doğal uranyum veya zenginleştirilmemiş yakıtı kullanmasını sağlar. Dolayısıyla, yakıtın kullanılabilirliği ve maliyet etkinliği açısından potansiyel avantajlar sunarlar [22], [36].

5. *Florid-Toryum Reaktör (Molten Salt Reactor Experiment - MSRs)*

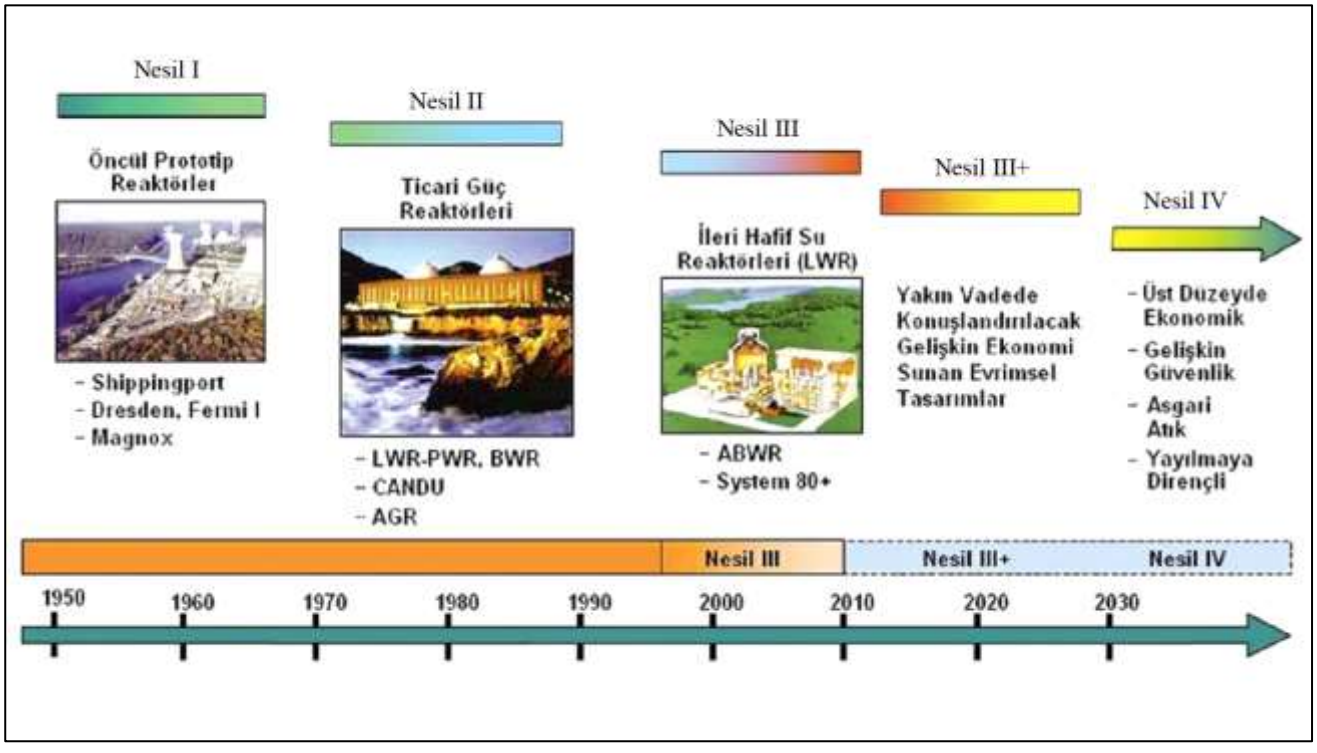
Florid-Toryum Reaktörü (Ergimiş Tuz Reaktör Deneyi), lityum veya berilyum gibi hafif elementler tarafından modere edilir. Bu elementler, soğutucu/yakıt matris tuzlarının birer bileşeni olan "LiF" ve "BeF_2", "LiCl" ve "$BeCl_2$" gibi tuzlarda bulunurlar. Bu tuzlar, moderasyon etkisi yaratarak reaktörde düzenleyici bir rol oynarlar [22].

B. Nükleer Reaktör Nesilleri

Nükleer reaktörler, teknolojinin evrimiyle birlikte farklı nesillerin ortaya çıkmasına olanak tanımıştır. Elektrik üretimi amacıyla 1950'lerde başlayan ilk reaktörler, 1. nesil olarak sınıflandırılmaktadır (Şekil 11). Enrico Fermi tarafından 1942'de geliştirilen atom pilinin ardından dünyanın ilk nükleer reaktörü olarak kabul edilmiştir. ABD'nin Idaho eyaletinde 1951'de 100 kW gücündeki ERB-I adlı deneysel reaktörde elektrik üretimi gerçekleştirilmiştir. Elektrik şebekesine güç sağlamak amacıyla kurulan ilk nükleer santral ise 1954'te Rusya'da faaliyete geçmiştir [39].

Nesiller:

1. Nesil:
   - Elektrik üretimi amacıyla 1950'lerde kurulan ilk reaktörler.
   - Enrico Fermi tarafından 1942'de geliştirilen atom pilinin ardından gelen reaktörler.
   - Dünyanın ilk nükleer reaktörü olarak kabul edilenler.
2. Nesil:
   - Ticari amaçlarla 1990'ların sonlarına kadar inşa edilen reaktörler.
   - PWR, BWR, PHWR, GCR gibi tipik reaktörler.
3. Nesil:
   - 2. nesil reaktörlerin yakıt teknolojisi, verimlilik ve güvenlik sistemleri gibi alanlarda geliştirilmiş versiyonları.
   - Japonya'da 1996'da faaliyete geçen Kashiwazaki-Kariwa Nükleer Santrali gibi örnekler.
4. Nesil:
   - Henüz teorik aşamada olan ve ticari işletmeye açılması için 2030 yılına kadar beklenen reaktör tasarımları.



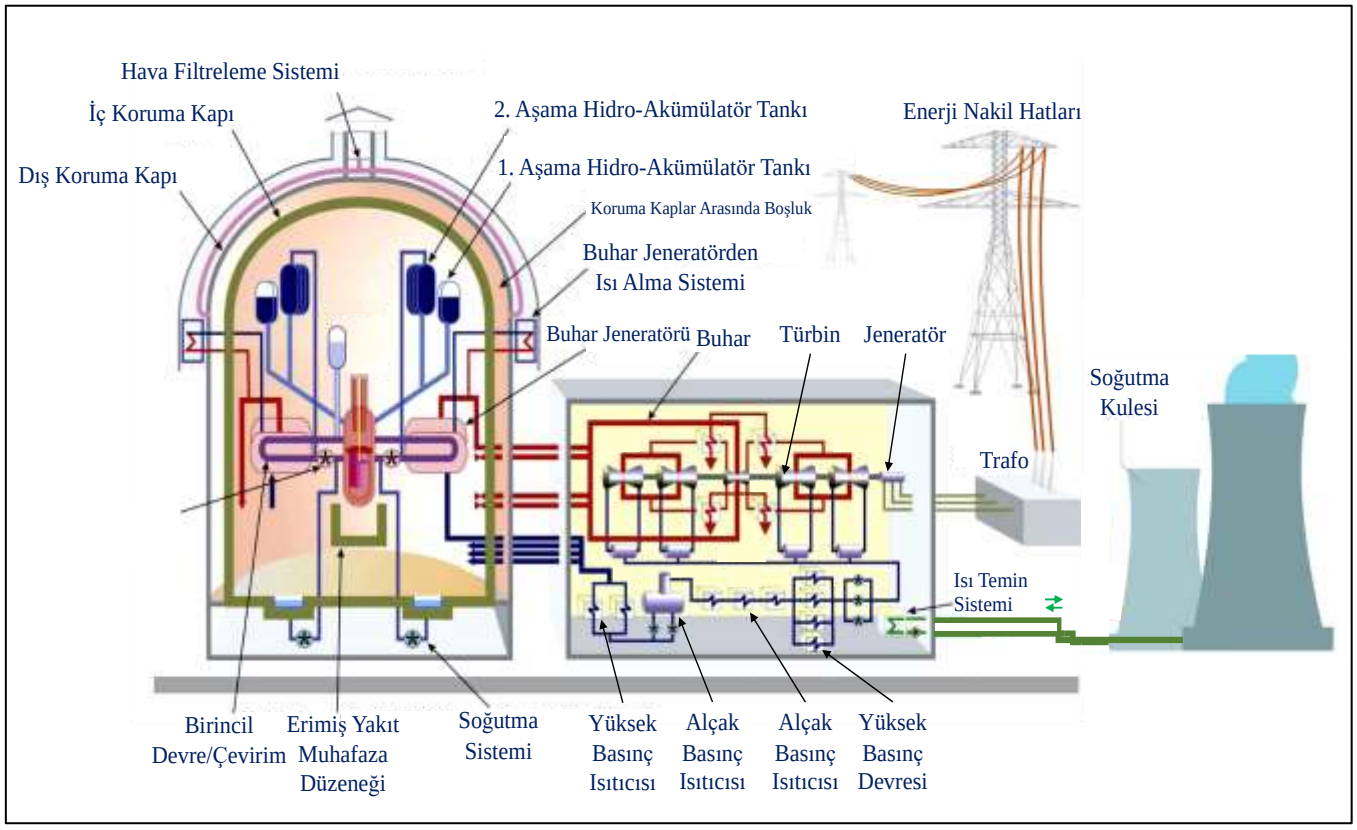
Şekil 11. Nükleer Enerji Reaktörleri Gelişimi [39].

IV. AKKUYU NÜKLEER GÜÇ SANTRALI'NIN TEKNİK ÖZELLİKLERİ

Akkuyu Nükleer Enerji Santralı, Türkiye'nin ilk nükleer enerji tesisidir ve Mersin ilinde, Türkiye'nin güney sahilinde konumlanmıştır. Bu santral, Rusya'nın devlet şirketi ROSATOM (ROSTECHNADZOR) tarafından geliştirilmekte olan bir projedir. İnşası, Türkiye ile Rusya arasında 2010 yılında imzalanan bir hükümetler arası anlaşma ile başlatılmıştır. Santral 4 üniteden oluşmaktadır, toplamda 4.800 megavatlık bir kapasiteye sahip olması ve yılda ortalama 35 milyar kWsaat üretim yapması beklenmektedir, bu kapasite, dört adet VVER-1200 tipi reaktör tarafından sağlanacaktır [40].

Santralı'nın temel tasarımı, çift devreli bir VVER (Su-Su-Enerji Reaktörü) olarak bilinmektedir. Bu tasarım, tipik bir ünitenin şematik gösterimi Şekil 12'de sunulmuştur. Reaktörün merkezinde yakıt bulunur ve su, yakıt elemanları arasındaki boşluklardan yukarı doğru hareket ederek fisyon sürecinde ortaya çıkan ısıyı uzaklaştırır. Bu su, ısıyı uzaklaştırmak için kullanılan "soğutucu" olarak adlandırılır ve çünkü ısı kaynağı radyoaktif olduğundan, soğutucu da radyoaktiftir. Bu durum, suyun saflığı ve kapalı bir sistem gerekliliği gibi kuralların titizlikle uygulanması gerektiğini açıkça ortaya koymaktadır [8].

Soğutma suyu, bir buhar üreteci olarak adlandırılan ara eşanjörün borularından geçirilir. Üreteç içerisinde, ikinci devrede bulunan su ısınır ve buhar haline dönüşür. Oluşan buhar, türbin şaftını döndürür. Bu düzenek sayesinde, ikinci devredeki besleme suyu ile birinci devredeki soğutucu suyun karışması önlenir ve ikinci devrenin radyoaktif kirlenmesi engellenir. Reaktör ve birinci devre, koruyucu kabın içerisinde yer alır ve burada bulunan emici vantilasyon sistemleri, içerideki basıncı atmosferik basıncın altında tutar. Bu yöntem, kirli havanın kontrolsüz bir şekilde yayılmasını önler ve santral çevresine zarar vermez [8].



Şekil 12. Akkuyu nükleer santrallı bir ünitede temel üretim akım şeması.

A. *Reaktör Tasarımı ve Tipi*

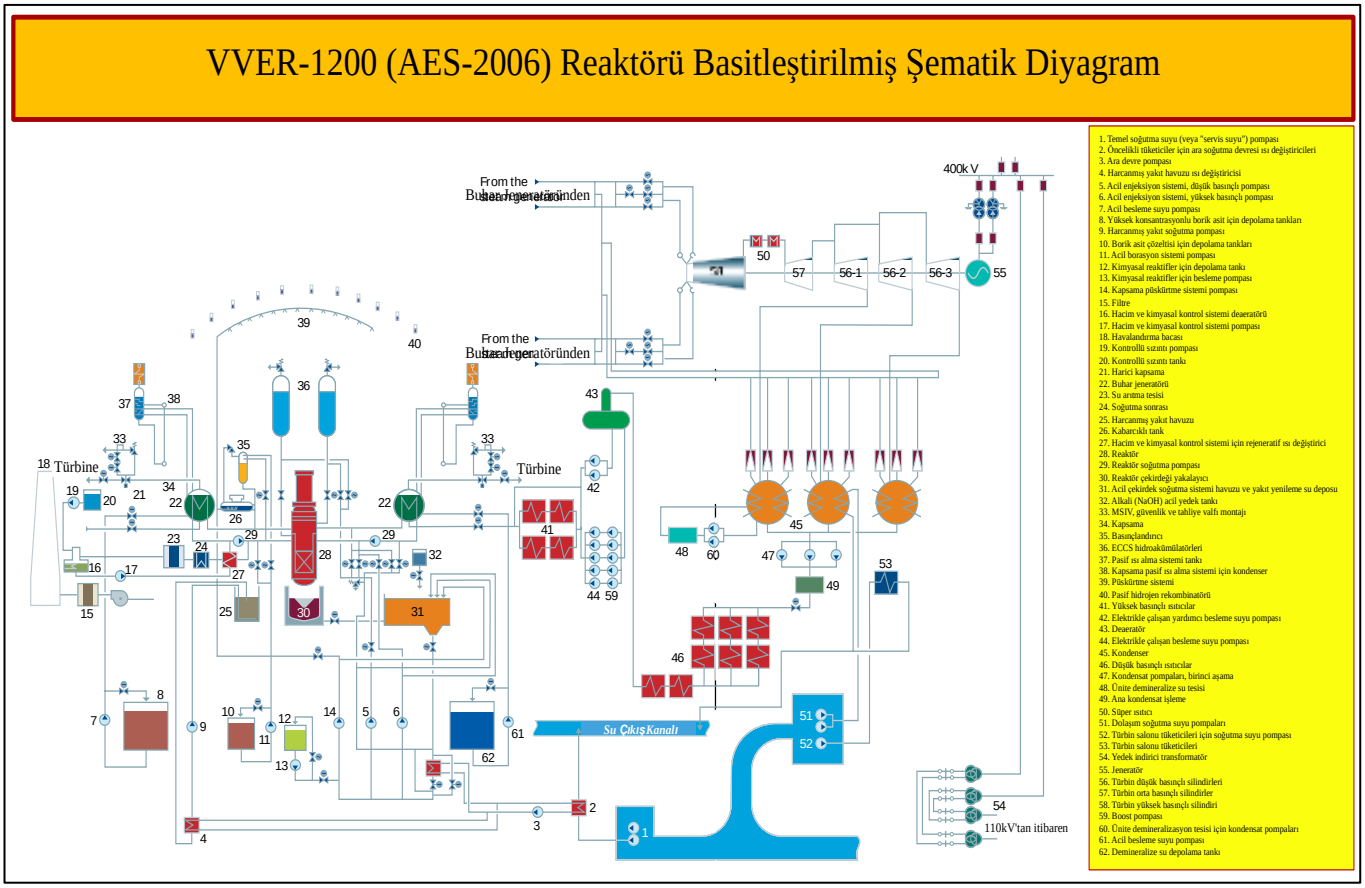
Akkuyu'da faaliyet gösteren reaktör, VVER-1200 üçüncü nesil versiyonunu temel alarak basınçlı su reaktörü tipindedir [41]. VVER-1200, 3200 MW termal güce sahip dört dolaşım devreli bir basınçlı su reaktörüdür ve hafif suyu nötron yavaşlatıcı ve soğutucu olarak kullanır. Reaktör çekirdeğinde toplam 163 adet yakıt demeti bulunmaktadır ve yakıt ikmali 12 aylık periyotlarla gerçekleştirilmektedir. Yakıt döngüsü süresi ise dört yıldır. Bu reaktörde %3.6 oranında zenginleştirilmiş U-235 izotopu kullanılmaktadır [40].

Bu tür reaktörlerde hafif su, hem nötron moderatörü hem de soğutucu olarak kullanılır. VVER reaktörü, dünyanın en güvenli reaktörlerinden biri olarak kabul edilmektedir [8], [42].

Reaktör, çift kat koruma sistemi ile donatılmıştır. İlk koruma seviyesinde, 169 ton ağırlığında, 5,8 metre yüksekliğinde ve 6,1 metre çapında bir koruyucu yer almaktadır. Ayrıca, reaktör tasarımı, tehlike anlarında elektrik beslemesine ihtiyaç duymadan çalışabilme yeteneğiyle desteklenmiştir. Güvenlik önlemleri, kontrol çubukları, aktif ve pasif acil durum soğutma sistemleri, acil durum borik asit enjeksiyon sistemi ve reaktör çekirdeği ile yakıt havuzundan acil durumda ısı transferini içeren önlemleri içerir [42]. Tablo 2'de Akkuyu santrallerinde kullanılan reaktör özellikleri sunmaktadır.

Reaktör kabı, yakıt ve kontrol çubuklarını koruyarak reaktörün işlevselliğini sağlamaktadır (Şekil 14). Herhangi bir reaktörün temel özellikleri, yüksek güç çıkışından kaynaklanmaktadır. Örneğin, 1 MWth gücündeki bir reaktör, zirkirleme reaksiyonları sonucunda 3x10^16 çekirdek fisyonunu içerir. Reaktör kabında, aktif çekirdek yakıt elemanları bulunmaktadır. Her bir yakıt elemanı, belirli miktarda yakıt çubuğunu içerir. Reaktör üst yapısında kontrol çubukları ve ilgili bileşenler yer almaktadır. Dışsal radyasyona karşı biyolojik zırhlama, beton yapı üzerinde sağlanmaktadır. Soğutucu, dört ayrı dolaşım döngüsünde dolaşır. Her döngü, ana dolaşım ("sirkülasyon") pompası ve boru hatlarından oluşur, soğutma suyunun basınçlı dolaşımını sağlar. Şekil 15, soğutucunun dört ayrı dolaşım döngüsünü göstermektedir. Her döngü, soğutma suyunun basınçlı dolaşımını sağlayan ana dolaşım ("sirkülasyon") pompası ve boru hatlarından oluşur [8]

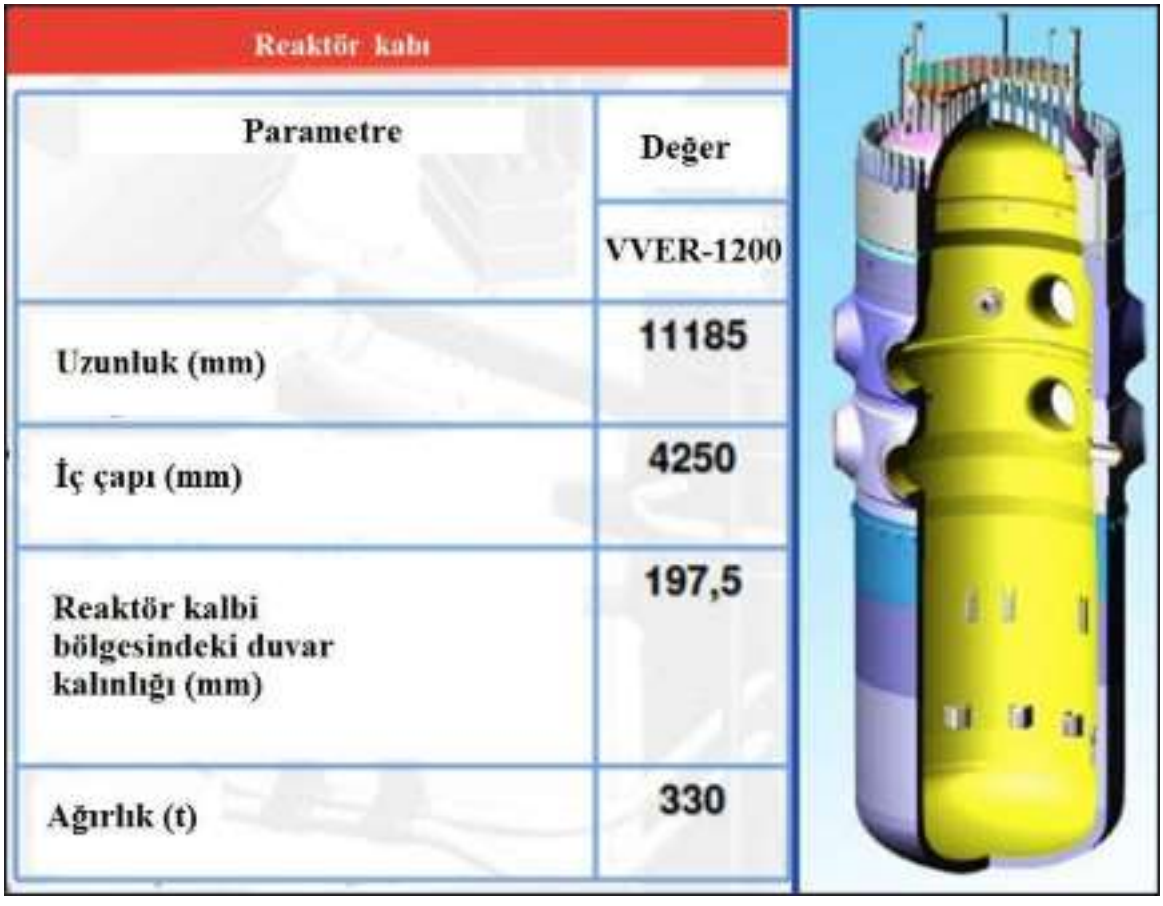
Nükleer güç santrallerinin güvenli işleyişiyle ilgili temel bir konu, yakıtın yanması sırasında ortaya çıkan radyoaktif maddelerin çevreye salınmasını önlemektir. Bu sorunu çözmek için, nükleer güç santrallerinde reaktör sistemleri ve bileşenlerinin tasarımında fiziksel bariyerlerin kullanılması öngörülmüştür. Buhar üreteci, soğutma suyunun dolaştığı küçük tüplerden oluşan bir bölümdür. Şekil 16, buhar üreteciyi göstermektedir. Buhar üreteci, soğutma suyunun dolaştığı küçük tüplerden oluşan bir bölümdür ve reaktörün termal enerjisini elektrik enerjisine dönüştürmek için kullanılır [8].



Şekil 13. VVER-1200 reaktörü basitleştirilmiş şematik diyagram [43].

Tablo 2. Kullanılan VVER-1200 reaktör özellikleri.

Kullanılan VVER Reaktör Özellikleri	
Kategori	Basınçlı su reaktörü
Nesil	III+
Reaktör Hattı	VVER (Voda Voda Energo Reactor)
Reaktör Modeli	VVER-1200/513 (TOI Standardı ile AES-2006)
Yakıt	235U (Düşük zenginleştirilmiş uranium)
Yakıt durumu	Sağlam
Ömrü (yıl)	60
Kullanılabilirlik (%)	90
Nötron enerji spektrumu	Termal
Birincil kontrol yöntemi	Kontrol çubukları
Birincil moderatör	su
Birincil soğutma sıvısı	Sıvı (hafif su)
Birincil kullanım	Elektrik üretimi
Güç (termal)	3,212 MWt
Isı tedarik kapasitesi (Termal)	300 MWt
Güç (elektrik)	1,200 MWel
Tasarıma dayalı maksimum yakıt tüketimi (yakıt grubu başına ortalama) (MWd/kgU)	60
Yakıt kampanyası süresi (yani çekirdekteki yakıt ömrü) (yıl)	4
Birincil soğutma suyu sıcaklığı çekirdek girişinde (°C)	298.2
Birincil soğutma suyu sıcaklığı çekirdek çıkışında (°C)	328.9
Reaktör kabı boyunca birincil soğutucu akış hızı (m3 /saat)	86000
Reaktör kabı çıkışındaki birincil soğutucu basıncı (MPa)	16.2
Buhar jeneratörü çıkışındaki buhar basıncı (MPa)	7



Şekil 14. Reaktör kabı [8].

Şekil 15. Buhar üreteci [8].

B. *Ana Ekipmanı*

Akkuyu NGS'nin temel ekipmanı, aşağıdaki bileşenlerden oluşmaktadır [8]:

- Dört adet VVER1200 tipi su reaktörü, her biri 60 yıllık ömrü olan ve 3.200 MW ısıl kapasiteye sahip. Bu reaktörlerde nükleer yakıt olarak uranyum dioksit kullanılmaktadır.
- Reaktör için soğutma ve moderatör görevi gören, borik asit içeren ve kimyasal olarak demineralize edilmiş su. Suyun konsantrasyonu işletme sürecinde değişkenlik gösterir.
- Her biri 6,9 MPa basınçla 1600+112 t/s kuru doygun buhar üretebilen dört adet yatay tip PGV-1000MKP buhar üreteci.
- Dört ana dolaşım pompa seti, GCNA-1391 modeli.
- Kullanılan bir türbin-jeneratör seti, K-1200-6,8/50 modeli.

Reaktör, buhar üreteçleri ve diğer birincil/ana ekipmanlar, çift katmanlı betonarme bir koruma kabı içerisinde yer alır. Bu çift katmanlı koruma kabı şunlardan oluşur:

- Acil durumlara dayanıklı, kaza kontrol (lokalleştirme) bölgesinde kullanılmak üzere tasarlanmış, ön gerilmeli betonarme iç koruma kabı.
- Dış etkenlere karşı koruma sağlamak ve acil durumlarda iç koruma kabından sızabilecek radyasyonu önlemek ve iki koruma katmanı arasındaki alana sınırlama getirmek amacıyla yapılan ön gerilmeli olmayan betonarme dış koruma kabı.

C. *Elektrik Sistemleri*

AKKUYU Nükleer Enerji Santralı'nın elektrik sistemleri, enerji üretimi ve dağıtımı ile yardımcı güç kaynaklarını içermektedir. Elektrik üretim ve dağıtım sistemi, 1.200 MW kapasiteli, 24 kV üreteç, 24 kV üreteç kesicisi, 24 kV akım kablolarını bağlayan ünite transformatörleri, esnek konnektörler ve 380 kV yüksek gerilimli şalt birimlerinden oluşmaktadır. SF6 izolasyonlu ana şalter / kontrol şalteri, 154 kV bağlantı ototransformatörleri ile 154 kV ve 380 kV bağlantı şaltları da bu sisteme dahildir [8].

Nükleer Güç Santralı yardımcı güç kaynağı sistemleri, işletim, bekleme ve acil durum güç kaynaklarını içerir. Bu sistem, 10 kV ve 0,4 kV AC ile 220 V, 110 V DC gerilim seviyelerinde dağıtım yapabilen bir altyapıya sahiptir. Yardımcı güç kaynağı, iç ve dış kaynaklar olmak üzere iki ana kısımdan oluşur. Normal işletme koşullarında, yardımcı güç kaynağı iç kaynağı türbin üreteci iken, acil durumlarda yardımcı güç kaynağı dizel üreteçler ve akümülatör bataryalarından sağlanır [8].

Santralin soğutma düzeni, deniz suyunun tek bir geçişte ısı değişim ünitesinden geçirilmesine dayanan bir sistemdir. Akkuyu NGS'nin soğutma suyu denizden temin edilmektedir. Güvenlik sistemleri için kullanılan nihai ısı kuyusu da deniz kaynaklıdır. Nükleer Güç Santralı güvenlik sistemleri, koruma, yerelleştirme, destek ve kontrol sistemlerini içerir. NGS ayrıca tasarıma dayalı ve tasarım dışı kaza yönetim sistemlerine de sahiptir [8].

NGS'nin güvenliği, iyonlaştırıcı radyasyon ve radyoaktif maddelerin çevreye salınımını engellemeye yönelik fiziksel bariyer sistemine dayanmaktadır. Bu bariyerlerin korunması ve etkin hale getirilmesi için teknik ve idari tedbirler alınmaktadır. Personel, nüfus ve çevre koruma tedbirleri de kesintisiz olarak uygulanmaktadır [8].

Yakıt matrisi, yakıt elemanları muhafazası, reaktör soğutucu akışkan devresinin sınırları ve reaktör ünitesinin sızdırmaz muhafazası gibi ana fiziksel bariyerlerden oluşmaktadır. Tüm bariyerler, etkinlik ve güvenilirlik açısından düzenli olarak kontrol edilmektedir. Gaz ve aerosol salımları, özel iyot ve aerosol filtreleri ile donatılmış ventilasyon sistemlerinden geçirilir [8].

V. SONUÇLAR

Bu çalışma, Akkuyu Nükleer Güç Santralı'nın teknik özelliklerini ve bileşenlerini detaylı bir şekilde inceledi. Aşağıdaki sonuçlar elde edilmiştir:

- Akkuyu Nükleer Enerji Santralı, Türkiye'nin ilk nükleer enerji tesisidir ve Rusya'nın ROSATOM tarafından geliştirilmektedir. Türkiye'nin güney sahilinde konumlanmış olup toplamda 4.800 megavatlık bir kapasiteye sahip olacak şekilde planlanmıştır.
- Santralın temel tasarımı, VVER-1200 tipi çift devreli bir basınçlı su reaktörüdür. Bu reaktörler, düşük zenginleştirilmiş uranyum kullanarak termal enerjiyi elektrik enerjisine dönüştürmektedir.
- Ana ekipmanlar arasında dört adet VVER-1200 tipi su reaktörü, buhar üreteçleri, ana dolaşım pompaları ve türbin-jeneratör seti bulunmaktadır. Tüm bu ekipmanlar çift katmanlı betonarme bir koruma kabı içerisinde yer almaktadır.
- Elektrik sistemleri, enerji üretimi, dağıtımı ve yardımcı güç kaynaklarını içerir. Normal işletme koşullarında, güç kaynağı türbin üretecidir ancak acil durumlarda dizel üreteçler devreye girer.
- Santralin güvenliği, iyonlaştırıcı radyasyon ve radyoaktif maddelerin çevreye salınımını engellemeye yönelik fiziksel bariyer sistemine dayanmaktadır. Ayrıca, gaz ve aerosol salımları için özel filtrelerle donatılmış ventilasyon sistemleri bulunmaktadır.

Bu sonuçlar, Akkuyu Nükleer Güç Santralı'nın teknik olarak güçlü, güvenli ve çevreye duyarlı bir tesis olduğunu göstermektedir. Gelecekte, bu santralin Türkiye'nin enerji ihtiyacına önemli bir katkı sağlaması beklenmektedir.

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Prospects for modernizing energy supply in the Republic of Uzbekistan: Introduction of modern technologies and sustainable development

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Abstract – This article examines a set of measures to solve the problem of energy supply in the Republic of Uzbekistan. The main directions include the modernization of energy infrastructure, the introduction of modern control and monitoring technologies, the development of renewable energy sources, the optimization of electricity consumption, the development of international cooperation and support for energy efficiency in industry. These steps are aimed at improving the reliability of energy supply, reducing energy losses and supporting sustainable development of the energy sector in Uzbekistan.

Keywords – energy supply, modernization, control technologies, renewable energy sources, energy efficiency, sustainable development, electricity

I. INTRODUCTION

Modern electrical energy management systems play a critical role in modernizing the energy infrastructure of the Republic of Uzbekistan. The country faces challenges such as increasing electricity consumption, the need to upgrade old energy networks and improve energy efficiency. The introduction of modern management systems is becoming strategically important to ensure sustainable development of the economy and social sector.

Key aspects of modernization are the introduction of digital technologies, integration of distributed energy sources and optimization of load management. Digital platforms allow you to automate the monitoring and management of energy processes, providing accurate forecasting of consumption and optimization of energy consumption. Integrating renewable energy sources requires the development of control systems that can efficiently integrate diverse sources into the grid.

Practical examples of successful implementation of such systems have already been observed in various countries, demonstrating a reduction in energy losses and an increase in the sustainability of energy supply. The introduction of modern electrical energy management systems is necessary to increase energy efficiency and reduce economic costs, contributing to the sustainable socio-economic development of the Republic of Uzbekistan.

Electric power quality assessment is a key aspect of energy infrastructure both globally and in the context of individual countries, including the Republic of Uzbekistan. The quality of electricity is determined by a set of technical parameters, such as voltage stability, frequency, harmonics, absence of interruptions, etc. These parameters are important not only for ensuring the reliability of electrical equipment, but also for maintaining consumer safety and the efficiency of production processes [3].

II. MATERIALS AND METHOD

Globally, power quality is regulated by international standards and guidelines, such as those of the International Electrotechnical Commission (IEC) and the European Association of Electricity Producers

and Distributors (EURELECTRIC). These standards establish requirements for power systems aimed at ensuring stable operation of networks and protecting consumers from possible risks associated with poor quality power supplies.

In the Republic of Uzbekistan, assessment and control of power quality also includes monitoring of technical parameters of network systems, carried out by national energy organizations and regulators. The importance of maintaining a high level of power quality in the country is explained not only by the needs of industrial and domestic consumers, but also by the desire to improve energy infrastructure in the context of rapid technological changes and sustainable economic development. Over the past 5 years, the volume of electricity production in Uzbekistan has increased from 61 billion kW/h to 72 billion kW/h, or 1.2 times, which indicates the relevance of this topic. Graph 1 shows the specific electricity consumption for the period 2022-2023.

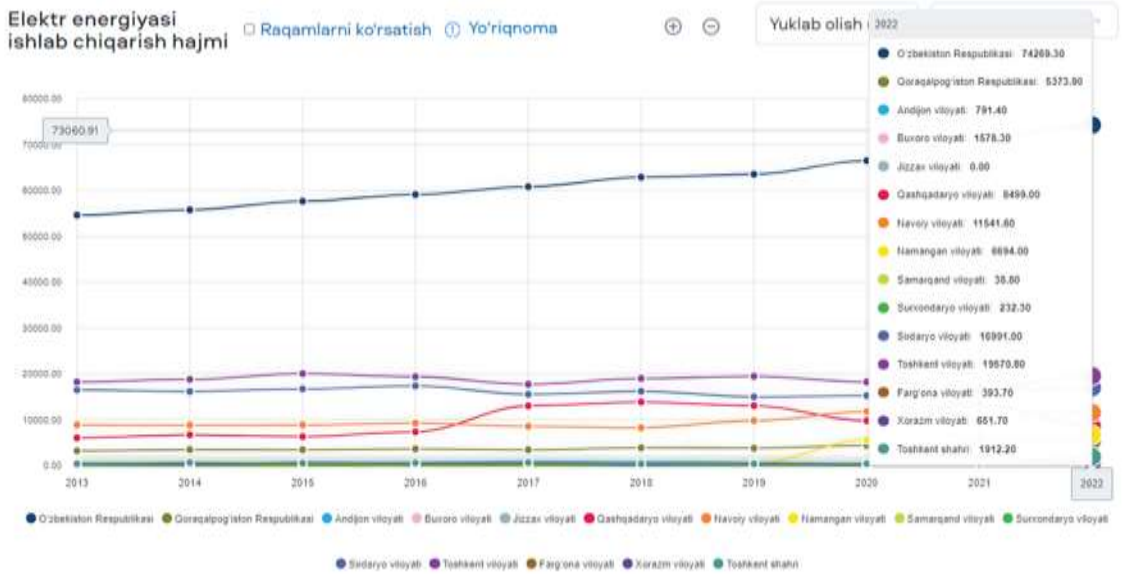

Fig. 1. Specific electricity consumption for the period 2022-2023.

Technical control of the quality of electrical energy includes a systematic analysis of various parameters of electrical networks, aimed at ensuring the stability and reliability of the power supply. Key aspects include monitoring voltage, frequency and harmonic distortion in the electrical network. This allows you to identify and manage potential problems, such as interruptions and failures that could affect the operation of sensitive equipment. It is also important to monitor power factor parameters, phase symmetry and other characteristics, which helps optimize the operation of power systems and increase energy efficiency [1].

However, in the Republic of Uzbekistan, several key aspects limit the effective implementation of modern electrical energy quality control standards and the modernization of the energy industry. Among the main problems are the insufficient technical equipment of the energy infrastructure, limited financial resources for investment, as well as the lack of modern regulatory and regulatory frameworks that meet international standards. Insufficient personnel qualifications and an imperfect monitoring and diagnostic system also play a significant role in this context.

The impact of insufficient implementation of modern electrical energy quality control standards in the Republic of Uzbekistan on production processes is manifested through a number of specific aspects. For example, frequent voltage fluctuations and instability in network frequency can lead to continuous interruptions in the operation of industrial equipment, especially those that require a stable power supply for their normal operation, such as automatic production lines and computerized systems.

In addition, inconsistencies in power quality parameters can lead to increased electricity consumption due to the need to compensate for energy losses when moving through poor-quality networks. This increases the operating costs of enterprises and reduces their competitiveness in the market. An example is

the heavy industrial sector, where even small power outages can lead to production downtime, significant economic losses and loss of consumer confidence [2].

III. RESULTS

Technical limitations can also hinder the adoption of modern technologies aimed at improving energy efficiency and reducing environmental impact. For example, the use of high-tech equipment such as variable frequency drives and automated control systems requires a stable and high-quality power supply for optimal operation. In conditions of insufficient control of power quality, such technologies may not operate at full capacity, which limits their effectiveness and profitability of implementation. The efficiency of production processes directly depends on the quality and stability of power supply, which makes the issue of increasing control over power quality critical for the modernization and development of the industrial sector of the Republic of Uzbekistan.

In the Republic of Uzbekistan, the issue of insufficient quality of electricity is an urgent problem that requires an integrated approach and solution through the modernization of energy infrastructure and the introduction of modern management and control technologies. One of the key areas for improvement is the replacement of outdated equipment such as transformers and distribution networks with modern components with increased efficiency and reliability. The project to modernize the electrical network in Tashkent became an example of the successful implementation of such measures, which led to a reduction in emergencies and increased efficiency of energy supply for the population [4].

The introduction of automated monitoring and control systems also plays an important role in improving the stability of energy supply. Remote energy quality monitoring systems allow you to quickly respond to deviations in network parameters, such as voltage and frequency, and take timely measures to eliminate them. This not only improves the reliability of power supply, but also reduces energy losses during the transmission process.

The use of modern technologies for monitoring and analyzing power quality also has a significant impact on energy processes. For example, the introduction of a system for remote monitoring of energy quality at large energy facilities in the Republic of Uzbekistan made it possible to reduce the frequency of failures and improve voltage regulation, which directly affects the production processes of industrial enterprises and residential areas.

To ensure sustainable development of the country's energy sector, it is also necessary to pay attention to improving the qualifications of technical personnel. This will allow specialists to effectively manage new technologies and methods for monitoring power quality, ensuring the stability and efficiency of energy systems.

Thus, the implementation of a set of measures to modernize infrastructure, introduce modern technologies and improve the skills of specialists is a necessary step to solve the problem of insufficient quality of electricity in the Republic of Uzbekistan. These measures contribute to improving energy supply, increasing the efficiency of production processes and the overall economic stability of the country.

The economic benefits of modernizing the energy infrastructure in the Republic of Uzbekistan are manifested through several key aspects:

- reduction in operating costs entailsthe introduction of modern equipment and technologies makes it possible to reduce the costs of operating energy systems. New equipment is more efficient to operate and requires fewer resources for maintenance and repair, which leads to significant savings for energy companies and the state budget.

- improving the quality of services indicates an increase in the stability of energy supply and a decrease in the frequency of emergencies, which have a beneficial effect on the economy. Improved energy supply contributes to the continuous operation of industrial enterprises, reduces losses in production processes due to power supply failures and improves the living conditions of the population.

- attracting investment and business development in the future will show improved infrastructure and energy supply creating a more attractive investment environment for local and international investors. A reliable energy system facilitates the development of new industrial and technological projects, which stimulates economic growth and creates new jobs.

IV. DISCUSSION

An example of an economic benefit would be improvements in energy efficiency in specific regions of the country. For example, thanks to the modernization of the energy network in one of the regions of Uzbekistan, it was possible to reduce energy losses during the transmission process by 15%, which led to savings of more than $2 million per year by reducing the consumption of resources to compensate for losses and repair equipment. This further stimulated the development of the local economy and improved the living standards of local residents [6].

The introduction of energy efficient technologies in the residential sector of the Republic of Uzbekistan is one of the key areas of modernization aimed at improving energy efficiency. For example, replacing old windows and installing thermal insulation materials in homes can significantly reduce heat loss and average annual heating costs by 20%. This will lead to savings for the population and a reduction in overall energy costs in the country. Considering that more than 30 million people live in the Republic of Uzbekistan, potential savings on heating can reach 6 billion USD. in year. This demonstrates not only the improvement in the living conditions of the population, but also the economic benefits of the energy infrastructure modernization strategy [2].

The introduction of modern control and monitoring systems for power grids makes it possible to reduce electricity losses during transmission and distribution. For example, the introduction of automated control systems can reduce losses by up to 10%, which, given the current volume of consumption in the Republic of Uzbekistan, estimated at 72 billion kWh per year, amounts to savings of up to 7 billion kWh annually. With an average electricity cost of 5 cents per kWh, this could result in savings of more than $350 million per year for the country. Such measures not only reduce the operating costs of the energy system, but also contribute to the sustainable development of the national economy."

The introduction of advanced energy-efficient solutions into the production processes of industrial enterprises of the Republic of Uzbekistan demonstrates significant economic efficiency. For example, a leading textile mill in the city of Tashkent, equipped with modern high-tech weaving machines with energy-saving features, reduced energy consumption by 20% in the first six months of operation. With an average annual consumption of 80 million kWh, this resulted in savings of 16 million kWh per year. Based on the current cost of electricity of 7 cents per kWh, the total savings reached $1.12 million per year. This made it possible to reduce operating costs and increase the competitiveness of products, ensuring the sustainable development of the enterprise and investing in the country's economy [5].

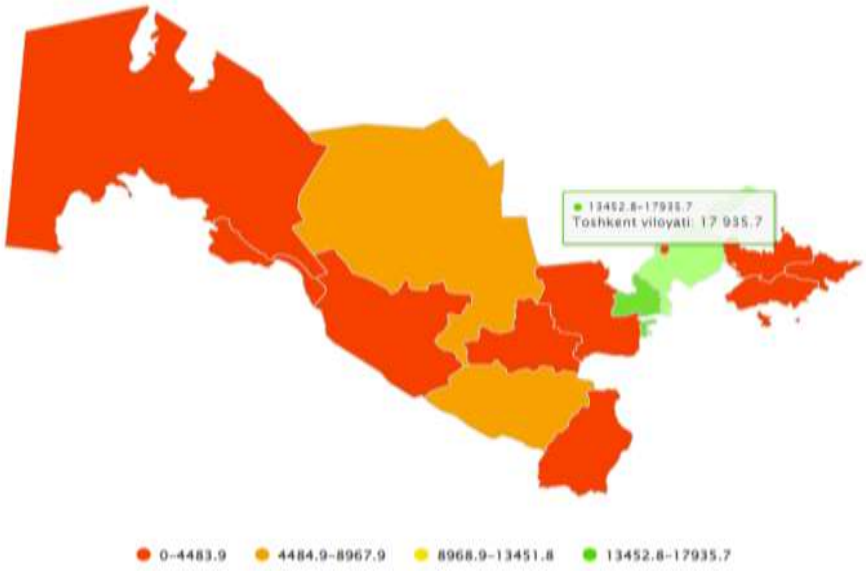

Fig. 2. Electricity consumption in the Tashkent region.

V. CONCLUSION

To solve the problem of energy supply in the Republic of Uzbekistan, a number of specific methods and measures can be proposed:

- Modernization and expansion of energy infrastructure, taking into account the replacement of outdated energy-intensive devices and equipment with modern and energy-efficient analogues, as well as the expansion of network infrastructure to improve access to electricity in remote and underserved areas.

- Introduction of modern control and monitoring technologies, taking into account the introduction of automated monitoring and network management systems for the rapid detection and elimination of emergencies, as well as the introduction of load forecasting systems and optimization of electricity distribution.

- Development of renewable energy sources (RES), taking into account the promotion of investments in RES, such as solar and wind energy, to diversify energy supply sources, as well as stimulating the construction and operation of alternative energy sources through tax incentives and government support.

- Optimization of electricity consumption, taking into account the introduction of energy-efficient technologies and standards in industry, construction and the housing sector, as well as conducting educational programs and energy saving campaigns among the population and enterprises.

- Development of international cooperation based on establishing partnerships with international organizations and countries to exchange experience and technologies in the field of energy, as well as attracting foreign investment and technical assistance for the implementation of major projects to modernize energy infrastructure [11].

-Development of energy efficiency in industry based on implementing programs for updating and modernizing industrial equipment in order to reduce energy consumption and increase the efficiency of production processes, as well as conducting energy efficiency audits at enterprises with the development of individual recommendations for optimizing energy consumption [8].

- Updating legislation and regulation in the energy sector through the development and implementation of new legislation and regulations that help stimulate investment in energy projects and the development of a competitive electricity market, as well as strengthening control over compliance with environmental standards and regulations in the energy sector to reduce the negative impact on environment [10].

- Increasing energy security through the creation of reserve energy capacities and systems for ensuring the reliability of energy supply in emergencies and accidents, as well as the development of measures to protect critical energy infrastructure facilities from cybersecurity threats and terrorist acts [9].

- Stimulating and developing small and medium-sized enterprises in the energy sector while supporting innovative start-ups and projects in the field of energy supply and energy efficiency through government programs and financial instruments, as well as creating favorable conditions for the development of the private sector in the field of alternative energy and distributed generation.

These measures can help improve the reliability and quality of electricity in the Republic of Uzbekistan, reduce energy losses and support the sustainable development of the country's energy sector [7].

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Arslandede Plütonunun (Doğu Pontidler) Jeolojisi ve Mineral Kimyası

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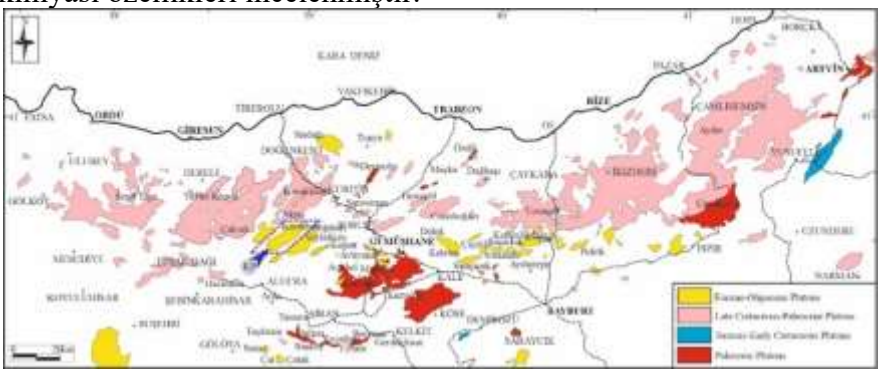
Özet – Bu araştırma, Doğu Pontidler (NE Türkiye)'nin güneyinde Bayburt bölgesinde yer alan Orta Eosen yaşlı Arslandede Plütonu'nun jeolojisi ve mineral kimyası özelliklerini incelemiştir. Arslandede Plütonu, genel olarak KB-GD yönelimli olup yaklaşık 44 km²'lik bir alanı kaplamaktadır. Kayaçlar, gabroik diyorit den monzogranite kadar değişim gösteren geniş bir bileşim aralığı sergilemektedir. Birincil mineralleri plajiyoklaz (An_{25-48}), ortoklaz (Or_{69-88}), kuvars, amfibol (Mg#=0.59-0.67), biyotit (Mg#=0.58-0.62), piroksen (Mg#=0.70-0.75) ve Fe-Ti oksitler oluşturmaktadır. Amfibol minerallerinin mikroprob verilerinden hesaplanan kristalleşme sıcaklıkları 737°C ile 812°C arasında değişmektedir. Basınç tahminleri ise 0.09 ila 1.61 kbar arasında bir aralığı işaret etmektedir. Tüm veriler dikkate alındığında, incelenen Arslandede plutonunun sığ derinliklere (~ 1-5 km) yerleşerek katılaştığı söylenebilir.

Anahtar Kelimeler – Bayburt (KD Türkiye), Mineral kimyası, Termobarometre, Doğu Pontidler, Arslandede Plütonu

I. GİRİŞ

Alpin-Himalaya orojenik kuşağı içinde, kuzeydoğu Türkiye'de yer alan Doğu Pontidler, geniş bir plütonik ve volkanik kayaç topluluğunu barındırmaktadır [1], [2], [3], [4], [5], [6], [7], [8]. Bölgede yer alan plütonik kayaçlar, Permo-Karbonifer'den Geç Eosen'e kadar geniş bir yaş aralığına sahiptirler. Özellikle, Orta Eosen yaşlı plütonik kayaçlar, Doğu Pontidler'in güney kesiminde, kuzey bölgesine nazaran daha yaygındırlar (Şekil 1). Bu araştırmanın konusu olan Arslandede Plütonu, Doğu Pontidlerin güneyinde yer almaktadır (Şekil 1). İnceleme alanındaki Arslandede plütonu [6], [9] ve diğer Orta Eosen yaşlı plutonlar [6], [10], [11], [12] ile ilgili detay çalışmalar yapılmasına rağmen, Arslandede Plütonu'nun mineral kimyası ile ilgili herhangi bir çalışma yapılmamıştır. Bu çalışmada, Bayburt yöresinde yer alan Arslandede Plütonunun jeolojik ve mineral kimyası özellikleri incelenmiştir.



Şekil 1. Doğu Pontidlerdeki Paleozoyik-Eosen yaş aralığında oluşmuş plütonların dağılımı [6]'dan değiştirilerek)

A. Bölgesel Jeoloji

Çalışma alanı Alp-Himalaya Orojenik sisteminin bir parçası olan Doğu Pontidler'de yer almaktadır (Ketin 1966; Şekil 1). Doğu Pontidler'deki temel kayaçları; (1) Mavişist-fasiyesindeki metamorfik birimler ile

yüksek-T, düşük-P metamorfik birimlerinden oluşan Variskan metamorfik kompleksleri [13] ve (2) bu birimleri kesen Karbonifer yaşlı plütonlar [14], [15], [16], [17], [18], [19], [20], [21], [22], [23] oluşturur. Temel kayaçlar üzerine, uyumsuz olarak Erken-Orta Jura yaşlı volkano-tortul istif gelmiştir [24], [25], [26], [27], [28]. Bu istif, Erken-Geç Jura yaşlı intrüzyonlar tarafından kesilmiştir [29], [30], [31], [32]. Geç Jura-Erken Kretase dönemi, yoğun bir karbonat çökelimi ile karakterize edilir (Berdiga Formasyonu, [33]). Bu birimler Geç Kretase yaşlı volkanik kayaçlar tarafından uyumlu olarak örtülmüştür [34], [35], [36], [37], [38], [39] ve Geç Kretase yaşlı plütonik kayaçlar tarafından kesilmişlerdir [3], [4], [40], [41], [42], [43], [44], [45], [46], [47], [48]. Bölgede Geç Kampaniyen'den Maastrihtiyen'in sonuna kadar devam eden yüksek-K'lı magmatizma gözlemlenmiştir [49], [50]. [51] ve [52]'e göre, Anatolid-Torid bloklarının çarpışması Geç Paleosen ila Erken Eosen döneminde gerçekleşmiştir. Bölgede Erken Eosen yaşlı adakitik kayaçların varlığı [53], [54], [55], [56], [57], [58], yay-kıta çarpışmasının son aşamasını temsil eder. Doğu Pontidler'de Eosen yaşlı birimler, volkanik ve volkanoklastik kayaçlar, bazik ila orta dereceli piroklastikler, lav akıntıları ve dayklardan oluşur [1], [5], [59], [60], [61], [62]. Bu birimler, aynı yaştaki kalk-alkalen plutonlar tarafından kesilirler [2], [6], [10], [11], [58], [63], [64], [65], [66], [67]. Bölgede Geç Miyosen-Pleyistosen yaşlı volkanik ve kırıntılı kayaçlar ile Neojen yaşlı volkanik kayaçlar yaygın olarak gözlemlenmiştir [1], [51], [59], [68], [69]. Doğu Pontidler'in en yaşlı kayaçlarını ise Kuvaterner yaşlı traverten, alüvyon ve yamaç molozları oluşturmaktadır.

II. MATERYAL VE YÖNTEM

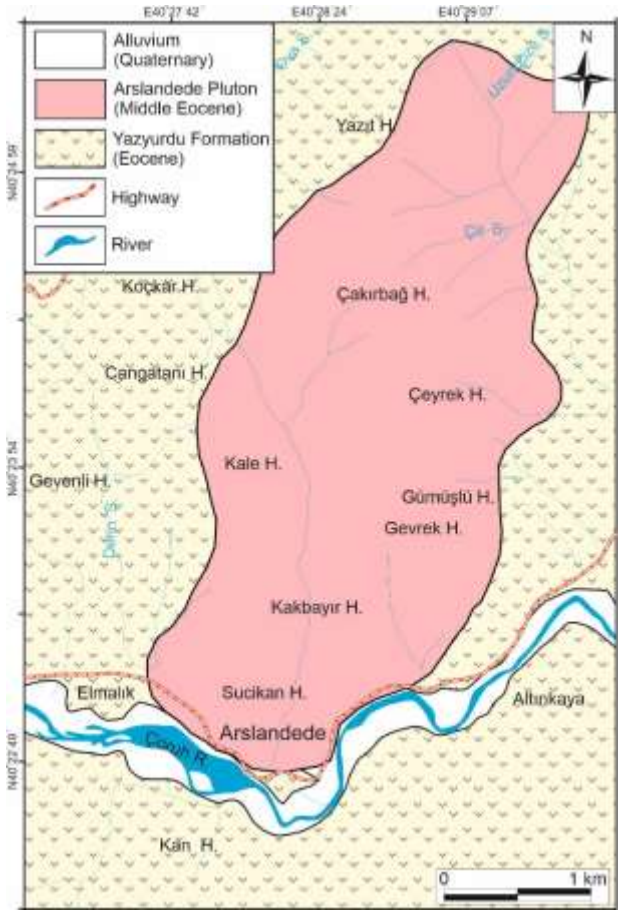
Arslandede Plütonu'ndan toplanan iki temsili kaya örneği (monzodiyorit ve kuvars monzonit) üzerinde mineral kimyası analizleri, Amerika Birleşik Devletleri'ndeki New Mexico Tech Üniversitesi Jeolojik ve Mineral Araştırma Laboratuvarı'nda elektron mikroprob teknikleri kullanılarak gerçekleştirildi. Analizler için cilalanmış ince kesitler kullanıldı. CAMECA SX 100 Elektron Mikroprobu, 15 kV ivme gerilimi ve 20 nA ışın akımı çalışma koşullarında kullanıldı. Al, Si, Ti, Ca, Mn, Fe, Mg, K ve Na gibi elementler için 10 µm'lik bir ışın çapı kullanıldı ve sayma süreleri 10 saniye idi. Piroksen, amfibol, epidot, zirkon ve Fe-Ti oksit mineralleri için analiz sırasında odaklanmış bir ışın çapı olarak 1 µm kullanıldı. Mika, feldspat ve klorit analizlerinde olası Na kaybını azaltmak için 10 µm odaklanmamış bir ışın kullanıldı. Standartlaştırma için Nielsen ve Sigurdsson (1981) tarafından tanımlanan sertifikalı referans malzemeleri (diopsit, kaersütit, albit, ortoklaz, biyotit, manyetit ve anortit (UCB)) kullanıldı.

III. BULGULAR

A. İnceleme Alanının Jeolojisi

Bu çalışmanın odak noktası olan Arslandede Plütonu, Doğu Pontidler'in güney kesiminde, Bayburt ilinin kuzeyinde, Arslandede köyü yakınlarında yer almaktadır (Şekil 2). Arazi gözlemleri, Tersiyer-Kuaterner dönemine ait volkanik ve plütonik birimlerin yaygın varlığını ortaya koymaktadır. Eosen yaşlı Yazyurdu Formasyonu, çalışma alanındaki en eski birimi temsil etmekte olup, Orta Eosen yaşlı Arslandede Plütonu tarafından kesilmektedir. Bu birimler, uyumsuz olarak Kuaterner alüvyonları tarafından örtülmektedir (Şekil 2). Eosen yaşlı Yazyurdu Formasyonu, ağırlıklı olarak andezit, bazalt ve bunlarla ilişkili piroklastik birikimlerden oluşan bir dizi içermekte olup, arada yer yer kumtaşı tabakaları bulunmaktadır (Şekil 2). Andezit ve bazalt genellikle gri renkte olup, yer yer kül sarısı veya kahverengimsi tonlarda da gözlenmektedir. El örneği incelemesinde, plajiyoklaz ve mafik minerallerin varlığı gözlemlenmiştir. Volkanik breşler, andezit parçalarının (2-40 cm, yarı köşeli) bir matris içinde yer aldığı koyu gri ile yeşilimsi renk değişiklikleri sergilemektedir. Tüfler genellikle gri veya yeşil renkte ve gözenekli olup, boşluklar kalsit, epidot ve kuvars gibi ikincil minerallerle doldurulmuştur. Arslandede Plütonu, yaklaşık 3 km²'lik bir yüzey alanına sahip olup, yaklaşık 3 km uzunluğunda ve 1 km genişliğindedir. Arazi gözlemleri, plütonun aynı döneme ait volkanik birimlere sokulduğunu ve temas bölgelerinde kireçtaşlarının yeniden kristalleşmesine neden olduğunu göstermektedir. Plüton içinde soğuma çatlakları belirgindir. Bu çatlak sistemleri mekansal değişkenlik göstermekte olup, özellikle Arslandede ve Kakbayır Tepesi civarında seyrek olarak görülmekte ve iyi eklemli kaya kütlelerine yol açmaktadır. Buna karşılık, ana kaya temasına

yakın bazı bölümler yoğun şekilde çatlamış ve breşleşmiş plütonik kayaçlar sergilemekte olup, bu bölgelerde uygun blok gelişimi bulunmamaktadır. Arslandede Plütonu genellikle masif bir görünüm ile karakterize edilmektedir. Ancak, yerel alanlarda yer yer arenalaşma görülmektedir.



Şekil 2. Çalışma alanının jeolojik haritası [6], [9]'den değiştirilerek)

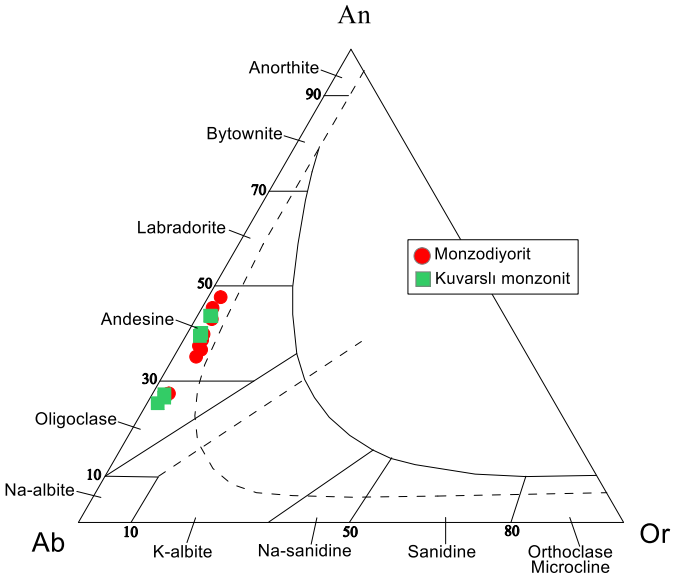
B. Mineral Kimyası

Arslandede plütonu, başlıca monzogabro, monzodiyorit, monzonit, kuvars monzonit ve granit'den oluşmaktadır. Başlıca mineraller plajiyoklaz, kuvars, ortoklaz, hornblend, biyotit ve piroksendir [6], [9].

B.1. Plajiyoklas

Çalışılan Arslandede Plütonu'ndaki plajiyoklaz minerallerinin mikroprob analizi, An_{25} ile An_{48} arasında bileşim değişiklikleri ortaya koymaktadır (Şekil 3). Hem mafik (monzodiyorit) hem de felsik (kuvars monzonit) litolojilerindeki plajiyoklazlar, SiO_2 içeriği %56 ila % 66, Al_2O_3 % 22 ila % 27, FeO^T % 0.2 ila % 0.5 ve K_2O % 0.3 ila % 0.7 arasında değişen içeriklere sahiptir.

Arslandede Plütonu'nun monzodiyoritlerinde bulunan plajiyoklazların farklı bileşimsel bölgelerinin varlığı genellikle salınımlı zonlama ile karakterizedir. Plajiyoklazlardaki An içeriğinin An_{25} ile An_{48} arasında değişmesi, mineralin büyüme sürecinde periyodik bileşimsel değişiklikleri göstermektedir.

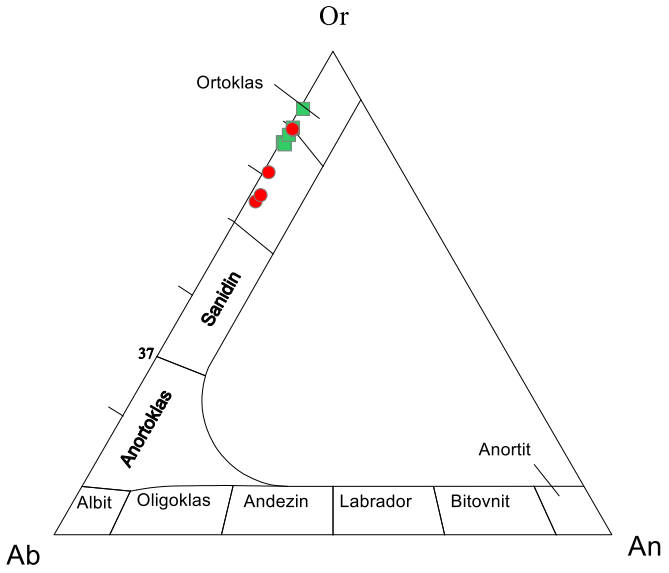


Şekil 3. Çalışılan plütonun feldispat bileşimlerini gösteren An-Ab-Or üçlü diyagramı [70]

B.2. K-Feldsipat

Eosen yaşlı kayaçların incelenmesi, çoğu örnekte K-feldspat minerallerinin varlığını ortaya koymuştur. Bu K-feldspat minerallerinin kimyasal analizleri, SiO_2 (% 65-66), Al_2O_3 (%18-19) ve BaO (%0.04-0.40) içeriğindeki değişkenlikler gözlenmiştir (Şekil 4).

K-feldspatlar genellikle ortoklaz bileşimini sergiler. Neredeyse tüm K-feldspat kristallerinin homojen bir bileşime sahip olduğu gözlemlenmiş ve kimyasal zonlamanın olmadığı anlaşılmıştır. Genel kayaç bileşimleri Or_{69} ile Or_{88} arasında değişmektedir (Şekil 4).

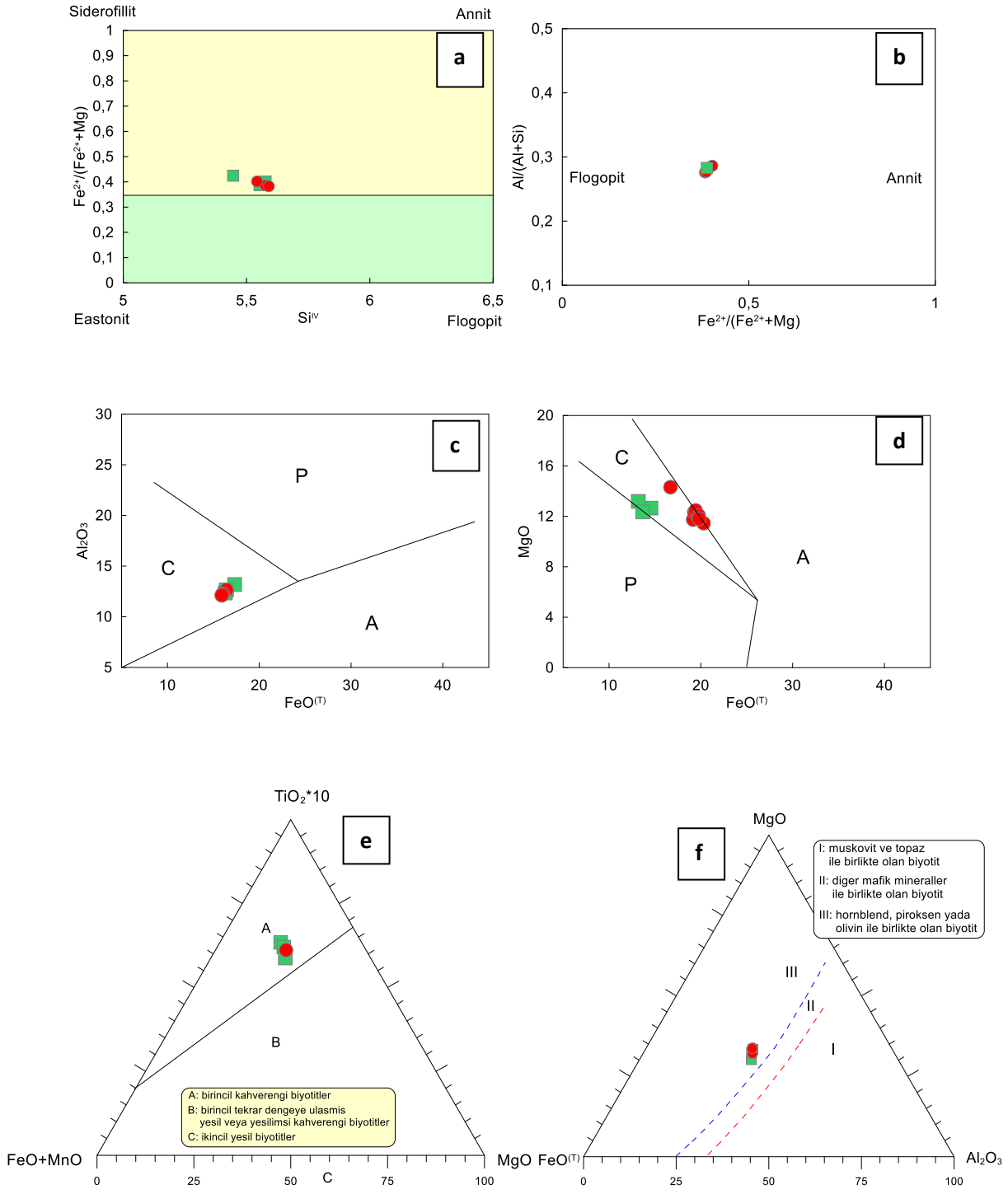


Şekil 4. K-feldspatların sınıflandırma diyagramı, An-Ab-Or diyagramı [71]

B.3. Biyotit

Biyotitlerin mikroprob analizleri, TiO_2 içeriğinin %4.4 ila % 5.3, Al_2O_3 içeriğinin % 12 ila % 13 ve MgO içeriğinin %13 ila %15 arasında değiştiğini ortaya koymaktadır. Mg# ($Mg/(Mg + Fe^{+2})$) ve Fe# ($Fe^{+2}/(Fe^{+2} + Mg)$) oranları sırasıyla % 0.58 ila % 0.62 ve % 0.38 ila % 0.42 aralığında değişmektedir. Bu değerler, biyotitlerin annit ile flogopit uç bileşimleri arasındaki bileşimlerle kristalleşmiş katılaşmış eriyik ürünler

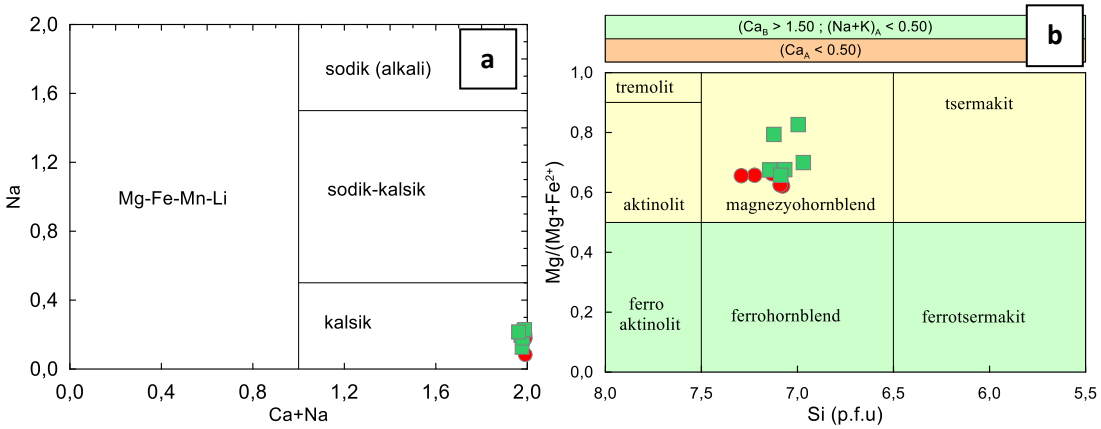
olarak oluşturulduğunu ve flogopit katı çözelti serisinin magnezyum açısından zengin ucu yakınında yer aldığını göstermektedir (Şekil 5a-b). Ayrıca, mikroprob analizleri, biyotitlerin $FeO^{(T)}$-Al_2O_3 diyagramında C alanında sınıflandırıldığını göstermektedir (Şekil 5c). Biyotitlerin MgO-$FeO^{(T)}$ diyagramında C alanında kümelendiğini göstermektedir (Şekil 5d). Biyotitlerin MgO-FeO+MnO-TiO_2^{*10} üçgen diyagramında birincil kahverengi biyotitler (A alanı) olarak sınıflandırıldığını göstermektedir (Şekil 5e). Biyotitlerin $FeO^{(T)}$-Al^2O^3-MgO üçgen diyagramına dayanarak hornblend, piroksen veya olivin ile birlikte bulunduğunu göstermektedir (Şekil 5f).



Şekil 5. Çalışılan kayaçlardaki biyotitlerin bileşimi: a) Si^{IV} - (Fe^{+2}/Fe^{+2} + Mg) diyagramı [72], b) $FeO^{(T)}$-Al_2O_3 diyagramı [73], c) $FeO^{(T)}$- Al_2O_3 diyagramı [73], d) $FeO^{(T)}$- MgO diyagramı [73], e) MgO-FeO+MnO-TiO_2^{*10} üçgen diyagramı [73], f) $FeO^{(T)}$-Al_2O_3-MgO üçgen diyagramı [74]

B.4. Hornblend

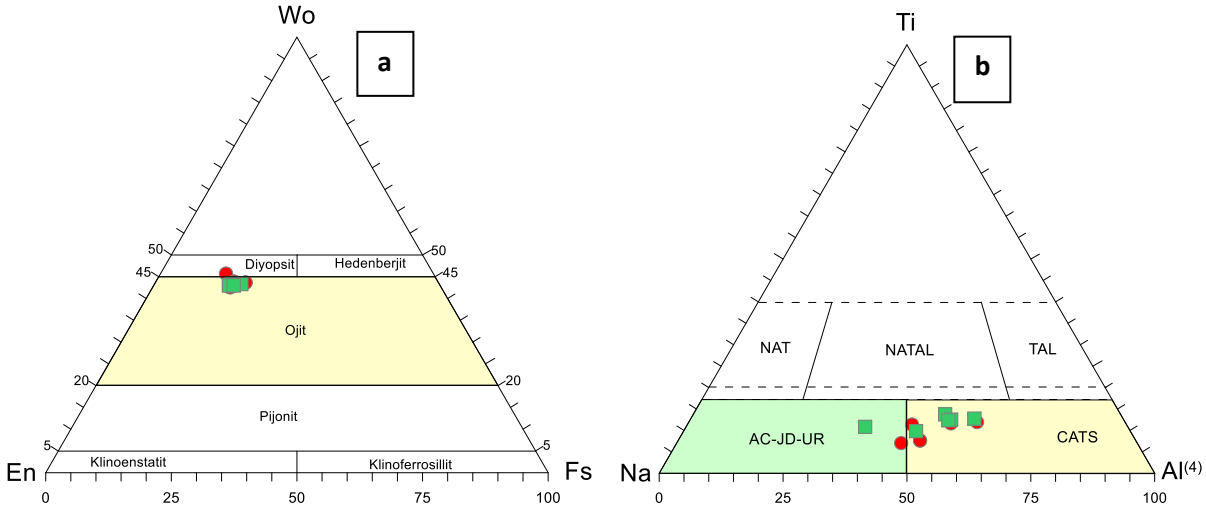
Çalışılan plütonik kayaçlardan yapılan amfibol mikroprob analizleri, Al_2O_3 içeriğinin % 4.7 ila % 5.6, SiO_2 içeriğinin % 48.0 ila % 49.9 ve Mg# değerlerinin % 0.59 ila % 0.67 arasında değiştiğini ortaya koymaktadır. Sınıflandırma diyagramları, tüm amfibollerin Na'ya karşı (Ca+Na) oranına dayanarak kalsik amfibol alanına ait olduğunu göstermektedir (Şekil 6a) ve [75]'e göre magnezyum hornblend kompozisyonuna sahip olduğunu göstermektedir (Şekil 6b).



Şekil 6. Çalışılan plütonik kayaçlardaki amfibol bileşimi [75]

B.5. Piroksen

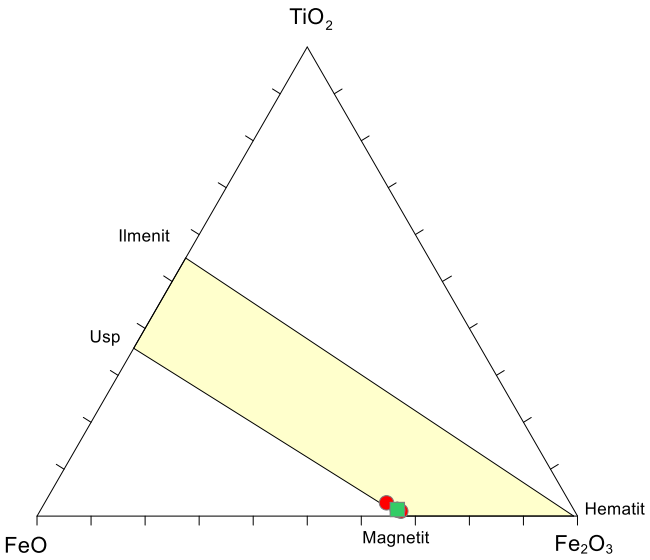
Piroksenler üzerinde yapılan mikroprob analiz sonuçlarına göre, Al_2O_3 içeriğinin % 0.5 ila % 1.4, SiO_2 içeriğinin % 52.0 ila % 53.1 ve Mg# değerlerinin % 0.70 ila % 0.75 arasında değiştiğini ortaya koymaktadır. Analiz sonuçlarına göre, örnekler Wo-En-Fs üçlü diyagramının Ojit bölgesinde kümelendi (Şekil 7a).



Şekil 7. (a-b) Wo-En-Fs, Ti-Na- $Al^{(4)}$ üçgen diyagramı [76]

B.6. Fe-Ti Oksit

Mikroprob analizlerinde, Fe-Ti oksitler, Fe# ($Fe^{+2}/(Fe^{+2}$ + Mg)) oranları % 0.35 ila % 0.37 aralığında değişmektedir. Şekil 8'da, örneklerin TiO_2-FeO-Fe_2O_3 üçlü diyagramında manyetit alanında kümeleştiği görülmektedir. TiO_2-FeO-Fe_2O_3 üçlü diyagramındaki örneklerin, minerallerin kimyasal bileşimlerinin belirli bir alanda kümelendiğini ve FeO ve Fe_2O_3 bileşenlerinin yoğunlaştığı bölgede bulunduğunu göstermektedir.



Şekil 8. Çalışılan plütonik kayaçlardaki Fe-Ti oksitlerin bileşimi [77]

C. Termobarometre Hesaplamaları

C.1. Amfibol-Plajiyoklas Termometresi

Magmalarının kristallenme sıcaklıklarının tahmin edilebilmesi için [78] tarafından önerilen amfibol-plajiyoklas termometresi kullanılmıştır. Bu termometrede sıcaklık T= 0.667 P - 48.98 + Y/- 0.0429 - 0.008314 LnK' formülüyle hesaplanmıştır. Bu termometrenin kullanımında öncelikli olarak amfibol-plajiyoklas denge kristallenmesine, biyotit, kuvars, K-feldispat, piroksen, Fe-Ti oksit ± sfen minerallerinin eşlik etmesi gerekir. Arslandede plütonunu oluşturan kayaçlarda [78] tarafından önerilen amfibol-plajiyoklas termometresi hesaplanan sıcaklıklar 737-812°C arasında olup, monzodiyoritlerde 745-788ºC, kuvarslı monzonitlerde 737-812ºC arasında değişmektedir (Tablo 1).

C.2. Amfibol-Plajiyoklas Barometresi

Plütonik kayaçlarda, hornblenlerdeki $Al^{(T)}$ içeriğinden yararlanılarak basınç tahmini yapılmak üzere kullanılan kalibrasyonlar aşağıda verilmiştir:

P (kbar)= 4.76 $Al^{(T)}$ - 3.01 [81];
P (kbar)= 5.03 $Al^{(T)}$ - 3.92 [79];
P (kbar)= 5.64 $Al^{(T)}$ - 4.76 [80].

Arslandede plutonunu oluşturan kayaçlarda yukarıdaki formüller yardımıyla hesaplanan kristallenme basınçları birbirine yakın değerlerdedir (Tablo 1). İncelenen plütondaki kayaçlara ait kristallenme basınçları 0.1–1.37 kbar arasında olup, monzodiyoritlerde 0.1–1.61 kbar, kuvarslı monzonitlerde 0.2–1.37 kbar arasında değişmektedir (Tablo 1).

Tablo 1. Arslandede Plütonu için amfibol-plajiyoklaz kullanılarak hesaplanan basınç tahminleri

	P (kbar) [79]	P (kbar) [80]	P (kbar) [81]	T (°C) [78]
Mineraller	Amfibol-Plajiyoklas			
Monzodiyorit				
Min	0.20	0.09	0.89	745
Max	0.97	0.72	1.61	788
Ort	0.48	0.44	1.16	772
SD (±)	0.31	0.32	0.29	16
Min Derinlik (km)	0.74	0.35	3.29	
Max Derinlik (km)	3.58	2.66	5.97	
Kuvarslı monzonit				
Min	0.15	0.35	0.84	737
Max	0.71	0.43	1.37	812
Ort	0.29	0.39	0.97	776
SD (±)	0.21	0.06	0.20	28
Min Derinlik (km)	0.54	1.30	3.10	
Max Derinlik (km)	2.63	1.59	5.07	

Min: Minimum, Max: Maximum, Ort: Ortalama, SD (±): Standart sapma. Derinlik kıtasal kabuk için 1 kbar = 3.7 km olarak alınmıştır [82].

IV. SONUÇLAR

Arslandede Plütonu, kuzeydoğu-güneybatı yönünde uzanan, elips şekilli bir plutondan oluşur. Yaklaşık 44 km²'lik bir alanı kaplar ve bileşim olarak monzodiyoritten kuvars monzonite kadar değişen litolojik değişkenlikler sergiler. Plütonik kayaçlar başlıca plajiyoklaz (Anortit içeriği: %27-48), ortoklaz (Ortoklaz içeriği: %73-91), kuvars, amfibol, biyotit, piroksen ve Fe-Ti oksitlerinden oluşur.

Arslandede Plütonunu oluşturan kayaçlardaki amfibollerin Mg# değerleri 0.63-0.73 arasında değişkenlik gösterirken, biyotitlerin Mg# değerleri 0.52 ila 0.58 arasında değişmektedir. Amfibol verilerinden elde edilen hesaplanmış kristalleşme sıcaklıkları 737°C ile 812°C arasında değişmektedir. Basınç değerleri ise 0.09 ila 1.61 kbar arasında değişmektedir.

Saha, petrografik ve termobarometerik tüm veriler dikkate alındığında, incelenen plütonların kıtasal kabukta sığ derinliklere (~ 1-5 km) yerleşmiş oldukları sonucuna varılabilir.

TEŞEKKÜR

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Integration of modern monitoring and control technologies into the energy infrastructure of the Republic of Uzbekistan: Prospects and economic benefits

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Abstract **–**This article discusses modern means of monitoring and control of electrical energy, their capabilities and advantages for ensuring the reliability and efficiency of energy supply. Particular attention is paid to technological solutions such as automated control and analysis systems, as well as their application in various industrial sectors and the domestic sector.

Keywords –Electrical energy, monitoring, control, automated systems, energy supply, energy efficiency, technology

I. INTRODUCTION

In modern conditions, sustainable and efficient energy supply is one of the key tasks for many countries, including the Republic of Uzbekistan. With the increase in electricity consumption and the increasing complexity of the energy infrastructure, there is a need to introduce modern monitoring and control tools that will ensure high quality and stability of electrical energy supplies. For the Republic of Uzbekistan, the use of such technologies is especially important due to a number of specific factors.

Firstly, the Republic of Uzbekistan is actively developing, which is accompanied by a significant increase in demand for electricity in both the industrial and domestic sectors. This requires the energy system not only to increase production capacity, but also to increase the efficiency of distribution and consumption of electricity. Modern monitoring and control tools, such as automated control systems (ACS), make it possible to optimize the processes of generation, transmission and distribution of electricity, reducing losses and increasing the overall reliability of energy supply [3].

Secondly, one of the main problems of the energy sector of Uzbekistan is the deterioration and insufficient modernization of the existing infrastructure. The introduction of modern monitoring and control technologies allows not only to quickly identify and eliminate faults, but also to carry out preventive measures for the maintenance and modernization of equipment. This helps to significantly reduce emergencies and increase the stability of the energy system as a whole. Third, Uzbekistan is actively seeking to diversify its energy sources, including the development of renewable sources such as solar and wind energy. Managing these sources requires the integration of sophisticated monitoring and control systems that ensure stability and efficiency of their operation. Modern means make it possible to integrate various energy sources into a single network, ensuring their uninterrupted operation and maximum efficiency of use [7].

In addition, improving the quality of electricity is an important aspect. Modern monitoring systems allow detailed analysis of power quality parameters such as voltage stability, frequency, harmonics and absence of interruptions. This is especially important for industrial plants, where the slightest fluctuations in power quality can lead to serious economic losses and reduced productivity. Thus, the introduction of modern means of monitoring and control of electrical energy in the Republic of Uzbekistan is a strategically important step aimed at ensuring reliable, efficient and sustainable energy supply. This not only helps

improve energy efficiency and reduce operating costs, but also creates conditions for further economic growth and improving the quality of life of the population.

II. Materials and Method

Modern means of monitoring and control of electrical energy include a variety of technological solutions aimed at increasing the reliability and efficiency of energy supply. The main areas of their application include automation of network management, analysis of power quality parameters, consumption forecasting and optimization of resource allocation.[2].

Automated control systems (ACS) play a key role in ensuring the stability of energy supply. They allow continuous monitoring of network parameters, prompt identification and elimination of faults, and optimization of power transmission and distribution processes. An example of successful implementation of automated control systems is the project to modernize the energy infrastructure in the Republic of Uzbekistan, which made it possible to reduce energy losses and increase the reliability of supplies.

Power quality is determined by a number of technical parameters such as voltage stability, frequency, harmonics and absence of interruptions. Modern analysis systems make it possible to study these parameters in detail and identify deviations that can negatively affect the operation of equipment and production processes. For example, the introduction of power quality monitoring systems at industrial enterprises can significantly reduce the number of emergency situations and increase overall productivity.

Modern technologies make it possible to accurately predict energy consumption and optimize resource allocation. This is especially important in environments with variable loads and intermittent energy sources such as renewable sources. Forecasting and optimization make it possible to reduce the costs of production and transmission of electricity, as well as improve the quality of service to consumers [4].

Some of the key systems and technologies used in intelligent electrical energy management systems (IECMS) include:

- Automated control systems (ACS) are a set of software and hardware designed for automatic collection, processing and analysis of data on the state of the energy system. They provide monitoring of the operation of all elements of the power system, including generators, transformers, power lines and distribution networks. ACS allow you to quickly respond to changes in system parameters, predict possible emergency situations and take preventive measures to prevent them. An example of the use of automated control systems is the SCADA (Supervisory Control and Data Acquisition) system, which is widely used for remote monitoring and control of energy facilities [1].

- Intelligent metering systems (AMR/AMI), (AMR - Automated Meter Reading) and intelligent metering systems (AMI - Advanced Metering Infrastructure) are designed to accurately measure and collect data on electricity consumption in real time. These systems allow control of consumption at the level of individual consumers and provide the ability to remotely control loads. The implementation of AMR and AMI helps to improve the accuracy of electricity metering, reduce commercial losses and improve interaction between energy suppliers and consumers.

- Distributed Energy Resource Management Systems (DERMS) are designed to integrate and manage various distributed generation sources, such as solar panels, wind generators, battery systems and other renewable energy sources. DERMS allow optimizing the operation of distributed energy sources, ensuring their effective integration into the overall energy system and helping to achieve a balance between electricity generation and consumption [5].

- Demand management systems (DMS), (DMS – Demand Management Systems) are aimed at optimizing electricity consumption by managing consumer loads. These systems reduce load peaks by redistributing consumption during periods of low demand, which helps reduce grid congestion and improve energy efficiency. DMSs can include technologies such as smart meters, circuit breakers, and appliance control systems.

- Predictive analytics and forecasting systems use machine learning algorithms and big data to analyze historical data and forecast future events in the power system. These systems allow you to predict loads, identify potential emergency situations and optimize maintenance planning. The introduction of such

systems helps to increase the reliability and stability of the power system, reduce operating costs and improve the quality of customer service [9].

- Cybersecurity in energy systems. In the context of digitalization of energy infrastructure, ensuring cybersecurity becomes a critical aspect. Modern information security systems include cyber threat protection systems such as firewalls, intrusion detection systems (IDS), data encryption and access control. These measures help protect energy infrastructure from cyber attacks, maintain data confidentiality and integrity, and ensure continuity of energy supply.

The introduction of intelligent electrical energy management and control systems based on modern technologies is a key factor for increasing the efficiency, reliability and sustainability of energy supply. These systems make it possible to optimize the processes of generation, transmission and distribution of electricity, reduce operating costs and improve the quality of customer service, which contributes to the sustainable development of the energy sector of the Republic of Uzbekistan.

III. RESULTS

Let's consider several examples of the successful use of modern means of monitoring and control of electrical energy in various industries. At large industrial enterprises, the introduction of automated control systems and analysis of power quality can significantly increase energy efficiency and reduce operating costs.

- Intelligent energy management systems Automated energy management systems have been installed at telecommunications facilities such as data processing centers (DPCs) and cellular base stations. These systems include intelligent controllers that provide real-time monitoring of network parameters such as voltage, current and frequency. As a result, it became possible to quickly identify deviations from normal indicators and take measures to eliminate them, which made it possible to reduce the frequency of emergency situations by 30%.

- Analysis of power quality made it possible to improve the reliability of power supply. For example, the average annual number of outages at telecommunications facilities decreased from 20 to 12 cases per thousand facilities, which ensured the continuity of equipment operation and improved the quality of services provided. Power quality analysis systems also identified areas with the greatest losses and instability, which made it possible to carry out targeted modernization measures and improve overall power supply quality indicators [1].

- Optimization of energy consumption, using intelligent control systems it was possible to significantly optimize energy consumption. As a result of the introduction of energy-saving technologies and optimization of equipment operating modes, electricity consumption at communication facilities decreased by 15%, which led to annual savings of about 1.5 million kilowatt-hours. This, in turn, reduced energy costs by $150 thousand per year, given the average cost of electricity in the region.

- Energy audits and equipment modernization, energy audits at communication facilities made it possible to identify outdated and inefficient equipment. After conducting audits and subsequent modernization, including replacing old transformers and uninterruptible power supplies with modern energy-efficient analogues, energy consumption at individual facilities decreased by 10-12%. This move also helped reduce heat losses and improve the overall energy efficiency of the telecommunications network.

- Renewable energy sources, to ensure sustainable development and reduce dependence on traditional energy sources, solar panels and wind generators have been installed at some base stations. As a result, the share of renewable energy in the telecommunications company's overall energy mix reached 5%, reducing carbon dioxide emissions by 200 tons per year and improving the company's environmental sustainability.

As facts show, the introduction of modern means of monitoring and control of electrical energy at communications and telecommunications enterprises in the Republic of Uzbekistan has made it possible to achieve significant improvements in the field of energy efficiency, reliability and sustainability of energy supply. These measures helped reduce operating costs, improve the quality of services provided and support the sustainable development of the industry.

The introduction of remote monitoring and control systems in residential buildings represents a significant step forward in improving energy efficiency and improving living conditions. Such systems include the installation of smart meters and automated lighting and heating control systems, which allow optimizing electricity and heat consumption in real time. Example of implementation in residential areas of Tashkent:

- Smart meters and lighting control systems. As part of a project to improve the energy efficiency of residential areas in Tashkent, smart electricity meters and automatic lighting control systems were installed. These technologies allow residents to monitor and manage their energy consumption more efficiently. Smart meters provide real-time consumption data, allowing residents to adjust their behavior and reduce excess energy consumption. As a result, the total energy consumption in these residential areas decreased by 15%.

- Economic indicators - a 15% reduction in energy consumption in residential areas of Tashkent provided significant savings. Based on the average energy consumption of one residential area of 3 million kilowatt-hours per year, the introduction of smart systems has reduced consumption by 450 thousand kilowatt-hours per year. Considering the average cost of electricity in the region is approximately $0.11 per kilowatt-hour, the total savings amounted to approximately $500 thousand per year.

- Heating and ventilation control systems. In addition to smart meters and lighting control systems, automatic heating and ventilation control systems have been introduced in some residential buildings. These systems regulate temperature and ventilation based on external and internal conditions, maintaining an optimal microclimate while saving energy. According to studies, such systems can reduce thermal energy consumption by 20%, which also makes a significant contribution to overall energy savings.

- Environmental performance is an integral part of the energy sector. Reducing energy consumption also helps reduce carbon dioxide emissions. Reducing electricity consumption by 450 thousand kilowatt-hours per year is estimated to reduce CO2 emissions by 360 tons per year, assuming an emission factor of 0.8 kg CO2 per kilowatt-hour for fossil fuel power plants. This is an important step towards improving the environmental situation and sustainable development of the city.

- Social aspects actively influence the implementation of remote monitoring and control systems, which not only improves economic and environmental indicators, but also helps improve living conditions for residents. The ability to monitor and manage energy consumption through mobile applications and interfaces makes these technologies convenient and accessible to a wide range of users. Increasing public awareness of the importance of energy conservation also plays a key role in creating a culture of responsible energy consumption.

Facts indicate the feasibility of widespread implementation of remote monitoring and control systems in residential buildings in Tashkent, which demonstrates significant advantages in both economic and environmental aspects. These measures improve energy efficiency, reduce energy costs and improve living conditions, which together support sustainable urban development.

In the energy sector, the introduction of modern monitoring and control tools can significantly improve the reliability and efficiency of energy supply. For example, modernization of distribution networks using automated monitoring and control systems has reduced the number of emergency situations by 30% and reduced energy losses by 10% [8].

IV. DISCUSSION

In the energy sector, the introduction of modern monitoring and control tools is a key factor in improving the reliability and efficiency of energy supply. Let's consider this using the example of communications and telecommunications enterprises, where a stable and high-quality power supply is critical to ensure the uninterrupted operation of network systems and equipment.

The introduction of modern monitoring and control tools at communications and telecommunications enterprises indicates an increase in the quality of supplied electrical energy:

- Modernization of distribution networks, implementation of automated monitoring and control systems for distribution networks at communications and telecommunications enterprises can significantly increase the reliability of energy supply. These systems involve the use of smart devices to measure and

analyze network parameters in real time. For example, smart voltage and current sensors are installed at key network nodes, providing constant monitoring of electrical energy parameters. As a result, the number of emergency situations in distribution networks is reduced by 30%, which significantly reduces equipment downtime and improves the quality of services provided.

- Reducing energy losses is one of the key factors. Modern monitoring and control systems also make it possible to reduce energy losses in distribution networks. For example, the introduction of automated control systems makes it possible to optimize network operating modes and promptly identify and eliminate faults. As a result, energy losses in distribution networks at communications and telecommunications enterprises are reduced by 10%. With an average electricity consumption of a communications enterprise of 50 million kilowatt-hours per year, this saves 5 million kilowatt-hours annually. Considering the average cost of electricity is $0.11 per kilowatt-hour, the savings amount to about $550,000 per year.

- Increasing the reliability and quality of services requires the introduction of modern monitoring and control tools, allowing communications and telecommunications enterprises to ensure a high level of reliability and quality of services. For example, remote monitoring and control systems allow you to quickly respond to changes in network parameters and prevent potential emergency situations. This is especially important for ensuring the uninterrupted operation of server and data centers, where even short-term power outages can lead to serious consequences, including data loss and financial losses [10].

- Technical indicators are continuously linked to intelligent monitoring systems to monitor many network parameters such as voltage, current, frequency, power factor and harmonic distortion. For example, the use of a SCADA (Supervisory Control and Data Acquisition) system allows not only to monitor current parameters, but also to predict their changes based on historical data and network behavior models. This allows communications and telecommunications enterprises to more effectively manage their energy resources and prevent emergencies before they occur.

- Economic and environmental indicators indicate that reduced energy losses and increased reliability of energy supply also lead to significant economic and environmental benefits. Reducing emergency situations and energy losses helps reduce operating costs and increase the profitability of communications and telecommunications enterprises. In addition, reducing energy consumption by 5 million kilowatt-hours annually reduces carbon dioxide emissions by 4 thousand tons per year, which improves the environmental situation and supports the sustainable development of the region.

The introduction of modern monitoring and control tools at communications and telecommunications enterprises can significantly increase the reliability and efficiency of energy supply, reduce energy losses and improve the quality of services provided. These measures contribute not only to economic but also environmental benefits, supporting the sustainable development of the energy sector and the economy as a whole [6].

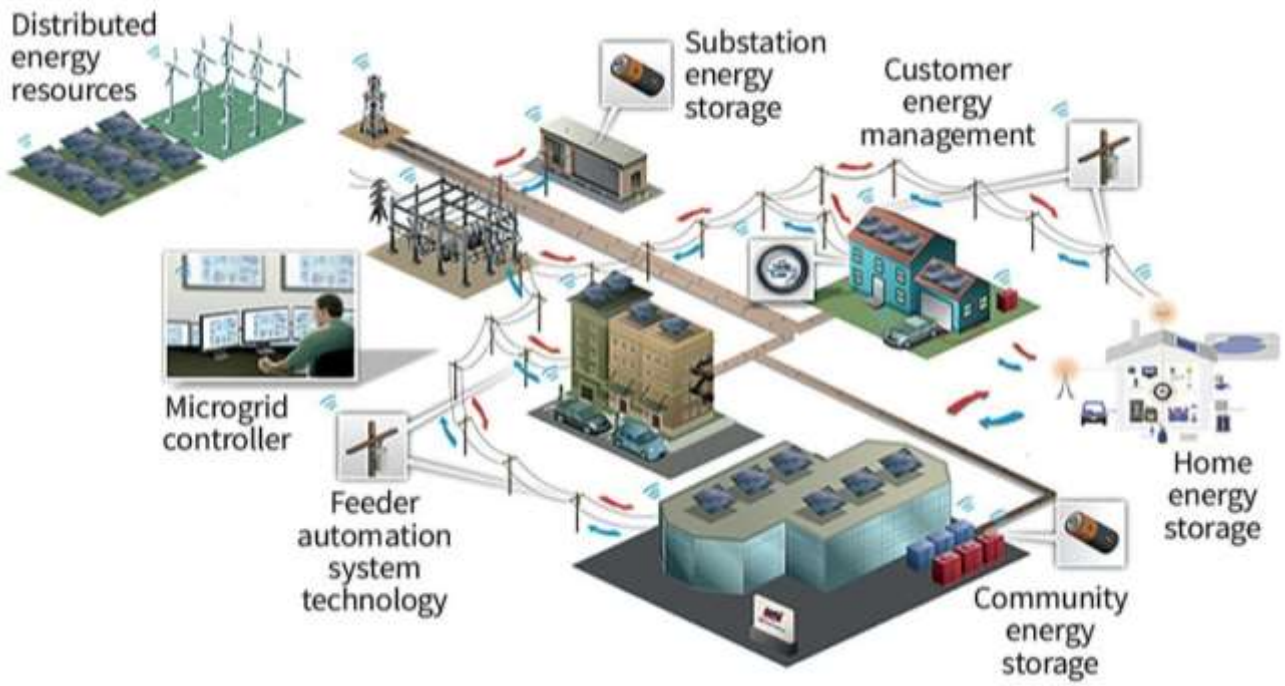

Fig. 1. Electricity consumption in the Tashkent region.

V. CONCLUSION

The introduction of modern means of monitoring and control of electrical energy in the Republic of Uzbekistan represents a strategic step towards increasing the efficiency and reliability of energy supply. The use of these technologies not only ensures prompt identification and elimination of emergency situations, but also significantly reduces energy losses, which is critically important in the context of increasing electricity consumption and the need to modernize energy infrastructure [11].

Modern automated systems make it possible to monitor and manage distribution networks in real time, which significantly increases their stability and reduces the likelihood of interruptions. For example, in the communications and telecommunications industry, where continuity of power supply is critical, the use of such technologies ensures the continuous operation of networks and services, minimizing risks and operating costs.

The economic benefits of implementing intelligent energy management systems come through significant reductions in operating costs and improvements in overall resource efficiency. Reducing energy losses and increasing energy efficiency directly affect the economic efficiency of industrial and residential facilities, which contributes to the long-term economic development of the region.

Reducing emissions of carbon dioxide and other harmful substances through increased energy efficiency is of environmental importance. These measures help improve the environmental situation and maintain sustainable development.

Thus, the introduction of modern means of monitoring and control of electrical energy is a necessary condition for ensuring reliable, efficient and sustainable energy supply in the Republic of Uzbekistan. These measures contribute to economic growth, improvement of living conditions of the population and the creation of a more sustainable and environmentally friendly energy system that can effectively cope with the challenges of our time [7].

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Cıvata Bağlantılarının Performanslarının ve Güvenilirliğinin Geliştirilmesi

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Özet – Cıvatalar günümüzde endüstride en çok kullanılan makina elemanlarından birisidir. Cıvatalar temel olarak çözülebilen bağlantıların teşkilinde ve güç (hareket) iletiminde yaygın olarak kullanılmaktadır. Cıvata bağlantılarının tasarımlarında ve bağlantının teşkilinde yapılacak olan birtakım düzenlemeler sonucunda bağlantının güvenirliği ve performanslarında iyileştirme sağlanabilmektedir. Bu çalışmada cıvata bağlantılarında montajdan, tasarımdan ve işletme koşullarından kaynaklanabilecek hataların önlenmesi, bağlantı performanslarının ve güvenirliklerinin artırılması için yapılması gereken faaliyetler sunulmaktadır. Ayrıca cıvata bağlantılarında çeşitli türlerde yapıştırıcıların kullanımı bağlantının performansının ve güvenilirliğinin geliştirilmesinde önemli bir rol oynamaktadır.

Anahtar Kelimeler – Cıvata bağlantıları; güvenirlik; tasarım; performans; çözülme

I. GİRİŞ

Cıvatalar günümüzde endüstride en çok kullanılan makina elemanlarından birisidir. Cıvatalar temel olarak çözülebilen bağlantıların teşkilinde ve güç (hareket) iletiminde yaygın olarak kullanılmaktadır.

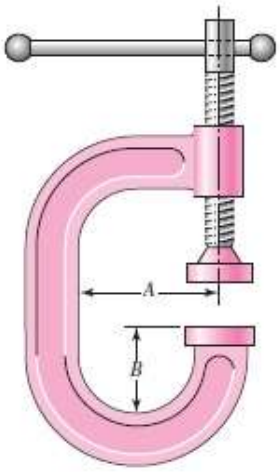
Cıvataların kullanıldığı alanlar oldukça çeşitlidir (Şekil 1) [1]:

- Bağlama elemanı olarak makina parçalarının montajında, çelik konstrüksiyonlarda, silindir kapaklarının montajında, boru flenşlerinde ve bazı parçaların temele tespitinde kullanılmaktadır.
- Gergi elemanı olarak yüksek gerilim hatları, halat bağlantıları ve ön gerilmeli sistemlerde kullanılmaktadır.
- Kapama elemanı olarak sızdırmazlık işlemlerinde ve yağ delikleri gibi yerlerde kör tapa elemanı olarak kullanılmaktadır.
- Ayar elemanı olarak hadde tesisleri gibi aşınma ve boşluk ayarı gereken yerlerde kullanılmaktadır.
- Ölçme elemanı olarak mikrometre gibi boyut ölçümü yapan aletlerde kullanılmaktadır.
- Hareket ve kuvvet iletim elemanı olarak vidalı pres, mengene, kriko vb. donanımlarda kullanılmaktadır.

Cıvata bağlantılarının kullanılmasında birtakım sakıncalar da bulunmaktadır:

- Ön gerilmeli cıvata bağlantılarında iletme kuvveti etkidiğinde ön gerilme kuvvetinde azalma olmaktadır.
- Cıvata bağlantılarında zamanla gevşeme (çözülme) oluşmaktadır.
- Cıvatada üzerindeki vida nedeniyle çentik etkisi oldukça büyüktür.
- Cıvata bağlantıları vida-somun dişleri arasındaki boşluklar nedeniyle iyi bir merkezlenme elemanı değildir.

a) Vidalı kriko



b) Mengene

c) Vidalı pres

Şekil 1. Cıvataların kullanılma yerleri

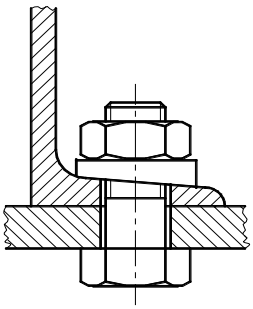
Bu çalışmada cıvata bağlantılarında montajdan, tasarımdan ve işletme koşullarından kaynaklanabilecek hataların önlenmesi, bağlantı performanslarının ve güvenirliklerinin artırılması için yapılması gereken faaliyetler sunulmaktadır.

II. YÖNTEM

Cıvata bağlantılarının tasarımlarında yapılacak olan birtakım düzenlemeler sonucunda bağlantının güvenirliği ve performanslarında iyileştirme sağlanabilmektedir:

a) Eğik rondela kullanımı:

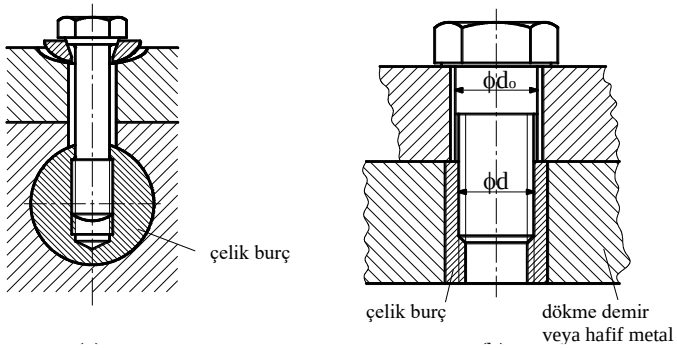
Çelik yapılarda kullanılan L, I ve benzeri profillerde olduğu gibi cıvata başı veya somunun temas yüzeyleri eğik konumda ise bağlantıda eğik rondela kullanılarak cıvata gövdesinin eğilmesi önlenebilir. Bu şekilde sıkma esnasında cıvatanın eğilmesi engellenebilecektir (Şekil 2) [2].



Şekil 2. Eğik rondela kullanımı

b) Burç içine diş açılması:

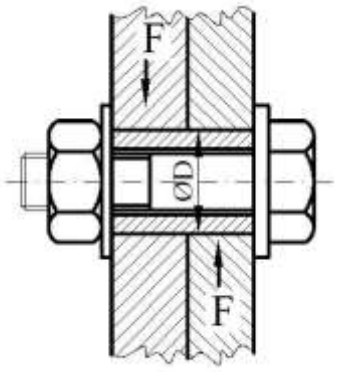
Parça içine kılavuz ile diş açılması durumunda hafif metal veya dökme demir gibi malzemelerde delik içindeki vida dişlerinin kolay aşınabilmektedir. Bu nedenle vidalanacak karşı parça içine bronz veya çelikten küresel veya silindirik bir burç geçirilir. Parça içine takılan bu burç içine vida dişleri açılır. Bu şekilde bağlantının daha uzun ömürlü olarak çalışması sağlanacaktır (Şekil 3).



Şekil 3. Burç içine diş açılması

c) Kesme burcunun kullanılması:

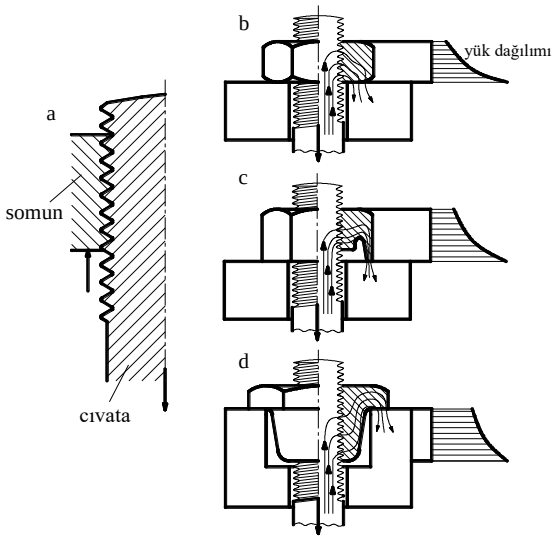
Cıvatalar kesme zorlanması etkisinde bırakılmamalıdır. Cıvata bağlantılarına çalışma esnasında enine kuvvet etkimesi halinde cıvata gövdesinde kesme gerilmesi ortaya çıkacaktır. Bu durumu engellemek için parçalar daha büyük çaplı delinerek deliklerin içine daha yüksek mukavemetli malzemeden üretilmiş bir silindirik kesme burcu takılarak cıvataya gelecek olan kesme gerilmeleri engellenerek cıvatanın güvenilirliği de artırılmış olacaktır (Şekil 4) [3].



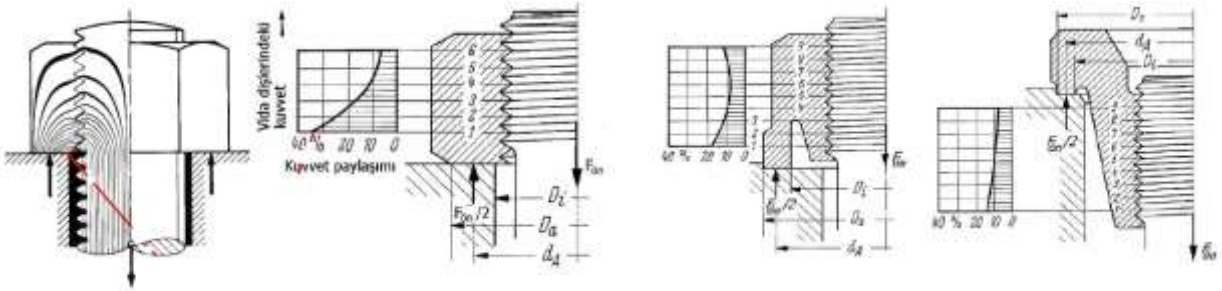
Şekil 4. Kesme burcunun kullanılması

d) Elastik somun kullanılması:

Genel olarak cıvata bağlantılarında cıvatanın üzerindeki gerilme dağılımı düzensizdir. Cıvata bağlantısında somun altındaki kırılmaların en büyük nedeni bağlantıya etkiyen eksenel kuvvetin, standart somunlarda, %35' inin hemen ilk vida dişlerinde iletilmesi ve buna çentik etkisinin de eklenmesidir. Somun içinde kalan 5. ve 6. dişler kuvvetin ancak %5' ini taşımaktadırlar. Hesaplamalarda ise kuvvetin dişler arasında eşit dağıldığı kabul edilmektedir. Normal bir cıvata–somun bağlantısında cıvata çekmeye, somun ise basmaya zorlanmaktadır. Şekil 5 ve 6' da standart cıvata–somun bağlantısında kuvvet akış çizgileri ve vida dişlerinde kuvvetin dağılışı görülmektedir. Gerilme yığılmalarını azaltmak için somunda tasarım değişiklikleri yapılabilir. Elastik somunda somuna bir kanal açılarak kuvvet etkisinde somunun esnemesi, ilk üç dişin esnekliğinin sağlanması ve dolayısıyla kuvvetin üst dişlere doğru yayılışı temin edilmektedir. Özel olarak tasarlanan ve elastik somun olarak adlandırılan somunda özel geometrisi nedeniyle somun çekmeye zorlanmakta ve yük dağılımı daha düzgün olmaktadır [4]. Normal somunlar üzerindeki gerilme yığılması elastik somunun kullanılması halinde %25-30 oranında azaltılabilmektedir. Elastik somunların kullanımı darbeli çalışmaların yoğun bir şekilde etkili olduğu özellikle havacılık endüstrisi gibi uygulamalarında cıvata bağlantısının performansının ve güvenilirliğinin iyileştirilmesinde önem kazanmıştır.



Şekil 5. Elastik somun kullanılması

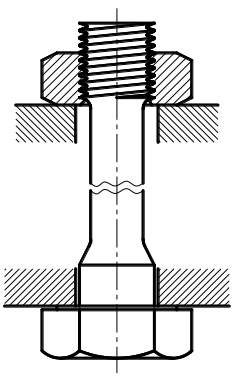


a) Normal somun b) Elastik somun

Şekil 6. Vida dişleri arasındaki kuvvet dağılımı

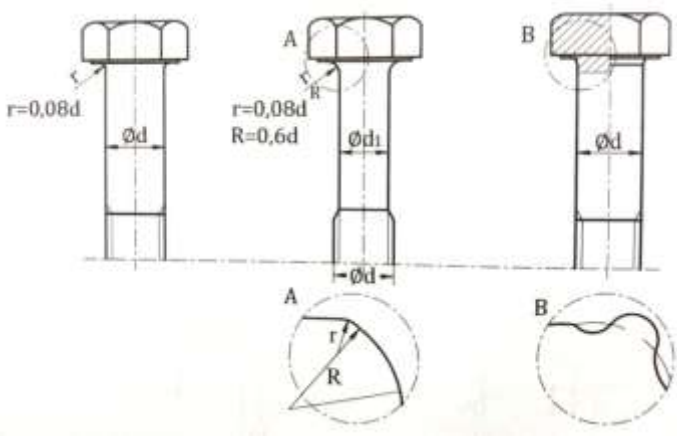
e) Cıvatada gerilme yayılışının düzgün hale getirilmesi:

Dinamik yükleme altında çalışan cıvata bağlantılarında gerilme yığılmalarını azaltacak yönde tasarımlar yapılmalıdır. Cıvata üzerindeki eksenel yükler ve cıvata gövdesindeki keskin köşeli boyutsal değişimler (çentik etkisi) gerilme yayılışında düğüm noktaları oluşturmaktadır. Bu bölgelerde gerilmelerde birikimlerin oluşması dinamik yükleme etkisinde kalan cıvatalarda yorulma sonucunda hasarların oluşmasına neden olmaktadır [5]. Cıvata–somun bağlantılarındaki gerilme yayılışını düzgün hale getirmek için cıvatanın tasarımında vidadan cıvata gövdesine geçiş yerinin tamamen somun içinde kalması ve geçiş yerlerinde büyük yuvarlatmaların yapılması yeterli olacaktır. Cıvata üzerinde gerilme yığılmalarının önlenmesi ile cıvatanın yorulma dayanımı ve güvenirliği de geliştirilmiş olacaktır (Şekil 7).



Şekil 7. Gerilme yayılışı iyileştirilmiş cıvata

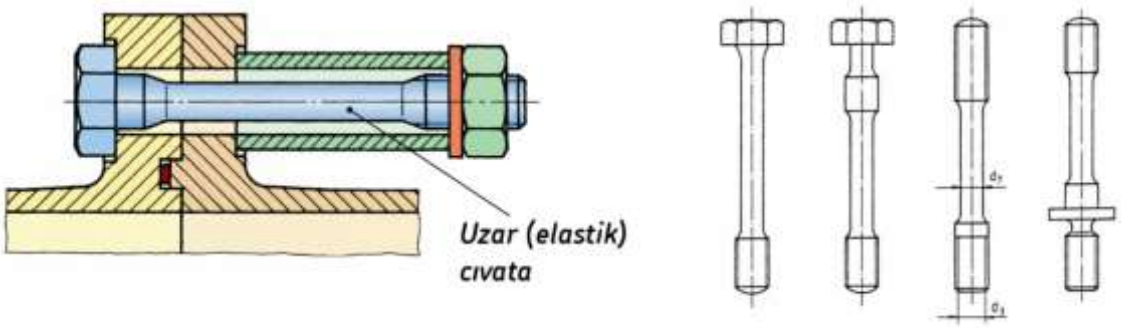
Cıvatada baş bölgesinin altında değişik formlarda radyüs verilerek çentik etkisini azaltmak mümkün olmaktadır (Şekil 8). Bu durumda dinamik yükleme etkisinde cıvatanın yorulma dayanımı iyileştirilerek yorulma ömrü artacaktır [6]. Bu sayede cıvatanın güvenirliği de iyileştirilmiş olacaktır.



Şekil 8. Cıvata başında çentik etkisinin azaltılması

f) Uzar (elastik) cıvata kullanımı

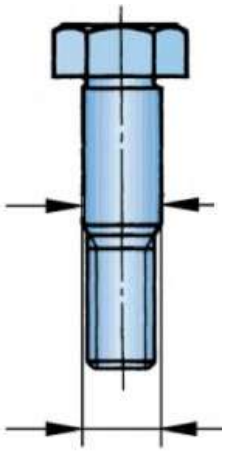
Dinamik yükleme etkisinde kalan cıvatalarda genlik gerilmesinin düşük olması cıvatanın mukavemetinin de yüksek olması anlamına gelmektedir. Bu nedenle özel olarak tasarlanan ve uzar cıvata olarak da tanımlanan elastiklik özelliği fazla olan cıvatalarda cıvatanın boyunun uzatılması ve kesitinin küçültülmesi cıvatanın yaylanma rijitliğini azaltarak cıvataya etkiyecek olan dinamik yükün küçültülmesini sağlayacaktır (Şekil 9). Uzar cıvatanın kullanılması halinde cıvataya etkiyen maksimum gerilme de azalarak dinamik yükleme etkisinde çalışan cıvatanın güvenirliğinin de yükseltilmesi sağlanmış olacaktır.



Şekil 9. Uzar (elastik) cıvata

g) Yüksek sıcaklıklar altında çalışan cıvatalar

Bazı cıvatalar kullanıldıkları yerlerde 150°C üzerindeki yüksek sıcaklıklara maruz kalabilmektedirler. Buhar kazanları, fırınlar ve içten yanmalı motorlar gibi yüksek sıcaklıkların var olduğu sistemlerde bağlantı amacı ile kullanılan cıvataların yüksek sıcaklıklara maruz kalması, sürünme ve gerilme gevşemesi gibi malzeme özelliklerini ortaya çıkarmaktadır. Sıcaklık etkisinde malzemelerin mukavemetleri ve elastiklik modülleri azalmaktadır. Sürünme olayında zamanla cıvata üzerindeki uzamalar artarak kesiti incelmekte ve bir süre sonra incelen kesit cıvata üzerindeki kuvveti taşıyamaz hale gelerek kopmaktadır. Cıvatanın sürünmeden kaynaklanan hasarlarını önleyerek güvenirliğini ve performansını artırmak mümkündür. Bu amaçla cıvata özel olarak yeniden tasarlanır ve gövde çapı olması gerekenden daha büyük yapılarak sürünmeden kaynaklanan hasarlar engellenebilir (Şekil 10).



Şekil 10**.** Sürünmenin engellenmesi için kullanılabilecek cıvata

h) Kimyasal maddelerin kullanımı

Özellikle titreşim etkisinde kalan cıvata bağlantılarında bir süre sonra çözülmeler ortaya çıkabilmektedir. Cıvata-somun bağlantılarında sıvı aneorobik esaslı yapıştırıcılar (Loctite) kullanarak bağlantının çözülmesi engellenebilmektedir. Cıvatanın dişleri üzerine yapıştırıcı uygulamasından sonra oksijen ile temas sonrasında kürlenme başlamaktadır. Cıvatanın montajı yapıldıktan sonra belli bir süre sonra katılaşan yapıştırıcı çözülmeyi engellemektedir (Şekil 11).

Şekil 11. Bir saplama üzerine yapıştırıcının uygulanması

Bazı durumlarda cıvata dişleri üzerinde belli bölgelere yapıştırıcı uygulanarak yüzeyleri kaplanabilir (Şekil 12). Bu kaplamaların içinde mikro kapsüller bulunmaktadır. Cıvataların montajı esnasında bu mikro kapsüller kırılarak yapıştırıcı madde açığa çıkar ve dişler arasındaki boşluğu doldurur. Bir süre sonra da sertleşerek bağlantının çözülmesi engellenir. Cıvata bağlantılarında burada ifade edilen yapıştırıcıların kullanımı bağlantının performansının ve güvenilirliğinin geliştirilmesinde önemli bir rol oynamaktadır.

Şekil 12**.** Yapıştırıcı ile yüzeyleri kaplanmış cıvatalar

III. SONUÇLAR

Cıvata bağlantılarının konstrüksiyonlarında ve bağlantının teşkilinde yapılacak olan birtakım düzenlemeler ile cıvata-somun bağlantısının güvenirliği ve performanslarında iyileştirme sağlanabilmektedir. Cıvata bağlantılarında tasarıma ile ve olarak yapıştırıcıların kullanımı bağlantının performansının ve güvenilirliğinin geliştirilmesinde önemli bir rol oynamaktadır.

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Malware Detection using different Machine Learning Models using Random Search and Different Features Subsets

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Abstract – Android devices are now widespread, with billions of users worldwide relying on them for communication, entertainment, and productivity. The widespread use of these devices makes them primary targets for malware attacks, which can compromise sensitive data, disrupt operations, and pose significant security risks. Consequently, the prevalence and sophistication of Android malware emphasize the critical need for robust security measures and vigilant user practices to mitigate these threats. To address this problem, we utilized various machine learning models and techniques frequently used in artificial intelligence studies, such as feature extraction, feature importance, feature subset selection and hyperparameter optimization. First, we trained our dataset, which contains 79 features, using a Random Forest classifier to obtain a feature importance ranking. Based on this ranking, we divided the top 50 features into five subsets containing the top 10, 20, 30, 40, and 50 features. We then conducted a comparative study by training 11 machine learning models with default parameters on these subsets. Our results showed that some models achieved up to 92% accuracy. For models that performed relatively poorly, we used the Random Search library to determine the best hyperparameters from a predefined parameter pool and fine-tuned these models. For instance, the XGBRF Classifier model, which initially achieved an average accuracy of 81% across the five subsets with default parameters, exceeded 92% performance after fine-tuning process.

Keywords – Android Operating System, Machine Learning, Feature Selection, Feature Extraction, Hyperparameter Fine-tuning

I. INTRODUCTION

As online threats continue to evolve and become more sophisticated, the necessity for advanced protection mechanisms has never been more critical. Malware attacks, which involve the deployment of malicious software to infiltrate, disrupt, or damage computer systems and networks, pose a significant threat to information security. These attacks can lead to severe consequences, including data breaches, financial loss, and compromised personal information. Highlighting the severity of Android malware threats, McAfee's 2023 "Mobile Threat Report" reveals a concerning 50% surge in malware detections on Android devices within the year alone. Notably, a large proportion of these malicious programs are designed to target and compromise users' personal and financial information [1]. This alarming increase underscores the urgent need for robust and adaptive security measures to protect users against such pervasive threats. Traditional security methods, which often rely on static and signature-based detection techniques, are increasingly inadequate in combating the rapidly changing landscape of cyber threats. Malware authors constantly develop new techniques to evade detection, rendering many conventional security solutions obsolete. As a result, there is a growing recognition that innovative approaches are necessary to stay ahead of cyber adversaries. In response to these challenges, cybersecurity professionals

are leveraging machine learning to bolster defenses against these threats. Machine learning models, with their ability to learn from vast amounts of security data, offer promising solutions for the detection and prevention of malware attacks. Unlike traditional methods, machine learning can identify patterns and anomalies in data that may indicate malicious activity, even if the specific malware variant has never been seen before. By continuously analyzing and learning from new security incidents, machine learning models can adapt to emerging threats in real-time. This dynamic capability is crucial in an environment where cyber threats are constantly evolving. Moreover, machine learning can enhance various aspects of cybersecurity, including threat intelligence, anomaly detection, and automated response mechanisms. For instance, machine learning algorithms can be employed to monitor network traffic and identify unusual behaviors that may signify a malware infection. Additionally, these models can assist in classifying and prioritizing threats, enabling security teams to focus their efforts on the most critical issues. The integration of machine learning into cybersecurity strategies not only improves the efficiency and effectiveness of threat detection but also helps in the development of proactive defense mechanisms.

In conclusion, as the landscape of online threats grows increasingly complex, the adoption of advanced technologies such as machine learning is essential for maintaining robust cybersecurity. By harnessing the power of machine learning, we can develop more sophisticated and adaptive defenses that can keep pace with the ever-evolving tactics of cybercriminals. This proactive approach is vital for safeguarding personal and financial information in an era where digital security is paramount.

1. Motivation

The exponential rise in mobile device usage, particularly Android smartphones, has been accompanied by an equally alarming surge in malware attacks targeting these devices. With Android being the most widely used mobile operating system globally, it has become a prime target for cybercriminals. Traditional antivirus solutions, which predominantly rely on signature-based detection methods, are increasingly inadequate in addressing the sophisticated and rapidly evolving nature of modern malware. This inadequacy is further compounded by the sheer volume of new malware variants that emerge daily, outpacing the ability of traditional methods to update and adapt. Given this landscape, there is a compelling need to explore and implement innovative approaches that can offer robust, adaptive, and proactive defense mechanisms. Machine learning (ML) techniques present a promising solution to this challenge. By leveraging the ability of ML models to learn from vast datasets and identify complex patterns, we can enhance malware detection capabilities beyond the limitations of traditional methods. This paper aims to investigate the application of machine learning in Android malware detection, providing a comprehensive analysis of its potential to revolutionize mobile security and protect users against the ever-growing threat of malware.

2. Novelty

The novel aspect of this study in Android malware detection lies in our innovative approach to enhancing model performance by categorizing various features into subgroups for comparative testing. During preprocessing with the Random Forest Classifier, we identified which of our 78 features most significantly impacted outcomes. Utilizing the importance rankings from this classification, we trained 11 different machine learning models using 5 distinct feature subsets. For models that initially underperformed, we conducted fine-tuning with a preselected list of hyperparameters. As a result, even the lower-performing models demonstrated approximately a 15% increase in accuracy, aligning more closely with the performance of the higher-performing models.

3. Related Works

Approaches to malware detection can be broadly categorized into static, dynamic, and hybrid methods. The static approach involves extracting features such as permissions, intent filters, strings, services, activities, Dalvik opcodes, and metadata from an app without executing it. The dynamic

approach extracts feature by running the app in an emulated environment or on a real device, capturing data such as system calls, binder calls, API calls, network usage, and memory usage. The hybrid approach combines static and dynamic analysis to leverage the strengths of each method. After analysis, the collected features are compiled into a dataset used to train and test machine learning (ML) models. For example, a Cat-Boost algorithm-based model achieved high accuracy in malware detection and family classification using static features like permissions and intents but struggled with advanced evolving malware and specific ransomware families [2] Another study extracted permissions and APIs from a large dataset of apps, but it was limited by its imbalance and outdated samples [3]. Dynamic analysis-based techniques, such as those using emulated platforms to extract system calls and binder calls, have shown promise but face challenges with malware that can detect emulated environments [4] also relied on an emulated dynamic malware analysis platform and used multiple types of features (e.g., system calls, binder calls, and composite behaviors). Droidbox [5], DroiMat [6], were developed using dynamic analysis in an emulator or sandbox, focusing on features such as permissions, intents, and API calls. Despite their excellent performance, these models failed to analyze malware with anti-emulation mechanisms. Notably, the ability to detect emulation is not limited to malware; other apps, such as those using Telephony Manager, can also detect emulators using methods like TelephonyManager.getDeviceId() [7]. Hybrid approaches have been highlighted for their higher accuracy, combining the benefits of static and dynamic analysis. Studies have used techniques like pseudo-label stacking autoencoders and VMI-based systems to achieve high detection rates [8]. In [9], [10], the use of hybrid analysis is further supported for effective identification of resource misuse and malware detection. In [11], a toolkit was used to mine different app platforms and user characteristics with the aim of studying the health and sustainable security of different apps. Even though this study provides significant insight into the evolution of the Android platform, the approach used has its limitations in terms of practicality and feasibility. It requires continuous data mining, crawling, and auto updating to achieve durable results. In [12], the static and dynamic characterization of Android apps developed between the years 2010–2017 was carried out. The authors present important findings along with recommendations related to app structure, behavior, and evolution. However, because the researchers only analyze benign apps, the recommendations cannot be generalized to malicious apps because malicious apps are very different from benign apps in terms of their metrics and behavior. In [13], a self-evolving detection solution, called Droidevolver, was developed and trained using a dataset consisting of API calls. The dataset used consists of 34,722 malicious samples from 2011 to 2016 and the final model achieved a F-measure of 95.27%. It is stated that this score decreased by 1.06% per year (on average) until it reached 89.97% in 2016. Because Droidevolver is based on static analysis, it inherits the limitations of this approach. Research has revealed the evolution of malware characteristics to evade detection, underscoring the importance of robust feature engineering and up-to-date datasets [14]. In [15], the dynamic evolutionary behavior of benign and malicious Android apps was evaluated on code-level execution. The dataset included 15,451 benign and 15,183 malicious samples from 2010 to 2017. The study uncovered metrics that differentiate between benign and malicious apps, suggesting these could inform durable malware detection solutions. However, its effectiveness relies on stable patterns across evolving malware versions, and the solution is limited by dynamic analysis conducted in emulated environments. Overall, while each approach has its strengths, the combination of static and dynamic analysis in hybrid methods appears to offer the most promise for effective malware detection.

II. Materials and Method

1. Dataset

For this study, we utilized the Android Adware and General Malware Dataset (CIC-AAGM2017) published by Lashkari et al. (2018) at the Canadian Institute for Cybersecurity [16]. The distribution of the samples in original copy of the dataset is illustrated in table 1. This comprehensive dataset supports the development and evaluation of machine learning models for malware detection and is stratified into three categories: benign, adware, and general malware. It includes 471,597 benign samples, 155,613

adware samples, and 4,745 general malware samples, covering a range of threats such as trojans, ransomware, and spyware. This diversity enables a deep learning-based approach to accurately recognize and differentiate between benign and malicious behaviours, thus enhancing the model's accuracy and robustness. Given the dataset's imbalance, with a predominance of benign samples, we combined the adware and general malware categories to create a more balanced distribution between benign and malicious samples, as shown in Table 2. This adjustment aimed to improve the effectiveness of the machine learning analysis. Using this modified dataset, we tested twelve different machine learning models to evaluate their effectiveness in detecting malicious software. These models, ranging from traditional algorithms like decision trees and support vector machines to advanced neural networks, were rigorously trained and tested in a consistent environment. This comprehensive testing provided valuable insights into each model's strengths and weaknesses in handling imbalanced data scenarios. To address the imbalance issue further, we considered expanding the minority group using synthetic data and employing the Tomek Links method to eliminate records from the majority group that are likely to overlap with the minority group. However, this study focused on comparing metric values obtained from models trained with default settings versus those trained with optimal parameters. Consequently, we conducted model training using a random selection of 150,000 records from each category.

Table 1. The original copy of the dataset.

Type	Number Of Sample
Benign	471597
Adware	155613
General Malware	4745

Table 2. The Dataset After Merging Adware and General Malware Samples

Type	Number Of Sample
Benign	471597
Adware	160358

2. *Machine Learning*

Machine learning, a subset of artificial intelligence, excels at identifying malicious Android apps by analysing comprehensive data about various app types [17], [18], [19]. By learning from both benign and malicious apps, it discerns patterns and anomalies indicative of malware, improving its accuracy over time with new data. This capability is crucial for addressing the ever-evolving cybersecurity threats. In this study, we employed 11 different machine learning methods to train our data, including Random Forest Classifier, Bagging Classifier, Extra Trees Classifier, Decision Tree Classifier, XGB Classifier, Extra Tree Classifier, Gradient Boosting Classifier, XGBRF Classifier, AdaBoost Classifier, SGD Classifier, and Logistic Regression.

3. Preprocessing Phase

In machine learning, an excess of features can complicate model training and degrade performance, especially when many features do not significantly contribute to predictions. This issue, known as overfitting, occurs when a model performs well on training data but poorly on new data. To mitigate overfitting, it is crucial to identify the most important features, assessing how much each one contributes to the model’s predictive accuracy. Various methods can determine feature importance. Models like decision trees and ensembles such as Random Forests inherently provide feature importance by indicating how each feature influences decision-making. Alternatively, model-agnostic methods like permutation feature importance can be employed. This technique involves shuffling features and observing the impact on model performance. By focusing on the most important features, experts can enhance model

efficiency, reduce computational requirements, and potentially improve both accuracy and interpretability. Table 3 illustrates the importance of features in the used dataset.

Table 3. The importance of features in dataset.

Feature	Importance	Feature	Importance	Feature	Importance	Feature	Importance
Init_Win_bytes_forward	0.139758	max_flowiat	0.014890	total_bhlen	0.008025	mean_biat	0.003587
mean_flowpktl	0.036615	min_bpktl	0.014333	min_idle	0.007868	FFNEPD	0.003325
fAvgSegmentSize	0.035807	mean_bpktl	0.014273	Act_data_pkt_forward	0.007583	std_biat	0.003229
min_flowpktl	0.035028	flow_psh	0.013952	min_flowiat	0.007040	sflow_bpacket	0.003052
Init_Win_bytes_backward	0.032844	max_bpktl	0.013604	min_fiat	0.006772	bAvgBulkRate	0.002590
mean_fpktl	0.032326	max_active	0.013109	sflow_fpacket	0.006674	std_active	0.002484
min_fpktl	0.031100	downUpRatio	0.012863	std_bpktl	0.006630	flow_syn	0.002338
flow_fin	0.030429	std_fpktl	0.012622	mean_fiat	0.006630	sflow_bbytes	0.002292
avgPacketSize	0.029486	fpsh_cnt	0.011903	fHeaderBytes	0.006630	bAvgPacketsPerBulk	0.002149
std_flowpktl	0.027086	flowBytesPerSecond	0.011867	std_fiat	0.006289	fAvgBytesPerBulk	0.001611
min_seg_size_forward	0.021968	max_idle	0.011778	bpsh_cnt	0.006038	std_idle	0.001366
total_fpktl	0.021593	total_fiat	0.011683	std_flowiat	0.006005	min_biat	0.001321
flowPktsPerSecond	0.021392	mean_idle	0.011176	bVarianceDataBytes	0.005941	fAvgBulkRate	0.001304
max_fpktl	0.020221	max_fiat	0.009292	total_fpackets	0.005896	fAvgPacketsPerBulk	0.000888
duration	0.019174	total_fhlen	0.009037	RRT_samples_clnt	0.004854	burg_cnt	0.000000
max_flowpktl	0.018588	sflow_fbytes	0.008956	total_biat	0.004495	furg_cnt	0.000000
fPktsPerSecond	0.018189	min_active	0.008731	total_bpackets	0.004186	flow_urg	0.000000
bPktsPerSecond	0.017771	mean_flowiat	0.008595	bAvgBytesPerBulk	0.004164	flow_ece	0.000000
bAvgSegmentSize	0.015477	total_bpktl	0.008340	max_biat	0.003846	flow_cwr	0.000000
flow_ack	0.015134	mean_active	0.008311	flow_rst	0.003597		

4. Model Fine Tuning Process

In the rapidly evolving field of machine learning, success hinges not only on selecting the optimal model but also on meticulously fine-tuning its parameters. Fine-tuning involves making precise adjustments to a pre-trained model to enhance its performance for a specific task or dataset. This practice is particularly crucial in transfer learning, where a model trained on a large dataset is adapted for a different, often smaller and more specialized, dataset. By leveraging existing knowledge, fine-tuning improves model accuracy and efficiency, ensuring it adapts well to new data. Hyperparameter optimization focuses on adjusting settings such as learning rate, number of layers, and batch size, which must be determined before training begins. These hyperparameters significantly influence model performance, and finding the optimal combination can enhance accuracy, reduce computational requirements, and improve generalization to new data. Random Search is an effective method for hyperparameter optimization due to its simplicity and efficiency. Unlike grid search, which exhaustively evaluates all possible combinations within a defined space, Random Search selects hyperparameters randomly from a specified distribution. This approach can explore a larger set of combinations in less time, making it ideal for high-dimensional search spaces where grid search would be computationally prohibitive. Random Search increases the likelihood of discovering highly effective hyperparameter settings that other methods might overlook, making it a valuable tool for machine learning practitioners.

In this study, we fine-tuned the XGBRF Classifier, which initially achieved lower scores compared to other models, using the Random Search library to optimize its parameters. The XGBRF Classifier integrates the concept of Random Forests into the XGBoost framework. Instead of using gradient boosting to sequentially build trees, it uses the Random Forest approach to create a collection of decision trees that are trained independently. This hybrid model aims to leverage the robustness and high accuracy of XGBoost while benefiting from the randomness and reduced overfitting characteristics of Random Forests. This fine-tuning process significantly improved the model's performance, demonstrating the importance and effectiveness of hyperparameter optimization in machine learning. The range values used for each hyperparameter is illustrated in table 4.

Table 4. The range of values used during hyperparameter tuning process.

Parameter	Values
n_estimators	50, 100, 200
max_features	auto, sqrt, log2
max_depth	None, 10, 20, 30
criterion	gini, entropy

III. RESULTS AND DISCUSSIONS

1. Evaluation Metrics

The measures we use to evaluate something include precision, recall, F-score, and accuracy. Precision is the number of right decisions divided by the total number of decisions in a specific category. It is figured out as:

$$Precision = \frac{TruePositive}{TruePositive + FalsePositive}$$

The term 'True Positive' refers to situations where malware attacks are correctly classified as malware attacks, while 'False Positive' refers to situations where non-malicious records are incorrectly classified as attacks:

$$Recall = \frac{TruePositive}{TruePositive + FalseNegative}$$

False Negative' refers to the situation where a record that is actually a malware attack is incorrectly classified as benign. Accuracy tells us how correct the decisions are compared to the real classification. The machine learning model's decision is only considered correct if it matches the real malware attack class in the dataset. It is figured out by adding up some numbers.

$$Accuracy = \frac{TruePositive + TrueNegative}{TrueNegative + FalsePositive + FalseNegative + TruePositive}$$

Where True Negative refers to the situation where a record that is actually a benign is correctly classified as benign. Finally, the F1-score is the harmonic mean of precision and recall. It is calculated as:

$$F_1 - Score = \frac{2 * Precision * Recall}{Precision + Recall}$$

2. Experiment Setup

In this research, we conducted extensive tests and evaluations of various machine learning models using a computer equipped with 32 GB of RAM and an i7 12th generation processor. This hardware configuration allowed for efficient and rapid computations. Our work did not necessitate the use of libraries like TensorFlow or PyTorch, nor did it require GPU acceleration. This setup was well-suited for our machine learning tasks, enabling quick processing and analysis without the need for the complex tools and resources typically associated with deep learning.

3. Obtained Results

In this study we carried on number of tests with 11 different machine learning models consist of Logistic Regression, Decision Tree Classifier, Extra Tree Classifier, XGB Classifier, XGBRF Classifier, Ada Boost Classifier, Random Forest Classifier, Extra Trees Classifier, Gradient Boosting Classifier, Bagging Classifier, SGD Classifier. The results of these machine learning classifiers are illustrated in table 5.

Table 5. Results obtained using the adopted machine learning classifiers.

	Model	Accuracy	Roc Auc	F1 Score	Precision	Recall
TOP 10 FEATURES	ExtraTreesClassifier	91.311.667	0.913063	0.914822	0.899897	0.930250
	RandomForestClassifier	91.293.333	0.912875	0.914791	0.898350	0.931845
	BaggingClassifier	91.181.667	0.911765	0.913510	0.898977	0.928522
	DecisionTreeClassifier	90.860.000	0.908548	0.910354	0.895885	0.925298
	ExtraTreeClassifier	90.723.333	0.907178	0.909106	0.893780	0.924966
	XGBClassifier	88.690.000	0.886832	0.889623	0.871284	0.908750
	GradientBoostingClassifier	81.533.333	0.815074	0.829973	0.771049	0.898648
	XGBRFClassifier	80.716.667	0.806994	0.817772	0.777299	0.862692
	AdaBoostClassifier	74.936.667	0.749025	0.774712	0.705350	0.859203
	SGDClassifier	64.616.667	0.645150	0.733947	0.589160	0.973083
	LogisticRegression	64.613.333	0.645481	0.708135	0.603873	0.855913
TOP 20 FEATURES	RandomForestClassifier	92.708.333	0.927044	0.928205	0.916904	0.939787
	BaggingClassifier	92.643.333	0.926426	0.926826	0.924741	0.928920
	ExtraTreesClassifier	92.181.667	0.921790	0.922694	0.915228	0.930283
	DecisionTreeClassifier	92.050.000	0.920480	0.921222	0.915717	0.926794
	XGBClassifier	90.816.667	0.908127	0.909574	0.898544	0.920879
	ExtraTreeClassifier	90.786.667	0.907846	0.908743	0.902930	0.914631
	GradientBoostingClassifier	83.473.333	0.834519	0.845785	0.794925	0.903599
	XGBRFClassifier	81.796.667	0.817787	0.828324	0.785904	0.875586
	AdaBoostClassifier	77.373.333	0.773518	0.788878	0.741399	0.842854
	SGDClassifier	65.671.667	0.656125	0.712232	0.614459	0.847008
	LogisticRegression	65.363.333	0.653434	0.675159	0.637399	0.717675
TOP 30 FEATURES	BaggingClassifier	92.680000	0.926790	0.927244	0.924487	0.930017
	RandomForestClassifier	92.581667	0.925777	0.926955	0.915699	0.938491
	DecisionTreeClassifier	91.961667	0.919596	0.920382	0.914480	0.926362
	ExtraTreesClassifier	91.833333	0.918306	0.919283	0.911476	0.927226
	XGBClassifier	91.145000	0.911416	0.912665	0.903032	0.922507
	ExtraTreeClassifier	90.420000	0.904174	0.905264	0.898041	0.912604
	GradientBoostingClassifier	83.210000	0.831911	0.842135	0.796833	0.892899
	XGBRFClassifier	82.263333	0.822474	0.831699	0.793476	0.873791
	AdaBoostClassifier	78.493333	0.784688	0.801171	0.746919	0.863922
	SGDClassifier	65.515000	0.654605	0.707196	0.615868	0.830326

	LogisticRegression	65.811667	0.657970	0.674216	0.645717	0.705347
TOP 40 FEATURES	BaggingClassifier	92.730.000	0.927293	0.927678	0.925714	0.929651
	RandomForestClassifier	92.310.000	0.923057	0.924373	0.912055	0.937029
	DecisionTreeClassifier	91.881.667	0.918797	0.919555	0.914046	0.925132
	ExtraTreesClassifier	91.493.333	0.914905	0.915945	0.907930	0.924102
	XGBClassifier	91.115.000	0.911116	0.912355	0.902870	0.922042
	ExtraTreeClassifier	90.048.333	0.900456	0.901629	0.894073	0.909314
	GradientBoostingClassifier	83.570.000	0.835515	0.845345	0.800678	0.895291
	XGBRFClassifier	82.456.667	0.824408	0.833523	0.795262	0.875652
	AdaBoostClassifier	78.368.333	0.783427	0.800633	0.744430	0.866015
	SGDClassifier	65.498.333	0.654440	0.706971	0.615802	0.829828
	LogisticRegression	65.840.000	0.658249	0.674873	0.645643	0.706875
TOP 50 FEATURES	BaggingClassifier	92.690.000	0.926893	0.927283	0.925289	0.929286
	RandomForestClassifier	92.261.667	0.922573	0.923911	0.911439	0.936729
	DecisionTreeClassifier	91.913.333	0.919113	0.919897	0.914072	0.925797
	ExtraTreesClassifier	91.468.333	0.914656	0.915677	0.907885	0.923603
	XGBClassifier	90.941.667	0.909368	0.911058	0.897530	0.924999
	ExtraTreeClassifier	89.800.000	0.897975	0.899087	0.892318	0.905958
	GradientBoostingClassifier	83.328.333	0.833078	0.844037	0.795059	0.899445
	XGBRFClassifier	82.756.667	0.827422	0.835668	0.800426	0.874157
	AdaBoostClassifier	78.793.333	0.787728	0.801584	0.755164	0.854086
	SGDClassifier	65.510.000	0.654557	0.707017	0.615925	0.829728
	LogisticRegression	65.883.333	0.658684	0.675100	0.646197	0.706709

The results demonstrated that creating subsets with various features can enhance model performance. However, excluding critical components can result in data loss and reduced model efficacy. To optimize performance, it is crucial to carefully analyse the data, reduce its dimensionality if necessary, and experiment with new features to determine the most effective combination. In this research, we focused on improving the performance of the XGBRF Classifier, which initially performed poorly in our five tests, by utilizing the Random Search library. Our goal was to enhance the model's accuracy and minimize classification errors. The table 6 illustrates the results of the original XGBRF Classifier applied to different group of features.

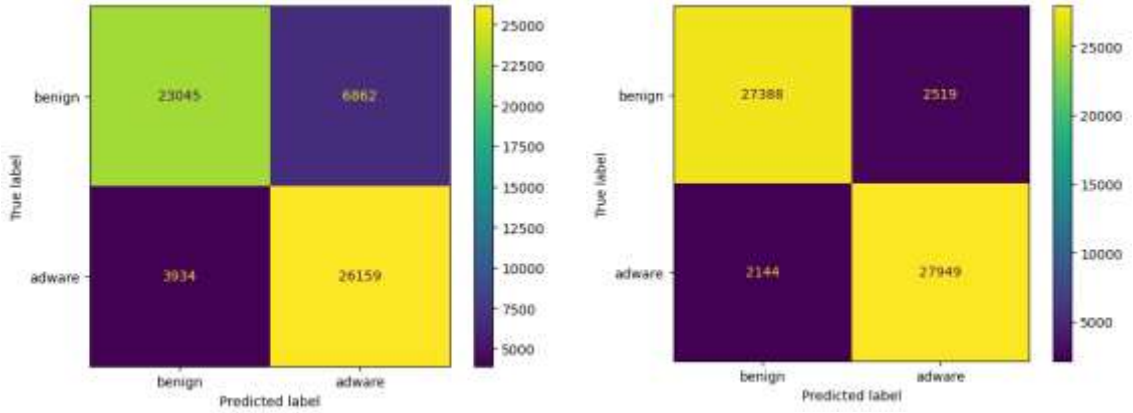
Table 6. Results of XGBRF Classifier before Fine Tuning

Feature Size	Accuracy	Roc Auc	F1 Score	Precision	Recall
10	80.716.667	0.806994	0.817772	0.777299	0.862692
20	81.796.667	0.817787	0.828324	0.785904	0.875586
30	82.263333	0.822474	0.831699	0.793476	0.873791
40	82.456.667	0.824408	0.833523	0.795262	0.875652
50	82.756.667	0.827422	0.835668	0.800426	0.874157

In order to boost XGBRF Classifier’s robustness, we utilized the Random Search library to fine-tune the n_estimators and max_depth parameters, criterion, max_depth. In this optimization process, the cross-validation parameter was set to 5, guaranteeing a strong assessment of the model's execution over diverse folds of the information. The results of XGBRF classifier after the tuning process was as illustrated in Table 7. Figure 1 illustrates comparison between the confusion matrixes of XGBRF classifier before and after the hyperparameter tuning process.

Table 7. Results of XGBRF Classifier After Fine Tuning

Accuracy	Cross Validation mean	F1 Score	Precision	Recall
0.92168	0.91981	0.92233	0.91747	0.92725



XGBRF Classifier without fine-tuning *XGBRF Classifier with fine-tuning*

Figure 1. Comparison between the confusion matrixes of XGBRF classifier before and after the hyperparameter tuning process

IV. CONCLUSION AND FEATURE STUDY

In our study, we evaluated 11 machine learning models using an Android Malware Dataset. To ensure robust results, we conducted tests on 150,000 samples from our imbalanced dataset's target categories. After balancing the dataset, we employed the Random Forest Classifier to rank the importance of our 79 features. Using subsets containing the top 10, 20, 30, 40, and 50 most significant features, we trained and tested these models. The Random Forest Classifier, Bagging Classifier, Extra Trees Classifier, and Decision Tree Classifier consistently outperformed the other models. To assess the models' sensitivity to hyperparameter optimization, we performed tests and found that the XGBRF Classifier, initially performing lower than the successful models, significantly improved through optimal parameter tuning using Random Search. Post fine-tuning, the model, which initially achieved an average accuracy of 81% across five subsets, achieved up to 92% accuracy. This underscores the importance of dataset balancing, normalization, scaling processes, and parameter optimization in achieving high performance.

In future studies, we aim to enhance machine learning model performance by effectively applying normalization, standardization, and the Cluster Centroid library, particularly beneficial for handling imbalanced datasets.

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PEM YAKIT PİLİ HÜCRESİNDE $PdZr_2$/C ANOT KATALİZÖRÜN AKTİVİTESİ

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Özet **–** Anot ve katot tarafında meydana gelecek reaksiyonlar için aktif bölge sağlayan oksidasyon ve indirgenme reaksiyonlarının oluşabilmesi için yakıt pilinin her iki tarafında da bulunması gereken katalizörler yakıt pilinde hayati öneme sahiptirler. Pt ve Pt bazlı katalizörlerin yüksek maliyeti PEM yakıt pili teknolojisinin ticarileştirilmesi önündeki büyük engellerden bir tanesidir. Kullanılan platin ve platin bazlı alaşımların yüksek fiyatı, rezervlerinin azlığı ve zayıf elektrokimyasal kararlılığı nedeniyle PEM yakıt hücrelerinin uygulama alanlarını önemli ölçüde sınırlamıştır.

Bu çalışma da, PEM yakıt hücresinin MEA'sın da kullanılmak üzere, 1:2 atom oranlarında paladyum ve zirkonyum alaşımı, Vulcan 72-R aktif karbon ile birlikte sentezlendi. Sentezlenen $PdZr_2$/C katalizörü PEM yakıt hücresinde anot katalizörü olarak, yakıt hücresinin performansı değerlendirildi. Çalışmada, katot kısmı oksijen gazı yerine güçlü bir oksitleyici madde olan ozon (O_3) gazı ile beslendi. Farklı hücre sıcaklıklarında $PdZr_2$/C katalizörünün ölçülen akım yoğunluğu ve güç yoğunluğu değerlerinden polarizasyon eğrisi oluşturularak, PEM yakıt pilinin değişen hücre sıcaklığına göre aktivitesi ve verimliliği değerlendirildi. H_2/O_3 PEM yakıt hücresinin 40 ºC hücre sıcaklığında açık devre voltajından 1.46 V olarak ölçüldü. $PdZr_2$/C katalizörü, H_2/O_3 ortamında çalışılan hücre sıcaklıklarında; 70°C'de 91 mA/cm^2, 60°C'de 86 mA/cm^2, 50°C'de 81 mA/cm^2 ve 40°C'de 72 mA/cm^{2}lik akım yoğunluğu değeri ölçüldü. Yine, aynı sıcaklıklar da sırasıyla 30.94 mW/cm^2, 27.52 mW/cm^2, 25.11 mW/cm^2 ve 23.04 mW/cm^2'lik güç yoğunluğu değerleri ölçüldü. Hücrenin sıcaklığı arttıkça katalizörün katalitik aktivitesinin arttığı görüldü.

Anahtar Kelimeler – PEM yakıt pili, anot, katalizör, ozon, akım

I. GİRİŞ

Artan küresel enerji talebinin yanı sıra, eş zamanlı olarak üretim maliyetlerinde de artış yaşanıyor. Bu koşullar yenilenebilir enerji kaynaklarının kullanımının arttırılması ve yaygınlaştırılmasının kolaylaştırılması ihtiyacını doğurmuştur [1, 2]. Hidrojenin gelecekte yenilenebilir kaynaklardan enerjinin dönüştürülmesi ve depolanmasında önemli bir rol oynayacağı öngörülmektedir [3]. Güneş, rüzgar, jeotermal ve biyokütle gibi çeşitli yenilenebilir enerji kaynaklarının kullanımında hızlı ve önemli bir artış görülüyor. Enerji taşıyıcıları arasında alternatif bir elektrik güç kaynağı olan Proton Değişim Membranlı (PEM) yakıt hücreleri, kimyasal enerjiyi elektrik enerjisine dönüştürmedeki yüksek verimleri nedeniyle son zamanlarda ilgi odağı haline gelmiştir [1]. Ancak katalizörlerin dayanıklılığı ve maliyeti PEM yakıt hücrelerinin ticarileştirilmesinin önünde engel teşkil etmektedir [4]. Yüksek aktivitesi nedeniyle karbon destekli Pt ve Pt bazlı (Pd, Ru gibi), hem anot hem de katot katalizörleri olarak kullanılır, ve bu da

maliyeti önemli ölçüde artırır. Bununla birlikte, bu malzemeler, Pt nanopartiküllerinin çözünmesi veya toplanması ve karbon destek korozyonu nedeniyle uzun vadeli stabilitesi zayıftır [5]. Son yıllarda, PEM yakıt pili hücresinde anot ve katot katalizörleri için Pt bazlı katalizörlere daha uygun alternatifler bulmak amacıyla değerli olmayan metallerden katalizörler geliştirme yönünde girişimlerde bulunulmuştur. PtCo/C [6], PdNi/C [7], PtFe/C [8], PdMo/C [9] gibi bimetaller ve metal oksitlerle birlikte karbon destekli platinin kısmen kullanılmasıyla elektronların maliyetini azaltmak için çeşitli çalışmalar yapılmıştır. PEM yakıt pillerinde anot kısmı hidrojen ile beslenir iken katot kısmı hava/oksijen ile beslenmektedir. Bu çalışmamızda, kimyasal indirgenme yöntemi ile PEM yakıt pili hücresinde anot katalizörü olarak kullanılması için PdZr2/C katalizörü sentezlendi.
PEM yakıt hücresi H_2/O_3 gazları ile beslenerek farklı hücre sıcaklıklarında (40, 50, 60 ve 70 ºC) çalıştırılarak polarizasyon eğrileri oluşturulup, $PdZr_2/C$ katalizörünün performansı değerlendirildi.

II. MATERYAL VE YÖNTEM

2.1.$PdZr_2$/C katalizörünün sentezi

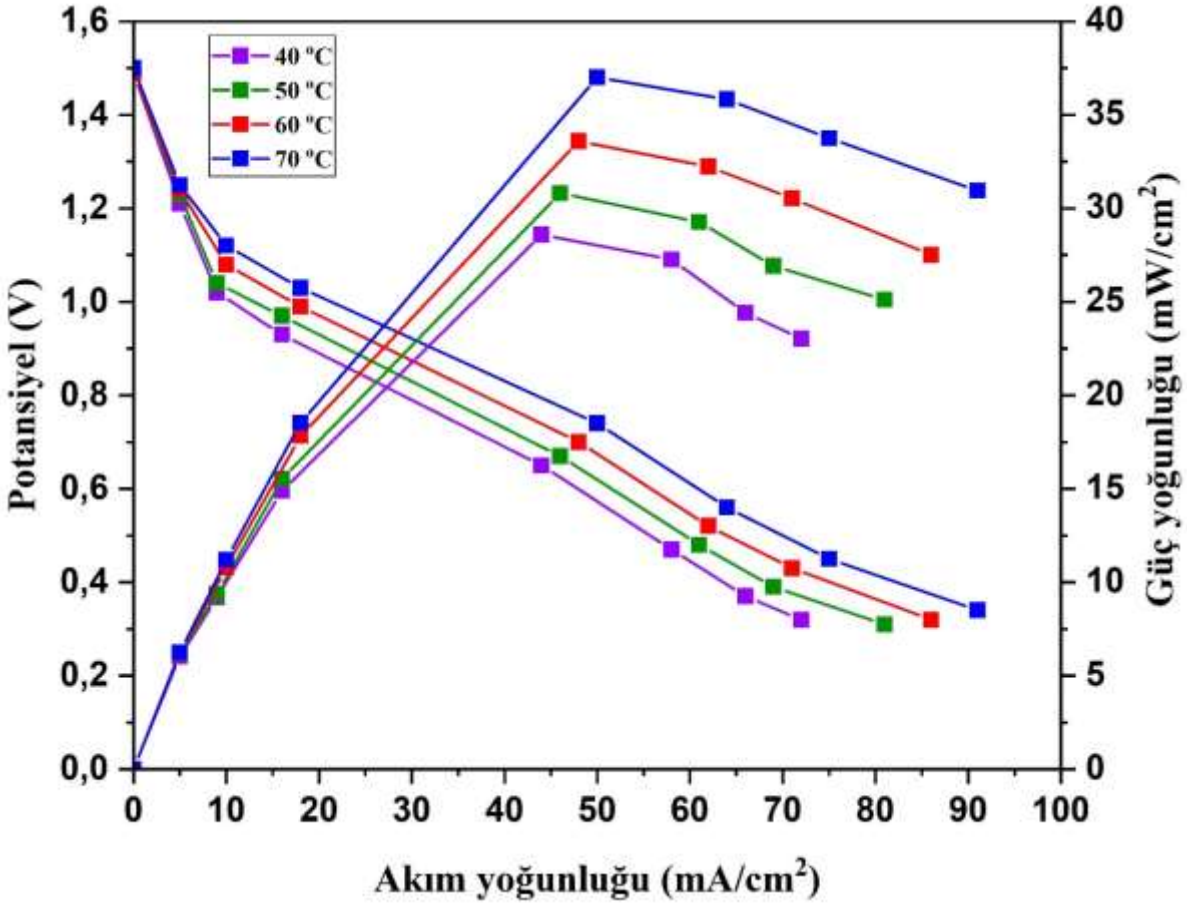
Karbon destekli PdZr (1:2), katalizörü kimyasal indirgeme yöntemiyle hazırlandı. Paladyum klorür ve zirkonyum klorür metal öncüleri olarak, sodyum borohidrür ise indirgeyici ajan olarak kullanıldı. Katalizörlerin tümü ağırlıkça %20'yi destekleyecek şekilde metal yüklemesi ile sentezlendi. İlk olarak PdZr/C katalizörü için uygun miktarda paladyum klorür ve zirkonyum klorür gibi bir metal öncüsü su içinde çözüldü. Yine başka bir beherde ağırlıkça %80 karbon (Vulcan XC-72), 10 mL etil alkol içerisinde 1 saat boyunca dağıtıldı. Daha sonra karbon çözeltisine paladyum klorür ve zirkonyum klorür ilave edildi ve 30 dakika boyunca ultrasonik bir karıştırıcı kullanılarak homojenleştirildi. Çözeltinin pH'ı 0,5 M NaOH eklenerek 11'e ayarlandı ve ardından çözelti 80 °C'ye ısıtıldı. Daha sonra 0,25 M NaBH4 çözeltisi yavaş yavaş damlatılarak 80 °C çözelti sıcaklığında indirgeme işlemi gerçekleştirildi. Elde edilen süspansiyon süzüldü ve çökelti, nitrojen gazı ortamında 90 ºC'deki Etüvde 5 saat kurutuldu.

2.2. MEA'nın hazırlanması

Membran elektrot tutucusu (MEA), Nafion 117 membranının anot katalizörü olarak kulllanılan PdZr2/C ve katot katalizörü olarak kullanılan Pt/C elektrokatalizörleri arasına yerleştirildi. Daha sonra, 132 °C'de ve 1000 psi basınç altında 3 dakika boyunca sıcak presleme işleminin uygulanmasıyla oluşturuldu.

III. BULGULAR VE TARTIŞMA

Tek hücreli PEM yakıt pilinde anot katalizörü olarak kullanılan Pd_2Zr/C katalizörü farklı hücre sıcaklıkların (40, 50, 60, 70 ºC) da H_2/O_3 ortamında akım yoğunluğu-gerilim değerleri ölçümleri yapılarak polarizasyon eğrileri oluşturuldu. Oluşturulan polarizasyon eğrileri Şekil 1 de gösterildi. bilime katkısı yorumlanmalıdır.



Şekil 1. Farklı PEM yakıt pili hücre sıcaklıklarında PdZr2/C katalizörünün polarizasyon eğrisi (anot:$PdZr_2$/C, katot: Pt/C katalizörleri; Hidrojen debisi 20 $mldk^{-1}$ ve O_3 debisi 10 $mldk^{-1}$).

Şekil 1 incelendiğinde, artan hücre sıcaklığıyla PEM yakıt pilinin performansının arttığı gözlemlendi. Pd metalinin Zr metali ile alaşımlandırılması sonucunda, İki metalden kaynaklanan işlevler ve ligand etkisi yakıt hücresi performansını artırdığını gösterdi. Ayrıca, oksijen /hava yerine kullanılan ozon gazı (O_3) yakıt hücresinin açık devre voltajını arttırmış[10] olup 40 ºC hücre sıcaklığında 1.49 V ve 70 C hücre sıcaklığında ise 1.50 V olarak ölçülmüştür. Sıcaklığın ve Pd/Zr atom oranının etkisi açık bir şekilde PEM yakıt pili uygulamasında belirgindi. Sentezlenen PdZr/C elektrokatalizörü kararlı durum koşulları altında mükemmel uzun vadeli stabilite gösterdiği yapılan uygulamalar sonucunda belirlendi. PEM yakıt pilinin farklı hücre sıcaklıklarında ölçülen aktivite değerleri Tablo 1 de sunuldu.

Tablo 1. $PdZr_2$/C katalizörünün PEM yakıt pili hücresinde ki performans değerleri

Katalizör	OCV (V)	Akım yoğunluğu (mA/cm^2)	Çalışma voltajı (V)	Güç yoğunluğu (mW/cm^2)	Sıcaklık (ºC)
$PdZr_2$/C	1.49	72	0.32	23.04	40
	1.49	81	0.31	25.11	50
	1.49	86	0.32	27.52	60
	1.50	91	0.34	30.94	70

Tablo incelendiğinde, O_2/hava yerine O_3 kullanımının yakıt pilinin açık devre voltajını ve aktivasyon kayıp bölgesindeki kayıpları azalttığı görüldü. Ayrıca, daha önce yapmış olduğumuz Pd/C ile kıyasladığımızda yakıt pilinin performansını arttırdığı görüldü.

IV. SONUÇLAR

$PdZr_2/C$ katalizörü PEM yakıt hücresinde anot katalizörü olarak kullanılması arttan hücre sıcaklığı ile beraber yakıt pilinin performansını arttırdığı görüldü. Ayrıca, çalışmada, katot kısmı oksijen gazı yerine güçlü bir oksitleyici madde olan ozon (O3) gazı ile beslenmesi de performansı arttırdı. Sonuç olarak, PdZr2/C katalizörünün artan hücre sıcaklıklarında ki aktivitesi şu şekilde; 40 ºC>50 ºC> 60 ºC > 70 ºC sıralanır.

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Implementing a Stock Price Prediction Model with Deep Neural Networks

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Abstract – Big data and deep learning technologies, which are one of the biggest focal points of data science, have recently been interested in which stocks investors will invest in. With the development of digital media, stock price prediction by selecting meaningful data from thousands of data sources has become an important issue. In this study, a Gated Recurrent Unit (GRU) based regression analysis is performed to predict time series data containing ADANI stock price information consisting of 10 columns and 3200 rows. As a result of the experimental studies, a GRU-based model consisting of 6 layers is proposed. In order to determine the effect of the proposed model on performance, it is compared with the classical GRU-based model. As a result of the experimental studies, 0.93 R^2 score performance value was achieved with the proposed GRU, while 0.74 R^2 score performance value was achieved with the classical GRU based model. In order to consolidate the performance results obtained, the outputs of both models were also evaluated in terms of MSE, RMSE, MAPE, MAE performance measures commonly used in the literature. The proposed GRU model achieved values of 0.0009, 0.0192, 21.53, 0.0168 in terms of MSE, RMSE, MAPE, MAE performance measures, respectively. The classical GRU model reached values of 0.0013, 0.0395, 31.35, 0.0221 in terms of MSE, RMSE, MAPE, MAE performance measures. Although the proposed GRU model outperformed the classical GRU model, there are some divergences between the actual values and the predicted values.

Keywords – GRU, Deep Learning, Big Data, Big Data Analyst, Stocks

I. INTRODUCTION

The dynamic system that is affected by various parameters such as economic conditions, political events, public opinion, and geopolitical factors is called the stock market [1]. Although there are many researchers who want to predict the movements of the dynamic stock market system depending on different factors, this process is difficult. Although investors and traders who use the stock market for investment purposes want accurate predictions, being able to predict it with very little error is a great performance indicator. In order to achieve the specified performance in this sense, researchers have developed many approaches to predict the stock prices of companies on the stock exchange. However, the accuracy performances of these developed methods and approaches are generally insufficient.

An analytical review can be performed by combining existing data from different sources. Establishing a relationship by integrating data will be useful in understanding what is going on in a business [2]. Raman et al. seek to determine how positive and negative emotions affect company performance [2]. As a result of these studies, it is reported that news such as a data breach in a company reduces stock prices from 45.6% to 14.6% [3]. When the unfortunate events in the company spread, the spread of negative feelings towards the relevant company will increase. When companies that were not affected by the global stock prices, which experienced a sharp decline in 2016, were examined, it was determined that these companies made accurate growth forecasts by taking into account news from external factors in

addition to past stock prices [4], [5]. For these reasons, analysts and researchers make a stock price prediction by examining the impact of public opinion and investors on the stock price with sentiment analysis, instead of evaluating only the previous stock price [2]. Sentiment analysis is a subfield of natural language processing designed to obtain meaningful data in an increasing pile of words. With sentiment analysis, it is attempted to extract the emotional tone underlying a data content [6]. It is necessary to automatically extract meaningful data from the mass of raw data that increases day by day [7]–[11]. By analysing text data from many sources such as data obtained from social networking sites, news texts, reports prepared for the relevant stock exchange company, the sentiment in the market about that company can be obtained. Stock market investors, traders, and financial analysts state that high performance can be achieved in predicting market trends by combining these approaches [12].

The following parts of the article consist of 4 sections. In the second section, some of the recently published and related studies on this subject are summarized. In the third section, the data and methods used in the article are mentioned. At the same time, the performance evaluation metrics of the GRU model used and recommended within the scope of the article are mentioned in this section. In the fourth section, the performance results of both models obtained as a result of the experimental studies are presented with tables and graphs. The work has been concluded in the last section.

II. Related Works

In data science, big data analytics and deep learning models are two important points. In recent years, remarkable results have been achieved with these focal points in precision agriculture, health and computer vision studies [13]–[15]. Big data analysis becomes very important in environments where large raw data are shared instantly, such as the stock market. Investors who want to increase their current economic resources by making profits are trying to figure out when to buy and when to sell stocks [12]. Although investors have professional financial advisors to tell them which stocks to invest in, concerns about trusting these decisions are common. In terms of investment consultancy, investment banks such as Lehman Brothers and Goldman Sachs have been providing financial consultancy for years. However, thanks to financial social networks, many small, medium and large investors around the world bring together their experiences and direct investors to the shares of the best companies. The need for realistic and technologically advanced studies in these directions is increasing day by day. At this point, the studies in the literature are briefly summarized.

Sohangir et al. used various neural network models such as LSTM, doc2vec, CNN to analyse stock market sentiments published on StockTwits [12]. Wang and Sambasivan examined the messages in the StockTwits dataset in terms of sentiment and grouped them as Bullish if they believed the stock price would increase over time, and as Bearish if they believed it would decrease over time [16]. Day and Lee state that information from financial sources should be analysed with deep learning to determine whether it is fake or not [17].

Das et al. developed a hybrid deep learning model to predict difficult-to-predict stock prices [1]. In their work, they use an approach that combines GRU, CNN, BiLSTM and LSTM-based models. They also tried to reduce the high dimensionality in the data set with principal component analysis, one of the classical machine learning algorithms. As a result of the studies, there is a need for new approaches that can predict stock prices by taking into account both quantitative and qualitative factors, providing better performance measures than traditional methods.

III. Materials and Method

In this study, the GRU approach, a Recurrent Neural Network (RNN) based method, was used to process time series data consisting of historical stock market data. A GRU-based method has been proposed to perform the specified operations. The proposed structure was compared with the classical GRU method in terms of MSE, RMSE, MAPE, MAE and R^2 score performance criteria.

A. Material

The study contains time series data containing ADANI stock price information consisting of 3200 rows and 10 columns [18]. Historical price data is reportedly taken from the YFinance portal. The sentiment scores of the news articles that make up the last three columns in the dataset have been deleted from the dataset. The values in the dataset were calculated with the forward padding technique. The information in the dataset covers the period between 1.10.2010 and 22.10.2023. Some of the data in the dataset is shown in Fig. 1.

3173	2023-09-12	2622.45	2626.6	2530	2535.7	2535.7	5.65877e+06	0.85927	0.000698343	0.140032
3174	2023-09-13	2545.7	2566.95	2496	2518.9	2518.9	1.78007e+06	0.99957	0.000290003	0.000139642
3175	2023-09-14	2541.85	2545	2506.05	2519.8	2519.8	1.21848e+06	0.00480424	0.000164078	0.995032
3176	2023-09-15	2519.8	2558	2514.2	2540.05	2540.05	1.547e+06	0.00480424	0.000164078	0.995032
3177	2023-09-18	2552	2555	2491	2502.45	2502.45	861677	0.00480424	0.000164078	0.995032
3178	2023-09-20	2502.4	2533.65	2458.9	2470.3	2470.3	1.28302e+06	0.998773	0.000343172	0.000883565
3179	2023-09-21	2479.8	2503.8	2461	2479.25	2479.25	1.27991e+06	0.997082	0.000263714	0.00265436
3180	2023-09-22	2489.95	2498	2460	2464.9	2464.9	865589	0.997082	0.000263714	0.00265436
3181	2023-09-25	2479.95	2489	2424	2482.1	2482.1	1.2169e+06	0.997082	0.000263714	0.00265436
3182	2023-09-26	2491	2499	2452.6	2457.95	2457.95	698863	0.997082	0.000263714	0.00265436
3183	2023-09-27	2460	2498	2445.1	2483.3	2483.3	1.07737e+06	0.997082	0.000263714	0.00265436
3184	2023-09-28	2489.95	2511	2446.7	2475.25	2475.25	2.22556e+06	0.997082	0.000263714	0.00265436
3185	2023-09-29	2462.05	2479.55	2405.05	2413.9	2413.9	1.6892e+06	4.90903e-05	0.000105332	0.999846
3186	2023-10-03	2418	2424.9	2372	2387.25	2387.25	2.0199e+06	4.90903e-05	0.000105332	0.999846
3187	2023-10-04	2402.2	2502.75	2392.25	2464.95	2464.95	2.85738e+06	4.90903e-05	0.000105332	0.999846
3188	2023-10-05	2477.95	2486.5	2446.4	2466.35	2466.35	1.13246e+06	4.90903e-05	0.000105332	0.999846
3189	2023-10-06	2466.35	2514.95	2466.05	2478.1	2478.1	1.51004e+06	4.90903e-05	0.000105332	0.999846
3190	2023-10-09	2440	2459.7	2411.3	2442.6	2442.6	1.40822e+06	0.000730938	0.998378	0.000891285
3191	2023-10-10	2443	2517.95	2443	2498.3	2498.3	1.77191e+06	0.000730938	0.998378	0.000891285
3192	2023-10-11	2533.9	2538	2482.5	2488.6	2488.6	1.62784e+06	0.000110662	6.60258e-05	0.999823
3193	2023-10-12	2499.9	2521.75	2490.65	2506.35	2506.35	1.80482e+06	0.000110662	6.60258e-05	0.999823
3194	2023-10-13	2488.9	2495	2422.35	2454.55	2454.55	2.27868e+06	0.000110662	6.60258e-05	0.999823
3195	2023-10-16	2454.55	2464.7	2421.85	2429.35	2429.35	803856	0.00153469	0.993242	0.00522311
3196	2023-10-17	2459.95	2462	2423.5	2428.4	2428.4	707543	0.00153469	0.993242	0.00522311
3197	2023-10-18	2440	2441.75	2401.05	2406.35	2406.35	776977	0.000467156	7.07794e-05	0.999462
3198	2023-10-19	2400	2414.7	2382.55	2402.2	2402.2	1.16882e+06	0.00363446	0.239781	0.756584
3199	2023-10-20	2398.05	2443.95	2382.05	2393.75	2393.75	1.24035e+06	0.499531	0.00042659	0.500042

Fig. 1. Part of the 10-column, 3200 rows of data in the dataset

B. GRU

Unlike the classical RNN, GRU models have a memory unit to control the data in RNN architectural models. In GRU models, information control is performed using all hidden states. GRU models, which have fewer parameters than classical RNN models, allow the development of algorithms with less computational load by bending faster. Although GRU models have the ability to operate with less data, they cannot perform too much backward processing [19].

There are two doors in GRU-based models [20]. The names of the gates in GRU models are reset and update gates respectively. The reset gate ensures that the data entering the GRU models and the memory are merged. Another gate in GRU models determines how long the states in the GRU will remain in memory. The equations of the update and reset gates are presented in Eq. 1 and Eq. 2 respectively.

$$Update\ gate\ \ (u_t) = \sigma\left(W^u x_t + U^{(u)} h_{t-1}\right), \tag{1}$$

$$Reset\ gate\ \ (s_t) = \sigma\left(W^s x_t + U^{(s)} h_{t-1}\right), \tag{2}$$

The terms U, h_{t-1} and W in Eqs. 1 and 2 denote cell unit, hidden layer values, and weight values, respectively. The sigmoid activation function is denoted by σ in Eq. 1 and Eq. 2 [21].

C. Evaluation Metrics

In this paper, two different models are used to forecast stock market data. The popular RNN-based method whose performance is to be measured in this study is the GRU architecture [22], [23]. MSE, RMSE, MAPE, MAE and R^2 values were used to evaluate the training and testing of the models used.

$$MSE = \frac{1}{m}\sum_{i=1}^{m}\left(Y_i - \hat{Y}_i\right)^2 \tag{3}$$

$$RMSE = \sqrt{\frac{1}{m}\sum_{i=1}^{m}\left(Y_i - \hat{Y}_i\right)^2} \tag{4}$$

$$MAPE = \frac{100}{m}\sum_{i=1}^{m}\left[\frac{Y_i - \hat{Y}_i}{Y_i}\right] \tag{5}$$

$$MAE = \frac{100}{m}\sum_{i=1}^{m}\left[\frac{Y_i - \hat{Y}_i}{Y_i}\right] \tag{6}$$

$$R^2 = 1 - \frac{\sum\left(Y_i - \hat{Y}_i\right)^2}{\sum(Y_i - \bar{Y})^2} \tag{7}$$

In order to measure the performance of the classical GRU model and the proposed GRU model, Eqs. 3-7 are used. In these equations, Y_i represents the actual value at index i while $\hat{Y}_i$ represents the value at index i.

D. Proposed GRU Model

In this study, a model consisting of 6 layers is proposed. In the first layer, GRU layer with ReLU activation function consisting of 300 units is defined. In the second layer, a dropout layer with a dropout rate of 0.30 is used. In the third layer, the GRU layer with ReLU activation function consisting of 300 units is used again. In the fourth layer, a dropout layer with a neuron dropout rate of 0.40 is used. In the fifth layer, a GRU layer with ReLU activation function consisting of 150 units was added. In the sixth layer, the regression layer is defined and the model is completed.

IV. Experimental Results and Discussion

The parameters in the classical GRU model and the proposed GRU model used in the study conducted in this paper are presented in Table 1.

Table 1. Parameters used in the models

Parameters	**Assigned Values**
Activation	ReLU
Loss	Mean absolute error
Optimizer	Adamax
Epochs	40
Batch size	64
Layers	6

Table 2 presents the training performance results of the models. Looking at the training performance values obtained from the GRU-based proposed model and the GRU model, the proposed model gave a better performance result than the classical GRU model.

Table 2. Training performance results of the models

Model	Loss	MSE	MAPE	MAE
Proposed Model	2.8780e-04	0.00287	2.77	0.0134
GRU Model	3.2201e-04	0.00322	2.94	0.0143

Table 3. Test performance results of the models

Model	Loss	MSE	RMSE	MAPE	R^2 Score	MAE
Proposed Model	9.4514e-04	0.0009	0.0192	21.53	0.93	0.0168
GRU Model	0.0013	0.0013	0.0395	31.35	0.74	0.0221

A graphical representation of the performance results including the performance outputs in Table 2 and Table 3 are presented in Figs. 2, 3, 4 and 5.

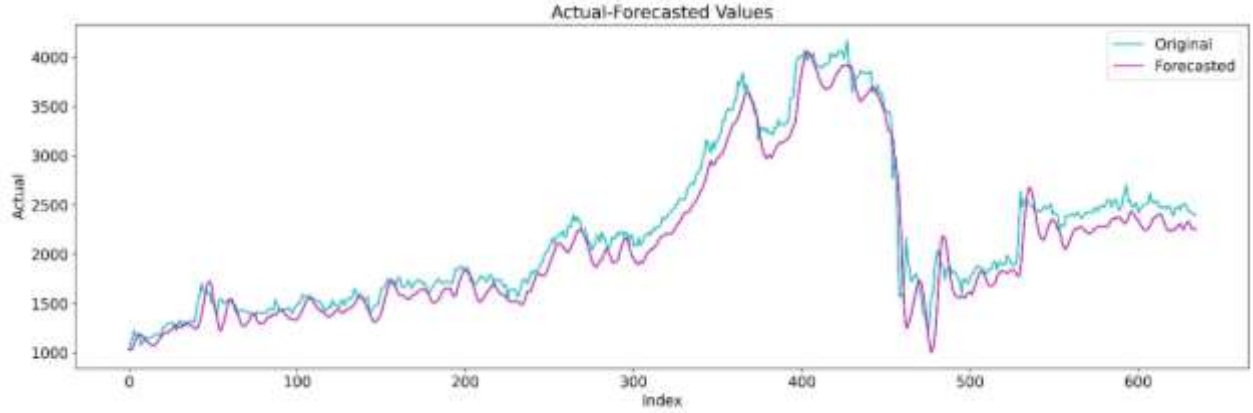

Fig. 2. The first 600 index images showing the agreement of the prediction outputs obtained with the proposed GRU model with the original values

Fig. 2 shows how close the proposed GRU model is to the original data. It can be seen that the prediction results of the proposed GRU model need to be further improved. At indices between 400 and 500, the difference is very small. The whole graph should be in this range. In future studies, it is aimed to propose a more accurate model.

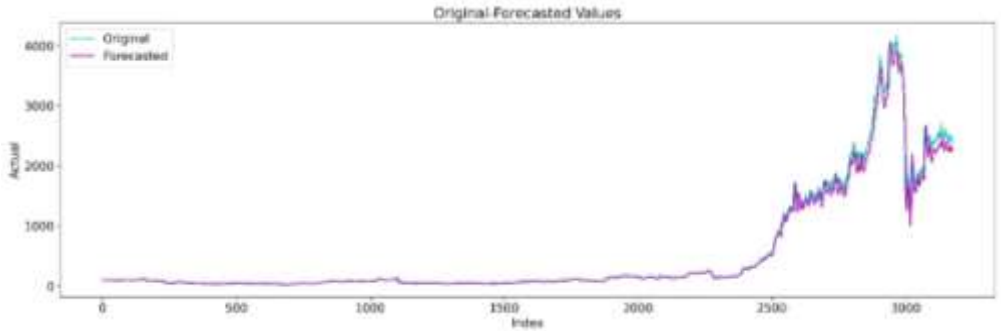

Fig. 3. The entire fit graph of the prediction outputs obtained with the proposed GRU model with the original values

Fig. 3 shows all the indices where the proposed GRU model has convergences and divergences between the original data and the predicted data. It can be seen that the prediction results of the proposed GRU model after the 2500th index need to be further improved. Fig. 4 shows the overlap of the prediction values of the classical GRU model with the actual values. When these values are analysed, it is observed that both graphs are quite different from each other. When the R^2 score values given in Table 3 are also examined, it is seen that there is a difference of 18% points between the proposed model and classical GRU.

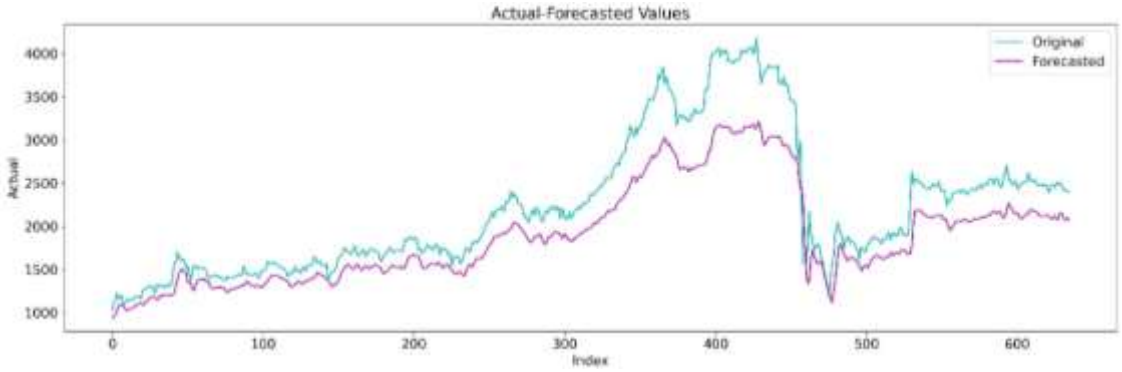

Fig. 4. The first 600 index images showing the agreement of the prediction outputs obtained with the classical GRU model with the original values

Fig. 5 shows the performance outputs of the classical GRU model together with the actual values. The graphs in Fig. 5 show that the prediction results of the classical GRU model are quite different from the actual values.

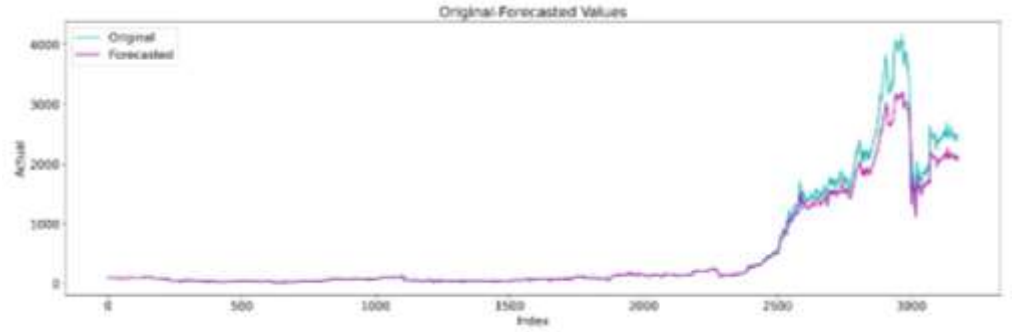

Fig. 5. The entire fit graph of the prediction outputs obtained with the classic GRU model with the original values

When the proposed GRU and classical GRU model outputs are evaluated together, it can be said that the performance results obtained are insufficient. In order to achieve better performance outputs, the GRU-based architecture model needs to be improved.

V. CONCLUSION

In this study, which includes a study that can be very useful for stock market investors, a regression analysis has been performed with two different models that perform price prediction over the stock market data named ADANI. The performance of this study, which was conducted without emotional analysis of ADANI data, was limited with an R^2 score of 0.93. In order to improve this performance result, it can be extended by performing sentiment analysis. Sentiment analysis needs to be integrated with big data consisting of raw data. In big data, information from thousands of economic commentary sources should be analyzed with sentiment analysis to decide whether a stock will be bullish or bearish. In this sense, this study will be further developed by improving the deficiencies mentioned in further studies. The proposed GRU model achieved an R^2 score of 0.93, while the classical GRU model achieved an R^2 performance value of 0.74. Even if the difference is high, the results obtained need to be improved in the following aspects.

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The premise of targeting nicotinic acetylcholine receptors for treating cancer

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Abstract – Cancer is a heterogenous disease which becomes even more heterogeneous during the course of disease progression. Classical and innovative therapeutic regimens have been limited in their efficacy and high in toxicity, opting for novel targeting candidates and more innovative treatment approaches. Nicotine acetylcholine receptors have emerged as potential targets for several pathologies, with a recent focus on cancer, due to their role in cell proliferation and induction of apoptosis apon exposure to cholinergic receptor antagonists and blockers. Nicotine has been shown to activate nicotinic acetylcholine receptors, with accumulating evidences which implicate these receptors with nicotine-induced carcinogenesis and chemoresistance. Herein we reveiw cholinergic pathway and nicotinic acetylcholin receptors and review recent experimental cell-based and *in vivo* studies focused on defining the role of cholinergic receptor subunits in cancer cells and respective cellular pathways. In addition, we summarize published data which focus on characterizing the response of nicotine acetylecholine receptor subunits to upregulation, blockage and targeting in cancer cells, which altogether offer insights for future therapeutic drug develoment strategies.

Keywords – Acetylcholine, nicotine, nicotinic acetylcholine receptors, cancer treatment, chemoresistance

I. INTRODUCTION

Neuronal and non-neuronal acetylcholine

Acetylcholine (ACh) plays a critical role in the regulation of cell proliferation and transmission of signals, both between neurons and non-neuronal cells, mainly by affecting the intracellular Ca^{2+} levels [1]. Within the nervous system, ACh behaves as a neuromodulator, by regulating the release of some neurotransmitters and influencing the neuronal networks. The main functions of ACh in the brain is the regulation of: neuronal excitability, firing of neurons in a coordinated pattern, synaptic transmission and plasticity [2]. It's role in several brain areas make it an important molecule in regulating cognitive and behavioral processes [3]. In addition ACh does also have important role in drug addiction, food intake, memory, attention, learning process and stress response [4]. ACh presence is detected at the neuromuscular junction and autonomic ganglia as well as, low but detectable levels, in blood lymphocytes and vascular endothelial cells [5]. The presence of acetylcholinesterase (AChE) in renal tubuli, epithelial cells of airway, cardiac myocytes, CD4+ T cells and trophoblasts in placenta, suggest the presence of ACh also in these cells [6]. The function of ACh in non-neuronal cells incudes the regulation of several biological processes, most notably the regulation of cell proliferation through the increase of intracellular concentration of Ca^{2+} [7].

Nicotinic Acetylcholine receptors

Ion channels are important players in many of the cellular pathways. Most of them open and close upon stimuli such as mechanical stress, voltage change across the membrane or ligand binding. Ligand gated ion channels are either stimulated by an intracellular or extracellular molecule. The ion showing the highest contribution to the inward current is Na^+, while Ca^{2+} is suggested to have a minor effect due to it's low concentration outside the cell [7]. Regarding its role as a second messenger however, Ca^{2+} is considered as having critical importance in regulating physiological processes through ion channel response [8]. Currenlty it is widely accepted that in cancer cells, channels regulating Ca^{2+} level are modulated, which implicates such channels with carcinogenesis [9], including sustained growth, drug resistance, angiogenesis and metastasis, thus this makes ion channels possible targets of treating cancer [10].

Nicotinic acetylcholine receptors (NAChRs) are ligand gated ion channels, composed of five subunits, in either homomeric or heteromeric conformation, permeable to Ca^{2+}, Na^+ and K^+ upon stimulation [11]. When bound to the ligand in high affinity, allosteric changes propagate to transmembrane domains, which results in channel opening and filtering system for selection of ions [12].

NAChRs are found to be present in skin keratinocytes, blood vessel endothelial cells and bronchial epithelial cells. In cells which are sensitive towards nicotine exposure, it is suggested that NAChRs mediate nicotine-induced toxicity [13].

A study where α3 subunit of NAChRs was blocked by antagonists in keratinocytes, found that this subunit was positively regulating cell-cell and cell-substrate adherence, yet negatively regulating the motility and migration of cells [14]. In another study on keratinocytes, it was found that nicotine induced Ca^{2+} uptake by the cells in a dose-dependent manner, which suggests the regulation of cell viability and motility of NAChRs via Ca^{2+} [15]. Similarly, there is evidence for implication of NAChRs in viability and motility of endothelial cells, mainly through α7 subunit [16, 17]. Studies focusing on the function of NAChRs on epithelial and endothelial cells imply the possibility that the effect of nicotine on the respiratory and cardiovascular system, is mediated by the contact nicotine has with NAChRs [18].

The effect of NAChRs on cancer

Smoking remains one of the major risk factors for lung cancer development, even though most of lung cancer subtypes are not related to smoking. NAChRs are considered as the mediators between smoking and lung cancer. According to one article relying on genome-wide association studies (GWAS), allelic variations in the α3-α5-β4 gene cluster increase the risk of lung cancer development, suggested to be mediated through NAChR activation. Another study introduced a variant of α5 which is associated with higher susceptibility to lung cancer by 30% [19]. On the other hand, α3 subunit seems to negatively correlate with cell survival and with the expression level of α5 and α7 [20]. Lung cancer cells treated with nicotine, has resulted in its binding to α7, inducing more Ca^{2+} influx to the cells, followed by activation of voltage-gated ion channels and activation of MAPK, higher cell division and lower apoptosis [21]. However, there are contradictory results on the role of α7 on cell proliferation, mainly linked with the differentiation status of lung cancer cells [22].

Nicotine has been implicated with increase in cell proliferation and metastasis in pancreatic cancer cell lines, through NAChRs, by phosphorylating ERK1/2 [23]. The role of NAChRs in cancer progression has been also reveled in gastric cancer, where NAChRs have been activated by nicotine treatment [24]. In an article of lung and oral cancer, NAChRs have been shown to cooperate with VEGF and EGF and activating cell survival, while suppression of cell proliferation has been observed upon binding of nicotine to mitochondrial NAChRs [25]. Nicotine is also shown to increase resistance of tumor cells to chemotherapy and radiotherapy, resulting in cell proliferation inducing activity. Based on the findings, nicotine was also considered as an angiogenic and metastatic agent in lung cancer [26, 27].
In a study analyzing the expression of different NAChRs subunits in 276 breast cancer samples versus normal tissues, it was shown that α9 was the highest in expression. In mice, the overexpression of α9 induced increased tumor growth, whereas its downregulation reduced cell proliferation and tumor mass [28]. Upregulation of α9 and increase in cell proliferation was similarly observed upon nicotine treatment in another study [29]. On the other hand, inhibition of α7 blocked the induction of higher stem cell proliferation by nicotine [30]. In ER-negative patients, cholinergic pathway has also been associated with recurrence of cancer [31].

Downregulation of α5 in lung cancer has resulted in increased Ca^{2+} influx and cell motility while cell adhesion related genes were downregulated [32]. In another study of lung cancer, downregulation of α5 blocked nicotine-induced cell motility, suggesting again that nicotine affects cell proliferation and metastasis via α5 [33]. Similar results were also observed in gastric cell lines [34]. Downregulation of α5 in another study was followed by the inhibition of PI3K/AKT pathway and increase of apoptosis, suggesting the role of nicotine on the resistance of cancer cells toward chemotherapeutic agents [34]. α5 subunit was found to be upregulated in adenocarcinomas, suggesting its role in lung carcinogenesis. Tumor size was also correlated to α5 expression in CHRNA5-depleted small cell lung cell carcinoma (SCLC) cell line.

Cholinergic receptors as potential drug targets

Based on the implication of NAChRs in nervous system as well as in non-neuronal cells, NAChRs offers promises of treating several disorders [35]. Two drugs targeting NAChRs have been put in market, such as Varenicline and Mecamylamine, used for smoking cessation and hypertension, respectively [36, 37]. Due to their side effects mainly in nervous system, these drugs were not successful in therapeutics. Several other pathologies have been investigated for their treatment by targeting NAChRs, such as depression, epilepsy, Alzheimer's, pain and inflammation [35]. The focus of this study is to summarize the most recent published data on the implication of NAChRs with cancer and offer insights on the potential of targeting NAChRs to develop new cancer treatment strategies.

II. Materials and Method

This study is based on the articles published during the last 5 years on the role of NAChRs on cancer progression. It reviews the major findings of these studies and how those findings can be used to develop new targeting strategies for cancer.

III. RESULTS

Different publications focus either on one cholinergic receptor subunit, several of them, or all of them at the same time, to find the most important subunit affecting cancer initiation, progression and related pathways.

Studies on α5-NAChR are mainly focused on lung cancer and the implication of α5 in nicotine-induced effects. Studies on lung adenocarcinoma (LUAD) reveal a correlation of this NAChR subunit with the smoking status and cell survival via α5-nAChR/STAT3-Jab1-PD-L1 (Table 1) [38] and α5-nAChR/STAT3/NLRP3 [39] axis. Both of these studies show upregulation of α5 upon nicotine exposure of cells. In another study of chronic stress-induced LUAD, NAChR-α5 was upregulated in mice undergoing chronic stress which was then found to induce cell invasion [40]. The highest number of recent publications on cholinergic receptors' relation to cancer biology, focus on NAChR-α7 subunit, which is often upregulated in different cancer types. In one study, upregulation of α7 was mediated by endogenous Lynx1 upon nicotine exposure in lung adenocarcinoma A549 cells, which resulted in increased cell proliferation [41]. On the other hand, activation of α7 by nicotine in breast cancer MCF7 cells induced cell proliferation, motility and calcium signalling [42]. Targeting of α7 blocked nicotine induced increase of adrenaline/noradrenaline in A549 and H1299 lung cancer cells [43], whereas hepatocellular carcinoma cells upon downregulation of α7 and exposure to sorafenib, inhibited migration, colony formation and induced cell cycle arrest as well as apoptosis [44]. Several studies have applied α7 blockers to determine the efficiency of targeting this NAChR subunit, as a premise to treat cancer. Blocking α7 subunit by QND7 antagonist very effectively suppresed cell proliferation and migration, while inducing apoptosis in lung cancer H460 and A549 cells, comparable to cisplatin effect [45]. In addition, another drug, RL-RVG, decreased migration dhe eptithelial-to-mesenchymal transition of BGC and SGCA gastric cancer cells via α7 [46]. Methyllycaconitine citrate, an α7 nicotinic antagonist, was able to reverse the cell proliferation stimulatory effect of acetylcholine in erythroleukemia K562 cells, by decreasing the intracellular Ca^{2+} level [47]. In A549 lung cancer cells, sinomenine, reduced cell proliferation and migration, while increasing apoptosis. In addition, it caused reduced tumor volume *in vivo* throug α7 [48]. Similarly, other NAChR subunits-inhibitors have been used in other studies. In MDA-MB-157 breast cancer cells, α9α10 antagonist GeXIVA inhibited cell proliferation and iduced apoptosis [49]. Another study focused on the relation between nicotine, paxitacel effect and cholinergic refeptors mediation in MDA-MB231 breast caner cells. Nicotine was able to reverse the cytotoxic effect of paclitaxel via α7 and α9 [50]. Multiple cancer cell lines treated with Pinnatoxin G lost normal viability, which was correlated to α7, α4, and α9 [51]. NAChR blockers conotoxins MII, PnIA, RgIA, and ArIB11L16D applied in vitro and vivo, reduced cell viability and tumor growth (respectively) of Ehrlich ascites carcinoma (EAC) [52]. In another study, treatment of multiple lung cancer cells with α-conotoxin TxID (selective blocker of α3β4) rendered cells less viable, whereas cotreatment with Adriamycin increased the sensitivity of lung cancer cell to the chemotherapeutic drug treatment [53]. The immunoregulatory function of Treg cells on the other hand was revealed to be affected by several subunits of NAChRs. In addition, α2, α5, α9, and β2 were found to be differentially expressed in naive, Th1, Th2, Th9, Th17 and iTreg cells [54]. In another recent study, NAChRs were found to mediate the nicotine-promoted Warburg effect, metabolic reprograming, pHi homeostasis, migration and the overall cancer progression of A549 lung cancer cells [55].

Table 1: Recent articles on the implication of NAChRs in cancer

Year of publ.	NAChRs subunit(s) under study	Sample type	Results	Conclusions	References
2022	α5	-Lung adenocarcinoma (LUAD) cancer patient samples with smoking status. -Mice xenograft tumor models	- α5 was correlated with PD-L1 expression, smoking status and lower survival of LUAD in vivo -α5 mediated pSTAT3, Jab1 and PD-L1 expression. -downregulation of α5 increased T cell-mediated killing of LUAD cells and increased IL-2 secretion	α5-nAChR/STAT3-Jab1-PD-L1 axis can be used as therapeutic target for immunotherapy in LUAD	[38]
2022	α5	-A549 and H1975 (LUAD) -Patient specimens -Chicken embryo and mouse xenografts	-The expression of α5-nAChR was correlated with the expression of NLRP3 via STAT3 -Nicotine increased the level of α5, STAT3, NLRP3, CASP1, IL-1β and IL-18 -Nicotine effect on expression of NLRP3 and STAT3 was inhibited by the silencing of α5.	Nicotine promotes lung cell proliferation and migration via the α5-nAChR/STAT3/NLRP3 axis in lung cancer	[39]
2023	α5	Mouse model (LUAD)	-Chronic stress increases the level of acetylcholine and α5 -Chronic stress increases LUAD cell invasion via modulation of α5, DNA-methyltransferase (DNMT1) and fragile histidine triad (FHIT)	α5-nAChR/FHIT axis can be considered as therapeutic target for chronic stress-related LUAD	[40]
2020	α7	H460 and A549 (non-small cell lung cancer (NSCLC) cell lines	-Targeting α7 exhibited the highest cytotoxic effect and induced cell apoptosis in both cell lines at a level comparable to cisplatin - QND7 antagonist very effective in supressing cell proliferation and migration	QND7 needs further preclinical evaluation and demonstrates the potential of α7 as cancer drug target.	[45]
2019	α7	-BGC and SGCA (Gastric cancer cell lines) -mouse xenograft model	-rL-RVG suppressed the migration and reduced EMT of gastric cancer cells via α7-nAChR. -rL-RVG inhibits α7-nAChR-MEK/ERK-EMT to suppress migration of gastric cancer cells.	rL-RVG acts as a competitive antagonist of α7-nAChR to suppress the migration of gastric cancer cells through inhibiting α7-nAChR-MEK/ERK-EMT	[46]
2019	α7	Set of human epithelial cells	- Endogenous Lynx1 controls the nicotine-induced up-regulation of the expression of α7 type nAChRs in A549 cells as well as the cell growth -Co-localization of Lynx1 with α7-nAChRs was revealed in a cell membrane for lung adenocarcinoma A549 and colon carcinoma HT-29 cells, but not for breast adenocarcinoma MCF-7 and epidermoid carcinoma A431 cells.	Lynx1 is a homeostasis regulator of epithelial cancer cells	[41]
2021	α7	K562 (erythroleukemia cells)	-The cell proliferation stimulatory effect of acetylcholine was reversed by methyllycaconitine citrate (α7 nicotinic	Interaction of nicotinic receptors with different signalling pathways.	[47]

			antagonist) and atropine (the cholinergic antagonist). -ACh caused an increase in intracellular Ca^{2+}, methyllycaconitine citrate decreased intracellular Ca^{2+} level.		
2021	α7	-Mouse xenograft model -A549 (Non-small lung cancer)	-Sinomenine decreased cell proliferation and migration abilities but increased the percentage of apoptotic cells. -Tumor volume *in vivo* was significantly reduced after sinomenine treatment -The effects of sinomenine were abolished by the α7 nAChR antagonist mecamylamine and the allosteric modulator PNU-120596 -Sinomenine suppressed α7 expression (in vitro and in vivo), pERK1/2 and ERK1/2, TTF-1 and SP-1, while up-regulating Egr-1.	Sinomenine is a lung cancer inhibitor via α7 nAChR	[48]
2022	α7	Sorafenib-resistant hepatocellular carcinoma cells (HCC)	-Upon downregulation of α7 and exposure to sorafenib, migration and colony formation were inhibited. -Apoptosis and cell cycle arrest was observed	Overexpression of α7 suggests that it might be a therapeutic target for HCC cell resistance therapy.	[44]
2023.	α7	MCF-7 cells (breast cancer)	-Activation of α7 by nicotine or choline induced cell proliferation, motility and calcium signalling	A new role of G protein signalling in α7-related cell proliferation	[42]
2023	α7	A549 and H1299 (lung cancer)	-α7 inhibition blocks nicotine-induced increase of adrenaline/noradrenaline -nicotine decreases GABA levels; increases VEGF expression and PI3K/AKT activity; inhibits p53 activity in A549	VEGF is upregulated by α7 and downregulated by GABA and/or p53 in response to the nicotine	[43]
2020	α9 α10	MDA-MB-157 (breast cancer cell line)	GeXIVA (α9α10 nAChR antagonist) was able to inhibit cell proliferation and promote apoptosis	GeXIVA needs to be further investigated as potential agent for targeted therapy	[49]
2022	α7, α9	MDA-MB-231 (triple negative)	Nicotine reversed the cytotoxic effect induced by paclitaxel, via α7 and α9	In triple negative breast cancer patients treated by paclitaxel, nAChRs should be considered as targets	[50]
2021	α7, α4, and α9	HT29 (colon cancer), U87, LN18 and U373 (glioma cell lines), MDA-MB-231 (breast cancer cells), PC3 (prostate cancer cells)	Upon the treatment of pinnatoxin G on cancer cell viability all cell types lost viability, correlating with expression levels of α7, α4, and α9	Pinnatoxin G is a promising anticancer agent, with both cytostatic and cytotoxic effects.	[51]
2019	α3β4	A549, NCI-H1299, NCI-H1688, DMS114 (Lung cancer)	-Most of nAChRs are expressed in all cell lines -α3 and β4 were upregulated in A549 and NCI-H1299	Targeting of α3β4 shows a potential strategy for lung cancer therapy	[53]

			-A549 and NCI-H1299 treated with α-conotoxin TxID (selective blocker of α3β4) showed reduction in cell growth, whereas simultaneous treatment with adriamycin showed enhanced effect on cell growth inhibition		
2022	α2, α5, α9, and β2	Murine-induced Treg (iTreg) cells	-TGF-β1 production was suppressed by nicotine -α2, α5, α9, and β2-nAChRs were differentially expressed in naive, Th1, Th2, Th9, Th17, and iTreg cells	The immunoregulatory role of Treg cells is affected by the cholinergic system, probably through nAChRs.	[54]
2020	α6, α3β2, α9α10, and α7	-Af/WySnMv mice injected with Ehrlich ascites carcinoma (EAC) -EAC cells in vitro -splenocytes	-Conotoxins MII, PnIA, RgIA, and ArIB11L16D nAChRs blockers promoted tumor growth inhibition in mice -Survival rate of the tumor-bearing, drug treated mice increased - conotoxins reduced the viability of EAC cells and splenocytes	nAChR blockers MII, PnIA, RgIA, and ArIB11L16D have cytotoxic effects	[52]
2023	All subunits	A549 (Non-small lung cancer)	-Nicotine promoted the Warburg effect and accelerated migration of cells through the activation of nicotinic acetylcholine receptors. -Nicotine upregulated NHE1 and MCT4, and facilitated glycolysis.	Nicotine regulates metabolic reprogramming and pHi homeostasis via activation of nicotinic acetylcholine receptors and can therefore aggravate lung cancer progression.	[55]

IV. DISCUSSION

There is enough scinetific evidence that nicotinic acetylcholine receptors are implicated in different cellular pathways such as proliferation, adherence and migration, mainly suggested to be linked with Ca^{2+} uptake.

The majority of the studies published so far on functional characterization of these receptors are focused on the regulation of their subunits by agonists such as acetylcholine and nicotine or blocking of the receptor subunits. NAChRs are considered as the mediators between smoking and lung cancer. Nicotine is considered as an exogenous activator of NAChRs. It has been linked in reducing the effects of chemotherapeutic drugs and limiting therapeutic response [56]. Other data reveal increased sensitivity of cancer cells toward chemotherapeutic agents when deprieved of α7 [44][53], all of which urge more studies on NAChR blockers as drug sensitivity-increasing agents in patients receiving conventional chemotherapy, with a major focus on those cancers where chemoresistance is observed and/or in smoking patients. NAChRs-based therapies can also be offered in combination with chemotherapy drugs to decrease their dosing regimens and reduce the side effects [56].

Allelic variations in NAChR subunits encoding genes have been linked with susceptibility to lung cancer development, suggested to be mediated through NAChRs expression level. Studies on α7 subunit show a direct implication of α7 on cancer cell proliferation and progression. All the herein presented α7-based studies suggest this subunit can serve as a promising target in treatment of different cancer types [41-48]. One of the recent studies on *in vivo* mouse models, shows tumor growth inhibition and survival rate increase in mice treated with several NAChR blockers [52], opting for futher *in vivo* investigations. A very critical implication of NAChRs in cancer through nicotine-induced cancer progression. Targeting of NAChR subunits show premises of effectively treating nicotine-induced cancers [39][41][50]. Other findings implicate cholinergic system in previously unknown pathways such as immunity system [54], whereas others suggest development of cancer therapies by targeting α5-implicated axis, examples of which are nAChR/STAT3/NLRP3 in LUAD [39], α5-nAChR/STAT3-Jab1-PD-L1 via immunotherapy in LUAD [38] and α5/FHIT for chronic stress-related LUAD [40].

CONCLUSION

Acetylcholine receptors are promissing drug targets to treat cancers and reduce chemoresistace. More research on the influence of NAChRs on cancer initiation, progression and chemoresistance is needed to further establish new treatment modalities of cancers via targeting of cholinergic system. Available cholirgic receptor antagonists and new candidates should be considered for future in vivo reasearch and clinical trials.

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Determining the Effect of Energy Production and Consumption of Turkic Republics on Carbon Emission with Panel Data Analysis Method

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Abstract **–**The increasing population around the world causes human needs to increase. People's unconscious use of natural resources harms the environment. It is essential to use environmentally friendly products for a liveable world. People primarily need water, food, and energy to carry out their vital activities. Vehicles, equipment, infrastructure, transportation, machinery, and technology are required to meet other needs such as travel, communication, health, and education, which are in the order of needs due to human nature. Achieving these is possible with production, energy, and workforce. Considering all these, carbon emissions occur on our planet due to resource use, and our ecosystem is negatively affected. As a result of industrialization and the rapid development of technology, the problem of climate change and global warming has become a problem that concerns all countries of the world. Evaluating carbon emissions depending on energy production and consumption is an important issue. This study, it was aimed to determine the energy production and energy consumption affecting carbon emissions of Azerbaijan, Kazakhstan, Turkey, and Uzbekistan between 1995-2014. The Random Effects Model of the Panel Data Analysis method was used in the study. According to the study results, it is possible to say that green energy production and consumption in the Turkic Republics will reduce carbon dioxide emissions, while energy production and consumption obtained using fossil resources will increase carbon dioxide emissions. When a general evaluation of the study is made, this research reveals that the use of sustainable green energy is vital for the future of our world.

Keywords – CO2 Emission, Energy Production, Green Energy, Panel Data Analysis, Turkic Republics

I. INTRODUCTION

As a result of industrialization and rapid development of technology, climate change, and global warming have become a problem that concerns all countries of the world. In recent years, the number of studies focusing on the relationships between CO2 emissions and growth and energy production and consumption has been increasing. The fact that economic growth, which is the main goal of countries, is linked to energy consumption, brings about an increase in environmental pollution along with economic growth. It is known that the increase in industrial production harms CO2 emissions [1-3]. Urbanization, industrialization, population, electricity consumption, and technology have a significant impact on changing the economic structure. Industrialization accelerates urbanization. The negative effects of climate change due to carbon emissions are increasing. As CO2 emissions increase, the effects of climate change become more visible [4].

Energy is an important input in the production process. Energy has a very important place in growth and development policies. Environmental degradation, which occurs as an inevitable result of non-environmentally friendly industrialization, causes many costs to be incurred. Renewable energy both

contributes to preventing environmental degradation and is an alternative to fossil-based energy against the threat of depletion of fossil energy reserves [5].

Increasing concerns about climate change have made renewable energy an important research topic. Recent studies analyze carbon dioxide emission savings by using renewable energy as an individual source or in conjunction with conventional energy sources in conjunction with life cycle analysis methods. Some studies in the literature conducted in recent years can be given as examples of these analyses. [6-15]. The dependent and independent variables used in the study were created by examining the relevant literature.

This study aims to investigate the impact of Azerbaijan, Kazakhstan, Turkey, and Uzbekistan's GDP, fossil-based and renewable energy production, and consumption on CO2 emissions. For this reason, 6 different models were created, and because of the Hausman test, it was decided to use the Random Effects Model.

II. MATERIAL AND METHOD

Parametric and non-parametric methods are used both together and separately in economic studies. To conduct studies with parametric methods, different methods such as econometric studies, cross-sections, time series, and panel data are used. Since it is possible to handle data in both horizontal and vertical dimensions, panel data analysis was used in the study [16]. In the study, data from 4 Turkic Republics, namely Azerbaijan, Kazakhstan, Turkey, and Uzbekistan, were used in the horizontal dimension, and time-dependent data covering the years 1995-2014 were used in the vertical dimension. Panel data can be defined as a time series of the number of sections or cross-data with a time dimension [16]. Due to these features, panel data enable many different observations to be made regarding the same sampling unit [17].

The panel data regression equation is created differently from cross-sectional data and/or time series regression equation. Baltagi (2005) expressed this equation as follows [18]:

$$y_{it} = \alpha + \beta X'_{it} + u_{it} \quad (1)$$

where α invariant, β is the regression coefficient representing the slope, i = 1, ..., N section size and t = 1, ..., T(i) specifies the time series size. The X values calculated in the equation represent the independent variables. The one-way error component model is used in most panel data applications as follows [18]:

$$u_{it} = \mu_i + \nu_{it} \quad (2)$$

E (u_{it}) ~ N (0, σ^2) in the distortion term μi unobservable special effect, νit represents extra error. When creating regression, if the time series is the same for all cross-sectional data, it is defined as a balanced panel, otherwise, it is defined as an unbalanced panel [19].

Fixed Effects Approaches and Random Effects Approaches are used in panel data analysis regression estimates. Which of these models should be used depends on obtaining the desired results in the model [19]. The fixed effects approach also uses the Ordinary Least Squares (OLS) method, where the dummy variables of the group and all variables are fixed, while the random effects model assumes a structure of the error term by considering individual effects as a random component of the error term, and its parameters can be applied Generalized Least Squares (GLS) method [20].

When analyzed in the Fixed Effects Model, the form of the equation for each DMU, that is, cross-sectional data, is created as follows [21]:

$$y_{it} = \alpha_0 + \alpha_i S_{it} + \beta_n X_{nit} + \lambda_i(S_{ni}X_{nit}) + u_{it} \quad n = 1..M;\ i = 1\ldots N;t = 1...T \quad (3)$$

There are many parameters in the fixed effects model and since there is a problem of artificial variables, a random effects model was developed. This model was created as follows [19], [21-22]:

$$y_{it} = \beta_{0i} + \beta_n X_{nit} + e_i + u_{it} \quad n = 1. . . M;\ i = 1\ldots N;\ t = 1 ... T \quad (3)$$

There is no correlation between individual error terms and the autocorrelation between time series and cross-section terms [18-19]. When it is necessary to choose between fixed-effect and random-effect models in panel data analysis, the Hausman Test is used to decide the model choice. In this test, the fixed effect estimator is assumed to be consistent and unbiased [18]. The calculation method of the Hausman test is as follows [21]:

$$\chi^2 = (\beta_{SE} - \beta_{RE})'[Var(\beta_{SE}) - Var(\beta_{RE})]^{-1} (\beta_{SE} - \beta_{RE}) \quad (4)$$

Here, SE - Fixed Effects estimator, RE - Random Effects estimator Var (β_{SE}) ve Var (β_{RE}) - The estimation result of variance-covariance matrices, fixed and random effects models, and asymptotics is obtained. The hypothesis used in this test was created as follows [23]:

For Fixed Effects Model; H1: E (αi |xi) ≠ 0 (αi) There is a correlation between and explanatory variables.

For Random Effects Model; H0: E (αi |xi) = 0 (αi) There is no correlation between and explanatory variables. Where the difference between the estimators of two models is not systematic ((Probe> χ2) <%5) While the fixed effects model is preferred, if it is systematic ((Probe> χ2)>%5) random effects model is preferred [19].

Parametric and non-parametric methods are used both together and separately in economic studies. To conduct studies with parametric methods, different methods such as econometric studies, cross-sections, time series, and panel data are used. Since it is possible to handle data in both horizontal and vertical dimensions, panel data analysis was used in the study [16]. In the study, data from 4 Turkic Republics, namely Azerbaijan, Kazakhstan, Turkey, and Uzbekistan, were used in the horizontal dimension, and time-dependent data covering the years 1995-2014 were used in the vertical dimension. Panel data can be defined as a time series of the number of sections or cross-data with a time dimension [16]. Due to these features, panel data enable many different observations to be made regarding the same sampling unit [17].

III. DATA AND VARIABLES

The variables obtained from the World Bank's [24] website and used in the study are presented in Table 1.

Table 1. Variables used in the study

Abbreviations	**Definitions**
CO_2	Carbon dioxide emissions (Kt)
GSYH	Gross Domestic Product (GDP) (constant 2015, million USD)
YEŞEN	Green energy - Renewable energy consumption (% of total electricity production)
ENT	Energy consumption (GDP, constant 2017 PPP $/kg oil equivalent per unit)
ENK	Energy use (oil equivalent per capita, kg)
ELPGK	Electricity production from oil, gas and coal sources (% of total electricity production)
YENEL	Renewable electricity production (% of total electricity production)

This study aims to determine the energy production and energy consumption affecting carbon emissions of Azerbaijan, Kazakhstan, Turkey, and Uzbekistan between 1995-2014. Turkmenistan and Kyrgyzstan, which are other Turkic Republics, were not included in the study because all their data could not be accessed. Statistics regarding the data of the countries are presented in Table 2. When Table 2 is examined in the context of the data obtained, it is seen that the dependent variable, CO2, was highest in Azerbaijan in 1995, in Kazakhstan in 2013, in Turkey in 2014, and in Uzbekistan in 2002. The lowest was in 2010 in Azerbaijan, 2001 in Kazakhstan, and 1995 in Türkiye and Uzbekistan. Among the independent variables, GDP was the highest in all countries in 2014 and the lowest in 1995. The YEŞEN variable was most prevalent in Azerbaijan in 2010, in Kazakhstan in 2002, in Turkey in 1995, and in Uzbekistan in 1996. The least was in 1995 in Azerbaijan, 2008 in Kazakhstan, 2014 in Turkey, and 2000 in Uzbekistan.

Table 2. Statistical data of variables

Countries	**Indicators**	**CO_2**	**GSYH**	**YEŞEN**	**ENT**	**ENK**	**ELPGK**	**YENEL**
Azerbaycan	Minimum	32474,90	52501,88	4,45	607,72	1809,19	94,02	18,42
	Maxsimum	24311,90	8472,53	1,37	90,86	1279,55	81,58	5,63
	Mean	28245,22	27032,01	2,69	257,36	1469,48	89,66	10,31
	Std. deviation	2316,49	17043,37	0,78	160,03	112,53	2,84	2,89
Kazakistan	Minimum	260015,40	182201,98	2,77	386,22	4786,59	92,49	15,24
	Maxsimum	117443,40	58532,02	1,15	182,08	2324,55	83,39	7,51

	Mean	179489,66	108270,68	1,76	234,32	3500,72	88,07	11,30
	Std. deviation	47800,04	42999,06	0,47	52,03	860,59	2,80	2,33
Türkiye	Minimum	341671,50	814741,00	21,90	78,14	1574,74	82,61	42,94
	Maxsimum	168150,50	338182,36	11,51	63,25	1038,16	57,06	17,35
	Mean	248343,52	523128,00	16,23	72,80	1285,80	72,30	27,66
	Std. deviation	55703,43	144050,69	3,44	4,40	180,52	7,50	7,52
Özbekistan	Minimum	129888,00	80392,88	1,66	739,76	2110,55	87,46	23,00
	Maxsimum	98154,60	26042,60	0,72	234,71	1348,50	77,00	12,54
	Mean	117833,01	45276,43	1,20	517,90	1819,96	83,45	16,55
	Std. deviation	10200,16	17373,50	0,29	183,55	233,26	3,81	3,81

The ENT variable was most prevalent in Azerbaijan and Kazakhstan in 1995, in Turkey in 1996, and in Uzbekistan in 1998. The lowest was in 2010 in Azerbaijan and 2014 in Kazakhstan, Türkiye, and Uzbekistan. The ENK variable was most prevalent in Azerbaijan in 1995, in Kazakhstan in 2013, in Turkey in 2014, and in Uzbekistan in 1999. The least was in Azerbaijan in 2010, in Kazakhstan in 2001, in Türkiye in 1995, and in Uzbekistan in 2014. The ELPGK variable was most prevalent in Azerbaijan in 2014, in Kazakhstan in 2013, in Turkey in 2008, and in Uzbekistan in 1997. The lowest was in Azerbaijan in 2010, Kazakhstan in 2007, Türkiye in 1996, and Uzbekistan in 2008. The YENEL variable was most prevalent in Azerbaijan in 2010, in Kazakhstan in 2002, in Turkey in 1996, and in Uzbekistan in 2008. The lowest was in Azerbaijan in 2014, Kazakhstan in 2013, Türkiye in 2008, and Uzbekistan in 1997.

The models presented below were created to determine the factors affecting carbon dioxide emissions in the Turkic Republics between 1995 and 2014.

Model 1: $LnCO_2 = \beta_0 + \beta_1 LnGSYH + \varepsilon$

Model 2: $LnCO_2 = \beta_0 + \beta_1 LnYESEN + \varepsilon$

Model 3: $LnCO_2 = \beta_0 + \beta_1 LnENT + \varepsilon$

Model 4: $LnCO_2 = \beta_0 + \beta_1 LnENK + \varepsilon$

Model 5: $LnCO_2 = \beta_0 + \beta_1 LnELPGK + \varepsilon$

Model 6: $LnCO_2 = \beta_0 + \beta_1 LnYENEL + \varepsilon$

IV. RESULTS

The analysis results made with Models 1-6 are presented in Table 3. When Probe > $\chi 2$) > 5% was obtained in regression analysis because of the Hausman Test, random effects model results were used in all created models.

It can be seen from Table 3 that in all analyses, there is a statistical significance of 1% between the independent variables and the dependent variable. In the analysis of Model 1, it was estimated that carbon dioxide emissions in countries would increase by 0.544% because of a 1% increase in GDP. According to Model 2 analysis, it is predicted that a 1% increase in green energy, and renewable energy consumption as a percentage of total electricity production will reduce carbon dioxide emissions by 0.254%. According to the analysis conducted with Model 3 and Model 4, it is estimated that carbon dioxide emissions in countries will increase by 0.326% and 0.596%, respectively, because of a 1% increase in oil equivalent energy consumption per unit of $/kg and oil equivalent energy use per kg capita.

Table 3. Random Effects Model Results

Variables	1. Model	2. Model	3. Model	4. Model	5. Model	6. Model
Constant	-2,069*	11,31***	13,327***	7,114***	28,244***	9,034***
LnGSYH	0,544***					
LnYESEN		-0,254***				
LnENT			0,326***			
LnENK				0,596***		
LnELPGK					3,769***	
LnYENEL						-0,952***
δ_u						
δ_e	0,548	0,914	0,931	0,930	0,834	0,811
ρ	0 (fraction of variance due to u_i)					

Models	R^2	Wald χ	Hausman Test	
			χ^2	Prob
1. Model	0,679	155,65***	1,35	0,2450
2. Model	0,106	8,47***	0,03	0,8549
3. Model	0,075	7,83***	0,02	0,8922
4. Model	0,075	7,13***	0,06	0,8045
5. Model	0,257	22,90***	0,48	0,4871
6. Model	0,298	28,39***	0,47	0,4908

In the analysis of Model 5, it was estimated that carbon dioxide emissions in countries would increase by a very high rate of 3.769% because of a 1% increase in electricity production from oil, gas, and coal sources. According to Model 6 analysis, it is predicted that carbon dioxide emissions will decrease by 0.952% because of a 1% increase in renewable electricity production. Considering the δe results obtained from the regression analyses, it can be said that random effects are at a low level of 54.8% in model 1 only and are at a high level of 81.1% to 93.1% in the other models. The R2 value, which represents the explanatory power of the regression, was 67.9% only in model 1, and was below 30% in the other models. In Models 3 and 4, these values were 7.5%.

V. CONCLUSIONS

Industrial production and resource consumption are increasing due to the increasing population around the world. The use of fossil fuels to meet people's needs is increasing rapidly day by day. Unconscious use of fossil fuels negatively affects the environment and ecosystem. To leave a liveable world to future generations, environmentally friendly energy production and consumption must be prioritized, and this strategy must be implemented sustainably worldwide. When evaluated from this perspective, it is vital to analyze the relationship between carbon emissions and energy production and consumption very well.

In this study, it was tried to determine the energy production and energy consumption that affected the carbon emissions of Azerbaijan, Kazakhstan, Turkey, and Uzbekistan between 1995-2014. As a result of the study conducted with the data of the Turkic Republics between 1995 and 2014, it is possible to say that carbon dioxide emissions will decrease because of the production and consumption of green energy in the countries, and carbon dioxide emissions will increase because of the production and consumption of energy obtained from fossil resources. For this reason, it is suggested that countries should transfer more resources and investments to green energy production in the future.

Like many other studies, this study also has some limitations. It is an important limitation that the study was conducted in only four Turkic Republics. Another limitation is that the study covered the years 1995-

2014. Different countries and years may be used in future studies. When a general evaluation of the study is made, this research reveals that the use of sustainable green energy is vital for the future of our world.

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The Relationship Between Soil and Some Endemic Plant Communities Belonging to The Caryophyllaceae Family Growing Naturally Around Karakuyu Marsh (Afyonkarahisar - Turkey)

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Abstract **–** Karakuyu Marshes are located in the upstream of the Büyük Menderes River upper basin, within the borders of Dinar district of Afyonkarahisar province, and are also known as "Karakuyu Lake", "Çapalı Lake" and "İncesu Lake". The lake, which is connected to the Burdur Basin in the south, the Uluborlu Plain in the east and the Büyük Menderes Basin in the west, has the coordinates of 38° 15. north, 30° 52. east and an altitude of 950 m. The study area is located within the borders of Afyonkarahisar province in the Aegean Region Inner Western Anatolia and is located within the B3 square according to the quadrature system determined by Davis (1965-1988). The region has a "semi-arid Mediterranean Bioclimate" and an "Eastern Mediterranean type" rainfall regime. In the region, there are mostly Alluvial Soils, Hydromorphic Alluvial Soils, Colluvial and Brown Large Soil groups and reeds-swamps as land types. The majority of the research area is covered by Quaternary land. Nearly 100 vascular plants were identified in the study area located within the Iran-Turan floristic region. "Flora of Turkey and the Eastern Aegean Islands", "List of Plants of Turkey (Vascular Plants)", (Flora of Turkey (Vascular Plants) Checklist)" and Afyon Kocatepe University herbarium (AKÜ) were also used to identify the plants. According to Braun-Blanquet (1932), 6 plant communities were identified in the research area. These are *Eromogene ledebouriana* (Fenzl) Ikonn (iğne kumotu), *Bolanthus minuartioides* (Jaub. et Spach) Hub.- Mor. (havalotu), *Dianthus zonatus* Fenzl var. *zonatus* (kaya karanfili), *Minuartia anatolica* (Boiss.) Woron. var. *arachnoidea* McNeill (tıstısotu), *Saponaria prostrata* Willd. subsp. *prostrata* (ebemterliği), *Saponaria pumilio* Boiss. (zarif sabunotu). To carry out the research, plant communities along with their soils were collected, analyzed and evaluated. In order to find out the relationship between these plant communities, soil samples taken from 0-30 and 30-60 cm depths and their physical-chemical analyzes were determined primarily by soil structure, pH, salt, lime and organic matter, determined by the Ankara Soil Fertilizer and Water Resources Central Research Institute. It was interpreted according to the methods.

Keywords – Karakuyu Reeds and marshlands (Afyonkarahisar), Cayophyllaceae, endemic plants, soil features, vegetation-soil relationship

I. INTRODUCTION

Karakuyu Marshes are located in the upstream of the Büyük Menderes River upper basin, within the borders of Dinar district of Afyonkarahisar province, and are also known as "Karakuyu Lake", "Çapalı Lake" and "İncesu Lake". The lake, which is connected to the Burdur Basin in the south, the Uluborlu Plain in the east and the Büyük Menderes Basin in the west, has the coordinates of 38° 15. north, 30° 52. east and an altitude of 950 m. The study area is located within the borders of Afyonkarahisar Province, in

Mid-Western Anatolia, Aegean Region, and falls into B3 square according to the gryd system (Fig. 1). So far, Afyonkarahisar's close near, Sultan Mountains [1], Köroğlubeli Vegetation [2], Vegetation of Afyon Başkomutan Historic National Park [3], Akdağ Flora and Vegetation [4], Türkiye Geothermal Inventory [5], Akarçay Basin Hydrogeology [6], The Steppe Vegetation of Emir Mountain [7], Kumalar Mountain Flora [8], Ahır Mountain Flora [9], Emir Mountain Northern half of Flora [10], Emir Mountains South Half Flora [11], [12], Eber Lake (Afyonkarahisar) Flora [13], Evaluation of Eber Lake (Afyonkarahisar) Macrophytes in Terms of Restoration Ecology [14], and so on, have been found in such studies.

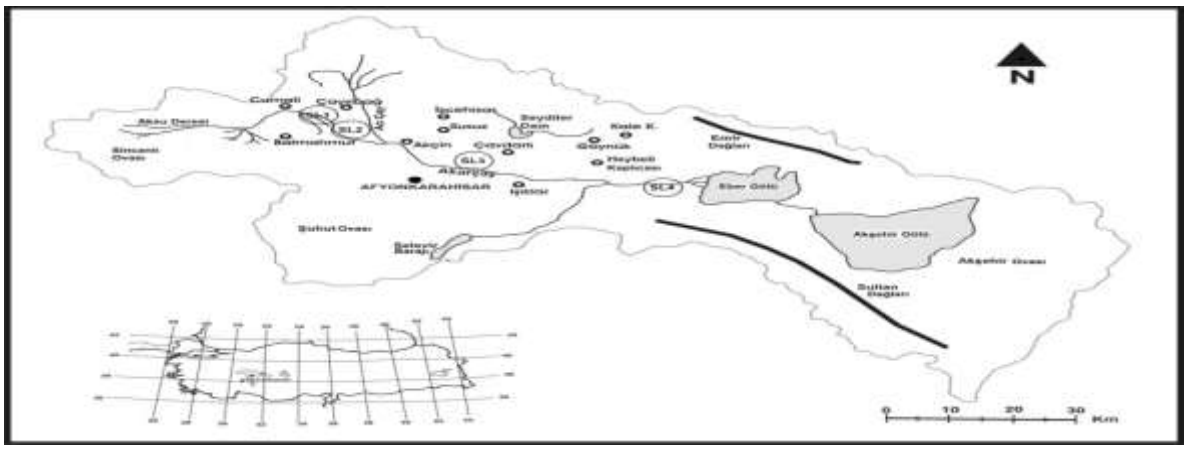

Fig. 1 Study area

II. Materials and Method

Nearly 100 vascular plants were identified in the study site, situated in the Irano-Turanian floristic region. Identification of the plants was based on “Flora of Turkey and the East Aegean Islands” [15]-[17] and "Türkiye Bitkileri Listesi (Damarlı Bitkiler)" (A checklist of the Flora of Turkey (Vascular Plants))” [18], and the herbarium of Afyon Kocatepe Üniversitesi (AKÜ) was also utilized. Most of the study area is covered by Quaternary lands. Bioclimate of the area is a combination of semi-arid - cold Mediterranean climates. The precipitation regime shows the characteristic of eastern Mediterranean. Most of the study area has alluvial soils, hydromorphic alluvial soils, colluvial soils, brown soils with reeds-marshs of land type. Floristic region of the area is a Irano-Turanian type and about 100 vascular plant types have been identified. 6 plant communities are identified regarding to [19] in the research area. These are *Eromogene ledebouriana* (Fenzl) Ikonn, *Bolanthus minuartioides* (Jaub. et Spach) Hub.- Mor., *Dianthus zonatus* Fenzl var. *zonatus*, *Minuartia anatolica* (Boiss.) Woron. var. *arachnoidea* McNeill, *Saponaria prostrata* Willd. subsp. *prostrata*, *Saponaria pumilio* Boiss.

Table 1. Analysis of the soil results

Plant Com. Num.	Depth cm	Water Saturation	Texture Class	EC ds/m	Total Salt %	Water Saturation at Soil pH	Organic Matter %	Phosphorus (P_2O_5) Kg/da	Potassium (K_2O) Kg/da	Lime $CaCO_3$ %
1	0-30	182	C	16,70	1,26	7,3	6,56	18,12	181,52	26,67
1	0-60	178	C	16,65	1,25	7,6	6,52	17,43	178,61	27,32
2	0-30	159	C	5,82	0,30	7,8	3,98	17,67	169,49	28,45
2	0-60	164	C	5,80	0,28	7,2	5,73	16,52	158,92	26,89
3	0-30	173	C	10,18	0,59	7,1	6,01	15,39	191,24	28,56
3	0-60	186	C	10,17	0,58	7,4	6,97	14,76	188,61	27,71
4	0-30	157	C	16,50	1,20	7,9	5,43	21,41	175,31	26,36
4	0-60	166	C	16,30	1,10	7,5	3,98	19,48	169,48	25,75
5	0-30	175	C	18,66	1,36	7,7	4,52	8,97	180,74	29,83
5	0-60	169	C	19,01	1,40	7,3	5,19	7,99	179,66	30,04
6	0-30	170	C	10,20	0,61	7,5	8,67	25,45	168,34	27,29

6	0-60	162	C	10,19	0,60	7,1	7,99	26,11	164,51	28,15

[1] *Eromogene ledebouriana*, [2] *Bolanthus minuartioides*, [3] *Dianthus zonatus* var. *zonatus*, [4] *Minuartia anatolica* var. *arachnoidea*, [5] *Saponaria prostrata* subsp. *prostrata*, [6] *Saponaria pumilio*

III. RESULTS

To find the relation of the plant community with soils, 12 soil examples which have a high capability of representation were taken from the deepness of 0-30 and 0-60 cms and their physical and chemical analysis were done in Ankara Toprak Gübre ve Su Kaynakları Merkez Araştırma Enstitüsü (Ankara Soil Fertilizer and Water Resources Central Research Institute) laboratories according to the methods determined by Reference [20] (Table 1). The area has "Mediterranean Bioclimate with low precipitation". "Eastern Mediterranean type" precipitation is recorded in the area [21], [22]. To reflect the climate values of the region, a climate diagram was drawn for the nearest meteorological stations, Dinar (Afyonkarahisar) [23]- [25] (Fig. 2). If the climate data of Dinar (Afyonkarahisar) meteorological station is applied to the climate classification formula of Reference [26], Dinar (Afyonkarahisar) show a "semi-arid, cold Mediterranean bioclimate" [27].

It mostly contains the major soil types as alluvial soils, hydromorphic alluvial soils, colluvial soils, and brown soils [28]. Nearly 100 vascular plants were identified in the study site, situated in the Irano-Turanian floristic region.

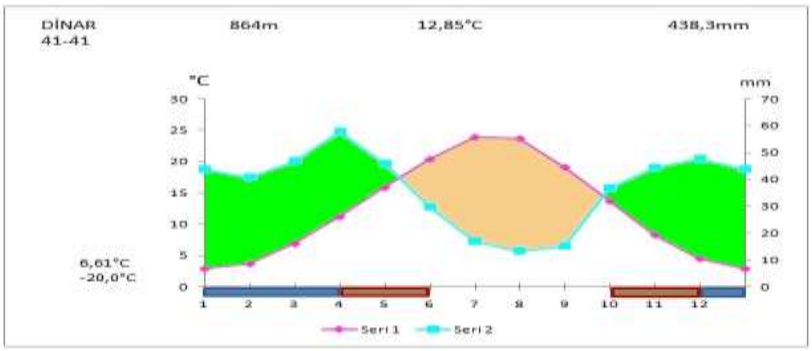

Fig 2. Walter climate diagrame

IV. DISCUSSION

To accomplish the research the communities of plant have been pulled up with their soil and the analysed and evaluated. To find the relationship with this plant communities 0-30 and 30-60 cm soil samples retrieved from the depths and their physical (In percent clay, silt, sand, texture, water saturation, field capacity, wilting point) - chemical [cations (Me/100 gr), anions (Me/100 gr), pH, $CaCO_3$ %, total salt %, EC, organic matter %, changable Na (Me/100 gr), changable K (Me/100 gr), SAR (Me/100 gr), B ppm] analyses and commented. According to the findings, the results vary as follow. In the group, cover of the vegetation is 55 % - % 85 and the number of species in the group is about 5-9. In the group's study field, Hydromorpic Alluvial exist in the soils. Soils are in clayey structure. The soil samples taken from the group are slightly salty to very salty, highly calcareous, organic material in the samples are high and phosphorus in the samples vary from moderate to very high with too much level of potassium. Soils are characterised by very slightly alkali with respect to pH.

V. CONCLUSION

In this study, the relationship of 6 plant communities with soil taken from depths of 0-30 and 30-60 cm was investigated. It is very important to have information about the ecology of these plant communities found in various places, especially about soil properties. Reaching the results of the same ecological conditions in nature without analysis constitutes the essence of the research. Similar studies to be conducted in the future will contribute to plant ecology.

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Tubular Surfaces under Möbiüs Transformation S

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Abstract – This document presents the Tubular surfaces under Möbiüs transformation S. In addition Mean and Gauss Curvatures of a Canal Surface are observed under Möbiüs transformation S. When Mean and Gauss Curvatures of a Canal Surface are observed under Möbiüs transformation S, it is examined whether it is invariant or not.

Keywords – Tube surfaces, curvatures, Mean curvature, Gauss curvature, Möbiüs transfornation

I. INTRODUCTION

In 3-dimensional Euclidean Space, a regular curve is described by its curvatures k_1 and k_2. The relations between the curvatures of a canal surfaces and the curvatures of the curve can be seen in many differential books and papers. Möbius transformations are the automorphisms of the extended complex plane $C_\infty : C \cup \{\infty\}$; that is the metamorphic bijections $M : C_\infty \to C_\infty$. A Möbiüs transformation M has following form as

$$M(z) : \frac{az+b}{cz+d}; a,b,c,d \in C \text{ and } \begin{vmatrix} a & b \\ c & d \end{vmatrix} \neq 0. \tag{1}$$

The set of all Möbius transformations is a group under composition. The Möbius transformation with $c = 0$ form the subgroup of similarities such transformations have the form as follows.

$$S(Z) = A(Z) + B; A, B \in C, A \neq 0. \tag{2}$$

The transformation $J(Z) = 1/Z$ is called an inversion. Every Möbius transformation M of the form (2) is a composition of finitely many similarities and inversions (e.g. [4,5]). In this paper Mean and Gauss Curvatures of a Canal Surfaces under Möbius transformation is obtained. These curvatures of the canal surfaces is invariant or not invariant for Möbius transformation.

II. PRELIMINARIES

A canal surface is defined as the envelope of a family of one parameter spheres. A canal surface is the envelope of a moving sphere with varying radius, defined by the trajectory $C(t)$ of its center and a radius function r(t): This moving sphere $S(t)$ touches the canal surface at a characteristic circle $K(t)$: If the radius function is constant, then the canal surface is called a tube or pipe surface.

Let α be a unit speed curve with tangent $T(s) = \alpha'(s)$ and let $N_1(s)$ be a arbitrary orthogonal unit vector to $T(s)$. If $N_2(s)$ is orthogonal to both $T(s)$ and $N_1(s)$, $N_2(s) = T(s) \times N_1(s)$ (positively oriented) according to this means that $\{T(s), N_1(s), N_2(s)\}$ is an orthonormal frame is called Bishop frame. Let $k_1(s)$ and $k_2(s)$ be Bishop parameters. The derivative formulae which correspond to Bishop frame and Bishop parameters are as follows (e.g. [1-8]).

(3)
$$\begin{aligned} T' &= k_1 N_1 + k_2 N_2, \\ N_1' &= -k_1 T, \\ N_2' &= -k_2 T, \\ k_1 &= \kappa \cos\alpha, \\ k_2 &= \kappa \sin\alpha, \\ \tau &= \gamma'. \end{aligned}$$

III. MEAN AND GAUSS CURVATURES OF A CANAL SURFACE

The Mean H and Gauss K curvatures of a tube surface are computed in reference (e.g. [3]) by 3 situations. These situations are as follows.

i. If the center curve is given with Frenet frame, then the tube is around the center curve α becomes $Y(s,\theta) = \alpha(s) + r(\cos\theta N + \sin\theta B),$ using derivative formulae of this equality and following equalities were obtained from the references (e.g. [2,3,6,7,8]).

(4)
$$\begin{aligned} K &= \frac{-\kappa\cos\theta}{r(1-r\cos\theta)}, \\ H &= \frac{1}{2}\left(\frac{1}{r} + Kr\right). \end{aligned}$$

ii. If the center curve is given with Bishop frame , then the tube around the center α becomes $Z(s,\theta) = \alpha(s) + r(\cos\theta N_1 + \sin\theta N_2),$ using derivative formulae of this equality, then following equalities from the references (e.g. [2,3,6,7,8]) were obtained.

(5)
$$\begin{aligned} K &= \frac{-k_1\cos\theta + k_2\sin\theta}{r\left[r(k_1\cos\theta + k_2\sin\theta) - 1\right]}, \\ H &= rK - \frac{K}{2(k_1\cos\theta + k_2\sin\theta)}. \end{aligned}$$

iii. Let W be a regular surface with a unit normal V and the center curve $\alpha : I \subset R \to W$ be a unit speed curve. In case the tube around the center curve α becomes $X(s,\theta) = \alpha(s) + r(\cos\theta P + \sin\theta S),$ using derivative formulae of this equality and following equations were obtained from the references (e.g. [2,3,6,7,8]).

(6)
$$\begin{aligned} K &= \frac{-k_g\cos\theta + k_n\sin\theta}{r(1-rk_g\cos\theta - rk_n\sin\theta)}, \\ H &= \frac{2r(k_g\cos\theta + k_n\sin\theta) - 1}{2r(rk_g\cos\theta + rk_n\sin\theta - 1)}. \end{aligned}$$

Let the center curve were obtained in $\alpha(s)$ be a spherical curve with order α^2 from the reference (e.g. [3]). According to the reference (e.g. [1]), if a space curve is a spherical curve, then the pair (k_1, k_2) lies on not passing through a line $gx + hy + 1 = 0$. For the $s-$parameter curves, from the reference (e.g. [3,7,8]). the equalities were computed such equalities $g = \cos\theta$, $h = \sin\theta$, $k_1\cos\theta + k_2\sin\theta + 1 = 0$, and,

(7)
$$\begin{aligned} K &= \frac{-k_1\cos\theta + k_2\sin\theta}{r\left[r(k_1\cos\theta + k_2\sin\theta) - 1\right]} = \frac{1}{r(r+1)} \\ H &= rK - \frac{K}{2(k_1\cos\theta + k_2\sin\theta)} = \frac{2r}{2r(r+1)}. \end{aligned}$$

IV. CURVATURES OF THE CANAL SURFACE UNDER MOBIUS TRANSFORMATION S

In here some preliminaries about Möbius transformation were given from the references (e.g. [4,5])..

Every Möbius transformation M of the form as follows is a composition of finitely many similarities and inversions (e.g. [4,5]). Möbius tranformations preserve distance and angle (e.g. [10]). Such as we can write following equalities.

(8) $$M(\alpha) = S(\alpha) o J(\alpha),$$

(9) $$\beta = \beta_1 o \beta_2 .$$

Let $A = (a_1, a_2)$ and the coordinates $(\alpha_1, \alpha_2, \alpha_3)$ of α be a point on the curve. Following equations were written in (e.g. [4,5]).

(10) $$\begin{aligned} S(\alpha) &= S(\alpha(t)), \\ S(Z + t_j) &= AZ + B + |A| t_j, \\ &= (a_1\alpha_1 - a_2\alpha_2 + b_1, a_1\alpha_2 + a_2\alpha_1 + b_2, |A| a_3, \end{aligned}$$

and,

(11) $$\begin{aligned} J(Z + t_j) &= \frac{\overline{Z} + t_j}{|Z|^2 + {t_j}^2}, \\ J(\alpha(t)) &= \left(\frac{\alpha_1(t)}{\|\alpha_1(t)\|^2}, -\frac{\alpha_2(t)}{\|\alpha_2(t)\|^2}, \frac{\alpha_3(t)}{\|\alpha_3(t)\|^2}\right). \end{aligned}$$

For the transformation S, the equalities of the curvatures under Möbius transformation were written in (e.g. [4,5]).

(12) $$\kappa^* = \frac{1}{|A|}\kappa,$$

(13) $$\tau^* = \frac{1}{|A|}\tau.$$

For the transformation J, let take $\alpha = (\alpha_1, \alpha_2, \alpha_3) \in S_o^2 \Rightarrow \|\alpha\| = 1$, and $J(\alpha) = \beta \in S_o^2$. Following equalities were obtained in (e.g. [4,5]).

(14) $$\tau = \frac{\det(\alpha', \alpha'', \alpha''')}{\|\alpha' \wedge \alpha''\|^2},$$

(15) $$\tau^* = \frac{\det(\beta', \beta'', \beta''')}{\|\beta' \wedge \beta''\|^2}.$$

From the reference (e.g. [9]), we have,

(16) $$\begin{aligned} \beta &= (\alpha_1, -\alpha_2, \alpha_3), \\ \beta' &= (\alpha_1', -\alpha_2', \alpha_3'), \\ \beta'' &= (\alpha_1'', -\alpha_2'', \alpha_3''), \\ \beta''' &= (\alpha_1''', -\alpha_2''', \alpha_3'''), \end{aligned}$$

and,

(17) $$\frac{\det(\beta', \beta'', \beta''')}{\|\beta' \wedge \beta''\|^2} = -\frac{\det(\alpha', \alpha'', \alpha''')}{\|\alpha' \wedge \alpha''\|^2},$$

(18) $$\tau^* = -\tau .$$

By applying the Möbius transformation on $\alpha, \kappa, \tau, K, H$, we have $\beta, \kappa^*, \tau^*, K^*, H^*$.

Theorem 1: If the center curve is given with Frenet frame, then the tube is around the center curve α becomes $Y(s,\theta)=\alpha(s)+r(\cos\theta N+\sin\theta B)$, we obtain the Gauss curvature of the Canal surface K^* is not invariant for Möbius transformation S.

Proof. After by applying S transformation, the Gauss curvature of the Canal surface K^* is obtained as follows.

(19) $$K^*=\frac{-\kappa^*\cos\theta}{r(1-r\kappa^*\cos\theta)}.$$

In beginning if radius $r=1$, then the equality (19) is obtained as:

(20) $$K^*=\frac{-\kappa^*\cos\theta}{1-\kappa^*\cos\theta)},$$

By substituting the equalities (12) and (13) in (19), we take following equality.

(21) $$K^*=\frac{-\frac{1}{|A|}\kappa\cos\theta}{r(1-r\frac{1}{|A|}\kappa\cos\theta)},$$

$$=\frac{-\kappa\cos\theta}{r(|A|-r\kappa\cos\theta)}.$$

This proves that the Gauss curvature of the Canal surface K^* is not invariant for Möbius transformation S.

Special case 1: If radius r is equal to 1, then the equality is obtained as follows.

(22) $$K^*=\frac{-\frac{1}{|A|}\kappa\cos\theta}{1-\frac{1}{|A|}\kappa\cos\theta},$$

$$=\frac{-\kappa\cos\theta}{|A|-\kappa\cos\theta}.$$

Corollary 1: This proof is proved that if the angle θ is constant or not, r is equal to 1 or not, K^* is not invariant for Möbius transformation S.

Special case 2: If the angle $\theta=2k\pi$, then the Gauss curvature K^* is not invariant for Möbius transformation S.

If the angle $\theta=2k\pi$, then the Gauss curvature K^* is obtained as follows.

(23) $$K^*=\frac{-\kappa}{r(|A|-r\kappa)}.$$

Special case 3: If the radius r is equal to 1, then the equality is written such following equality.

(24) $$K^*=\frac{-\kappa}{|A|-\kappa}.$$

Corollary 2: If the angle θ and r is equal to $2k\pi$ and 1, respectively, then the Gauss curvature K^* is not invariant for Möbius transformation S.

Special Case 4: If the angle $\theta=k\pi$, then the Gauss curvature K^* is not invariant for S transformation.

If the angle $\theta = k\pi$, then the Gauss curvature K^* is obtained as follows:

(25) $$K^* = \frac{\kappa}{|A| + \kappa}.$$

Corollary 3: If the angle θ and r is equal to $2k\pi$ and 1, respectively, then the Gauss curvature K^* is not invariant for Möbius transformation S .

Corollary 4: If the center curve is given with Frenet frame, then the tube is around the center curve α , surface is the Canal surface and the Gauss curvature K^* is not invariant for S transformation.

Theorem 2: If the center curve is given with Frenet frame, then the tube is around the center curve α becomes $Y(s,\theta) = \alpha(s) + r(\cos\theta N + \sin\theta B),$ we obtain the Mean curvature H^* of the Canal surface is not invariant for S transformation, and also Möbius transformation.

Proof: Let study the Mean curvature H^* of Canal surface under S transformation.

(26) $$H^* = \frac{1}{2}\left(\frac{1}{r} + K^* r\right),$$

By substituting the equality (19) in equality (26), then we take following equation.

(27)
$$\begin{aligned} H^* &= \frac{1}{2}\left(\frac{1}{r} + \frac{-\kappa^* \cos\theta}{r(1 - r\kappa^* \cos\theta)} r\right) \\ &= \frac{1}{2}\left(\frac{1}{r} - \frac{\kappa^* \cos\theta}{1 - r\kappa^* \cos\theta}\right), \\ &= \frac{1}{2}\left(\frac{1}{r} - \frac{\frac{1}{|A|}\kappa\cos\theta}{1 - r\frac{1}{|A|}\kappa\cos\theta}\right), \\ &= \frac{1}{2}\left(\frac{1}{r} - \frac{\kappa\cos\theta}{|A| - r\kappa\cos\theta}\right). \end{aligned}$$

This proves that the Mean curvature H^* of the Canal surface is not invariant for S transformation, and also Möbius transformation.

Special Case 5: If the radius r is equal to 1, then the Mean curvature H^* of the Canal surface is not invariant for S transformation.

If the radius r is equal to 1, then the Mean curvature H^* of the Canal surface is obtained as follows.

(28) $$H^* = \frac{1}{2}\left(1 - \frac{\kappa\cos\theta}{|A| - \kappa\cos\theta}\right).$$

Special Case 6: If the angle $r = 1$ and $\theta = 2k\pi$, then the Mean curvature H^* is not invariant for Möbius transformation.

By substituting $r = 1$ and $\theta = 2k\pi$ in equality (28), we get following equation.

(29) $$H^* = \frac{|A| - 2\kappa}{2|A| - 2\kappa}.$$

The equation (29) shows us that if the angle $r = 1$ and $\theta = 2k\pi$, then the Mean curvature H^* is not invariant for Möbius transformation.

Special Case 7: If the angle $\theta = k\pi$, then the Mean curvature H^* is not invariant for S transformation. If the angle $\theta = k\pi$, then the Mean curvature H^* is obtained as follows:

(30) $$\begin{aligned} H^* &= \frac{1}{2}\left(1 + \frac{\kappa}{|A| + \kappa}\right), \\ &= \frac{|A| + 2\kappa}{2|A| + 2\kappa}. \end{aligned}$$

We obtain the Mean curvature H^* is not invariant for S transformation. Thus, the Mean curvature H^* is not invariant for Möbius transformation.

Corollary 5: If the center curve is given with Frenet frame, then the tube is around the center curve and the Gauss curvature of the canal surface H is not invariant under Mobius transformation.

Special Case 8: If radius $r = 1$, $|A| = 1$ and $\theta = 2k\pi$, then we get the following equation.

(31) $$K^* = \frac{-\kappa}{1 - \kappa}.$$

Special Case 9: If radius $r = 1$, $|A| = 1$ and $\theta = k\pi$, then we get the following equation.

(31) $$K^* = \frac{\kappa}{1 + \kappa}.$$

Theorem 3: If the center curve is given with Bishop frame, then the tube around the center curve becomes $Z(s,\theta) = \alpha(s) + r(\cos\theta N_1 + \sin\theta N_2)$, we obtain the Gauss curvature of the canal surface K^* is not invariant for S transformation.

Proof: Now let apply transformation S and observe the Gauss curvature K^*. Remind that the angle is invariant under Möbius transformation.

(32) $$\begin{aligned} K^* &= \frac{-\kappa^* \cos\theta + \tau^* \sin\theta}{r\left[r(\kappa^* \cos\theta + \tau^* \sin\theta) - 1\right]}, \\ &= \frac{-\frac{1}{|A|}\kappa\cos\theta + \frac{1}{|A|}\tau\sin\theta}{r\left[r(\frac{1}{|A|}\kappa\cos\theta + \frac{1}{|A|}\tau\sin\theta) - 1\right]}, \\ &= \frac{-\kappa\cos\theta + \tau\sin\theta}{r\left[r(\kappa\cos\theta + \tau\sin\theta) - |A|\right]}, \end{aligned}$$

This shows that the Gauss curvature K^* is not invariant under S transformation. So, K^* is not invariant under Möbius transformation It comletes the proof.

Theorem 4: If the center curve is given with Bishop frame, then the tube around the center curve becomes $Z(s,\theta)=\alpha(s)+r(\cos\theta N_1+\sin\theta N_2)$, we obtain the Mean curvature of the canal surface H^* is not invariant for Möbius transformation.

Proof: Now let apply transformation S and observe the Mean curvature H^*.

(33)
$$H^*=r\left[\frac{-\kappa\cos\theta+\tau\sin\theta}{r\left[r(\kappa\cos\theta+\tau\sin\theta)-|A|\right]}\right]-\frac{\left[\frac{-\kappa\cos\theta+\tau\sin\theta}{r\left[r(\kappa\cos\theta+\tau\sin\theta)-|A|\right]}\right]}{2(\frac{1}{|A|}\kappa\cos\theta+\frac{1}{|A|}\kappa\sin\theta)},$$

$$=r\left[\frac{-\kappa\cos\theta+\tau\sin\theta}{r\left[r(\kappa\cos\theta+\tau\sin\theta)-|A|\right]}\right]-\frac{|A|(-\kappa\cos\theta+\tau\sin\theta)}{r\left[r(\kappa\cos\theta+\tau\sin\theta)-|A|\right]\left[2(\kappa\cos\theta+\kappa\sin\theta)\right]},$$

$$=\frac{2r(-\kappa\cos\theta+\tau\sin\theta)(\kappa\cos\theta+\kappa\sin\theta-|A|)}{r\left[r(\kappa\cos\theta+\tau\sin\theta)-|A|\right]\left[2(\kappa\cos\theta+\kappa\sin\theta)\right]},$$

$$=\frac{(-\kappa\cos\theta+\tau\sin\theta)(\kappa\cos\theta+\kappa\sin\theta-|A|)}{(\kappa\cos\theta+\kappa\sin\theta)\left[r(\kappa\cos\theta+\tau\sin\theta)-|A|\right]},$$

$$=\frac{-\kappa\cos\theta+\tau\sin\theta}{r(\kappa\cos\theta+\kappa\sin\theta)}.$$

The Mean curvature H^* is not invariant under Möbius transformation. This is the proof of the theorem.

Theorem 5: If the curve α is a spherical curve with order α^2 and $k_1\cos\theta+k_2\sin\theta+1=0$, then Gauss and Mean curvatures of Tube surfaces are invariant under Möbius transformation S.

Proof: If the curve α is a spherical curve, then the Gauss and Mean curvatures of Tube surfaces are obtained from the equalities (7) under transformation S as follows.

(34)
$$K^*=\left[\frac{1}{r(r+1)}\right]^*,$$

$$=\frac{1}{r(r+1)},$$

$$K^*=K,$$

and,

(35)
$$H^*=\left[\frac{2r}{2r(r+1)}\right]^*,$$

$$=\frac{2r}{2r(r+1)},$$

$$H^*=H.$$

This proof shows that if the curve α is a spherical curve, then the Gauss and Mean curvatures of Tube surfaces are invariant Möbius transformation S.

Corollary 6: If the curve α is a spherical curve, then the Gauss and Mean curvatures of Tube surfaces are invariant Möbius transformation S.

Theorem 6: Let W be a regular surface with a unit normal V and the center curve $\alpha : I \subset R \to W$ be a unit speed curve. In case the tube around the center curve α becomes $X(s,\theta) = \alpha(s) + r(\cos\theta P + \sin\theta S)$, then Gauss and Mean curvature of the Tube surfaces are not invariant under Möbius transformation.

Proof: After applying Möbius transformation S the equation (6), substituting (12) and (13) in final equality, this completes the proof of the theorem.

Corollary 7: If the center curve is given with the Frenet frame, then the tube is around the center curve α becomes $Y(s,\theta) = \alpha(s) + r(\cos\theta N + \sin\theta B)$, then Gauss and Mean curvature of the Tube surfaces are not invariant under Möbius transformation.

Corollary 8: If the center curve is given with Frenet frame, then the tube is around the center curve becomes $Y(s,\theta) = \alpha(s) + r(\cos\theta N + \sin\theta B)$, we obtain the Gauss curvature of the canal surface K^* is not invariant under Möbius transformation.

Proof: For the situation i. If the center curve is given with Frenet frame, then the tube is aroun the center $Y(s,\theta) = \alpha(s) + r(\cos\theta N + \sin\theta B)$, the Gauss curvature of the canal surface K^* is not invariant under Möbius transformation S. Because Möbius transformation becomes two part. One of them is transformation S, the other is transformation J. It can be said if the tube is around the center curve becomes $Y(s,\theta) = \alpha(s) + r(\cos\theta N + \sin\theta B)$, then Gauss and Mean curvatures of the Canal surface are not invariant under Möbius transformation.
In addition, we can say the same cases for the situations ii. and iii.
And also, remind that if the curve is spherical, it have to apply under transformation J.

V. CONCLUSION

The main conclusions of the study should be summarized in Gauss and Mean curvatures of Canal surfaces under Möbius transformation.

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Investigation of specific heat capacities of hafnium oxide (HfO_2) using Einstein-Debye approximation

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Abstract – A new Einstein-Debye approximation for calculating specific heat capacities of the hafnium oxide was proposed. The adoption of hafnium oxide (HfO_2) in semiconductor manufacturing is part of the industry's ongoing efforts to overcome challenges associated with scaling down the size of electronic components while maintaining or improving performance. It is worth noting that the field of materials science and semiconductor technology is dynamic, and ongoing research may lead to further advancements or new applications for hafnium oxide in the future. Using the calculation result as the input data for structural and application analysis, it will be possible to make optimum design of the devices considering both electromagnetic and mechanical conditions.

Keywords – Hafnium oxide, zirconium oxide, Einstein-Debye approach, Debye temperature

I. Giriş

Bilindiği gibi Einstein-Debye modeli, katıların ısı kapasitesinin daha kapsamlı bir tanımını oluşturmak için her iki yaklaşımı birleştirir. Düşük sıcaklıklarda Einstein katkısı baskın olurken, yüksek sıcaklıklarda Debye katkısı daha önemli hale gelir. Einstein-Debye modeli özellikle katılardaki ısı kapasitesi davranışının tüm sıcaklık aralığını tanımlamak için kullanışlıdır. Özetle, Einstein-Debye modeli, hem Einstein hem de Debye'nin birleştirerek katıların ısı kapasitesinin daha doğru bir temsilini sağlar. Bu modelin bazı basitleştirici varsayımlarda bulunduğunu ve gerçek malzemelerin tüm karmaşıklıklarını yakalayamayabileceğini ancak katılardaki ısı kapasitesini yöneten temel ilkeleri anlamak için değerli bir araç olarak hizmet ettiğini belirtmek önemlidir [1-3].

Hafniyum oksit **(** HfO_2 **)**, hafniyum ve oksijenden oluşan kimyasal bir bileşiktir. Yüksek dielektrik katsayılı malzemedir, yani yüksek bağıl geçirgenliğe veya dielektrik sabitine sahiptir. Bu özellik, yarı iletken teknolojisi alanında, özellikle de metal oksit yarı iletken (MOS) cihazların üretiminde çok önemlidir. Dielektrik Özellikler: Hafniyum oksit, yüksek dielektrik sabitiyle bilinir, bu da onu metal oksit yarı iletken alan etkili transistörlerde (MOSFET'ler) geçit dielektrik olarak kullanıma uygun hale getirir. Yüksek k dielektrikler, daha küçük transistörlerdeki kaçak akımı azaltmak amacıyla geleneksel silikon dioksitin (SiO2) yerine kullanılır [4-7]. Yarı İletken Endüstrisi: Yarı iletken endüstrisi, yüksek k dielektrik yığınları oluşturmak için diğer malzemelerle birlikte hafniyum oksidi benimsemiştir ve gelişmiş yarı iletken cihazlarda geçit dielektrik olarak genellikle silikon dioksitin yerini almıştır. Bu geçiş, geleneksel silikon dioksitin daha küçük transistörlerde kullanılmasıyla ilişkili sınırlamaların aşılmasına yardımcı olur. CMOS Teknolojisi: Tamamlayıcı metal oksit yarı iletken (CMOS) teknolojisi, yarı iletken endüstrisinde yaygın olarak kullanılmaktadır ve hafniyum oksit, geçit dielektrik özelliklerini iyileştirerek CMOS cihazlarının

performansının arttırılmasında rol oynamaktadır. Mikroelektronik: Hafniyum oksit, entegre devrelerdeki transistörlerin ve diğer bileşenlerin sürekli minyatürleştirilmesine izin verdiği için daha küçük özellik boyutlarına sahip mikroelektronik cihazların geliştirilmesinde kritik bir bileşendir. Termal Kararlılık: Hafniyum oksit, yarı iletken imalat işlemlerinde kullanılan malzemeler için önemli bir özellik olan iyi bir termal kararlılık sergiler [7-14].

Yukarıdaki açıklamalardan anlaşıldığı kadarıyla Hafniyum oksit uygulamaları ile teknolojinin farklı alanlarında önemli yere sahiptir. Bu çalışmada hafniyum oksidin C_p ve C_V öz ısı miktarları geniş sıcaklık aralığında Einstein-Debye modeli kullanılarak incelenmiştir. Alınan sonuçlar kaynaklardaki farklı yaklaşımlarla karşılaştırılarak doğruluğu incelenmiştir.

2. Hafniyum oksidin Einstein-Debye modeline göre incelenmesi

Bu çalışmada öz ısı miktarının hesaplamasında aşağıdaki formüller kullanılmıştır [1, 2]:

$$C_P(T) = C_V(T)\left(1+\frac{A_0 T}{T_m}C_V(T)\right), \quad (1)$$

$$C_V(T) = 3N_A k_B M\left(T,\theta_D,\theta_E\right), \quad (2)$$

burada $A_0 = 5.1x10^{-3} J^{-1}K\,mol$, T mutlak sıçaklık, T_m erime sıçaklığı, N_A Avogadro sayısır, k_B the Boltzmann sabiti, θ_D Debye sıçaklığı and θ_E is the Einstein sıcaklığıdır. (2) formülünde $M(T,\theta_D,\theta_E)$ fonksiyonu aşağıdaki formüle göre hesaplanır:

$$M(T,\theta_D,\theta_E) = L_V(T,\theta_D) + (s-1)A(T,\theta_E), \quad (3)$$

burada s bir örgüdeki atom sayısıdır. $L_V(T,\theta_D)$ fonksiyonu ise:

$$L_V\left(T,\theta_D\right) = (n+1)D_n\left(1,\frac{\theta_D}{T}\right) - \frac{\theta_D}{T}\frac{n}{e^{\frac{\theta_D}{T}}-1}. \quad (4)$$

tanımlanır. Burada $D_n(\beta,x)$ Debye fonksiyonudur:

$$D_n\left(\beta,\mathrm{x}\right) = \frac{n}{x^n}\int_0^x \frac{t^n}{(e^t-1)^\beta}dt\,. \quad (5)$$

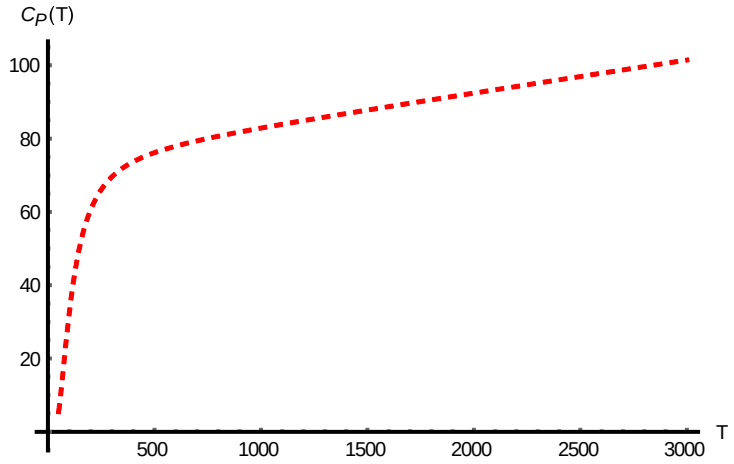
$A(T,\theta_E)$ fonksiyonu ise aşağıdaki formüle göre hesaplanır:

$$A\left(T,\theta_E\right) = \left[\frac{\theta_E}{2T}\frac{1}{\sinh\left(\frac{\theta_E}{2T}\right)}\right]^2. \quad (6)$$

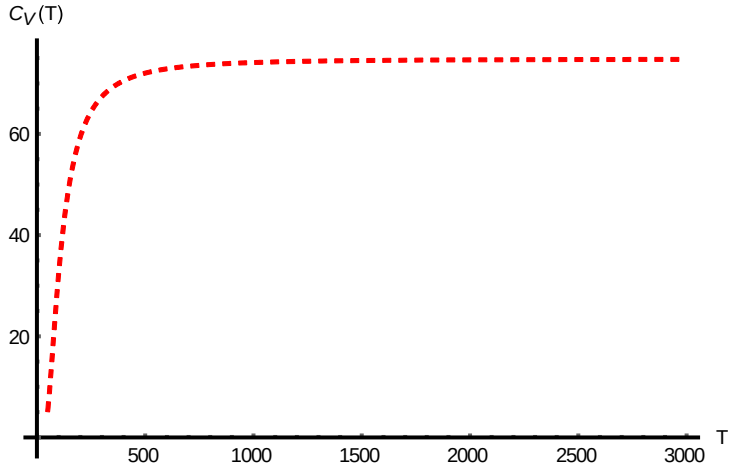
Burada Debye fonksiyonu $D_n(\beta,x)$ yakın zamanda yapılan çalışmadaki formüle göre hesaplanır [3]. Bu çalışmada geniş sıcaklık aralığında hafniyum oksit yarıiletkenin ısı kapasiteleri Einstein-Debye yaklaşımı kullanılarak incelenmiştir.

3. Tartışma ve sonuçlar

Hafniyum oksit kristal yapısına göre monoklinik, tetragonal ve kübik şekillerde olabilir. Bu çalışmada monoklinik yapıdaki hafniyum oksidin (m-HfO_2) ısı kapasitelerinin sıcaklığa göre değişmesi incelenmiştir. Hesaplama sonuçları kaynak [15]'de verilen sonuçlarla karşılaştırılmıştır. Hesaplama sonuçlarının kaynaklardaki verilerle karşılaştırması Şekil 1 ve 2'de verilmiştir. Şekillerdeki sonuçlar kaynaklardaki verilerle uyum içerisindedir. Bu önerilen yöntemin önemli olduğunun bir göstergesidir.



Şekil 1. Hafniyum oksidin C_p ısı kapasitesinin sıcaklığa göre değişmesinin sonuçları ($\theta_D = 484K, \theta_E = 320K, T_m = 3200K$)



Şekil 2. Hafniyum oksidin C_V ısı kapasitesinin sıcaklığa göre değişmesinin sonuçları ($\theta_D = 484K, \theta_E = 320K, T_m = 3200K$)

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Study of electrical conductivity of Titanium diboride in the wide temperature range using classical and quantum mechanical methods

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Abstract – Simple analytical formulas have been used for calculating the electrical conductivity of titanium diboride in a very general and versatile. The electrical conductivity of titanium diboride was calculated based on the Bloch-Gruneisen approach and the classical method in a wide range of temperatures. Titanium diboride's remarkable combination of hardness, high-temperature stability, and electrical conductivity makes it valuable in a range of applications, from industrial tools to electronic components and advanced materials. Its properties continue to be explored for further technological advancements. Titanium diboride is a subject of research for its unique properties. Scientists explore its potential applications in emerging technologies, including energy storage, electronics, and advanced materials. The suggested method requires only simple algorithmic computations, but accuracy is good, and convergence is satisfactory.

Keywords – Electrical conductivity, Titanium diboride, Bloch-Gruneisen approach, Debye temperature, resistivity

I. Giriş

Titanyum diborür (TiB2), titanyum ve bordan oluşan seramik bir bileşiktir. Çeşitli uygulamalarda faydalı olmasını sağlayan birçok önemli özelliğe sahiptir. Titanyum diborürün bazı önemli yönleri ve uygulamaları şunlardır. Sert ve Aşınmaya Dayanıklı Kaplamalar: Titanyum diborür olağanüstü sertliği ve aşınma direnciyle bilinir. Sonuç olarak, sıklıkla kesici takımlar, kalıplar ve aşındırıcı aşınmaya maruz kalan diğer bileşenler için kaplama malzemesi olarak kullanılır. Bu kaplamalar aletlerin dayanıklılığını ve ömrünü artırır. Yüksek Sıcaklık Uygulamaları: TiB2'nin yüksek erime noktası ve mükemmel termal stabilitesi vardır, bu da onu yüksek sıcaklıktaki ortamlardaki uygulamalar için uygun kılar. Yüksek sıcaklıklar içeren prosesler için potaların, ısıtma elemanlarının ve diğer bileşenlerin üretiminde kullanılır. Aşındırıcı Malzemeler: Sertliği nedeniyle titanyum diborür aşındırıcı malzemelere dahil edilir. Taşlama çarklarında ve aşındırıcı bileşiklerde kullanılabilir ve kesme ve taşlama performansının iyileştirilmesine katkıda bulunur. Seramik Matris Kompozitleri (CMC'ler): Titanyum diborür sıklıkla seramik matrisli kompozitlerde takviye fazı olarak kullanılır. Silisyum karbür (SiC) veya alümina (Al2O3) gibi malzemelere eklendiğinde kompozitin mekanik özelliklerini geliştirerek onu havacılık ve yapısal bileşenlerdeki uygulamalar için uygun hale getirir. Elektronik ve Yarı İletken Endüstrisi: TiB2'nin elektriksel iletkenliği ve kimyasal korozyona karşı direnci onu bazı elektronik ve yarı iletken uygulamalarda kullanışlı kılar. Elektriksel iletkenlik ve dayanıklılık kombinasyonunun gerekli olduğu bileşenlerde kullanılabilir. Zırh ve Balistik Koruma: Sertliği ve mukavemeti nedeniyle titanyum diborür zırh ve balistik koruma uygulamalarında dikkate alınır. Mermi darbesine karşı direnci arttırmak için kompozit zırh malzemelerinde bir bileşen olarak kullanılabilir. Refrakter Malzemeler: Titanyum diborür, yüksek sıcaklıklara ve zorlu koşullara dayanabilen refrakter malzemelerde kullanılır. Refrakter özellikleri onu metalurji ve cam endüstrilerindeki uygulamalara uygun hale getirir. Termal Bariyer Kaplamalar: Diğer malzemelerle birlikte

TiB2, havacılık ve gaz türbini motorlarındaki türbin kanatları gibi aşırı sıcaklık değişimlerine maruz kalan bileşenler için termal bariyer kaplamalarında kullanılır. Bu çalışmada teknolojide önemli bir malzeme olan titanyum diborürün özdirencinin sıcaklığa göre değişmesi klasik ve kuantum mekaniksel yaklaşımlar kullanılarak incelenmiştir.

2. Elektriksel iletkenlik için klasik ve kuantum mekaniksel yaklaşım

Materyallerin elektrik iletkenliği genel olarak aşağıdaki formüle göre hesaplana bilinir:

$$\sigma(T) = 1/\rho(T) \quad (1)$$

Burada $\rho(T)$ özdirenç olup kaynaklarda klasik ve kuantum yaklaşımları kullanılarak aşağıdaki formüllere göre incelene bilinir:

$$\rho(T) = \rho_0[1 + \alpha(T - T_0)] \quad (2)$$

Burada α, özdirencin sıcaklık katsayısı, T_0 sabit referans sıcaklığı, ρ_0, T_0 sıcaklıktaki özdirençtir.

Materyallerin özdirencinin sıcaklığa göre değişmesini incelemenin en iyi yöntemlerinden birisi de Bloch-Gruneisen yöntemidir. Debye modeli kullanılarak önerilen Bloch-Gruneisen yaklaşımına göre özdirencin sıcaklığa göre değişmesi aşağıdaki formüle göre hesaplanır [11-12]:

$$\rho(T) = \rho_{01} + (n-1)\rho'\theta_D \left(\frac{T}{\theta_D}\right)^n J_n\left(\frac{T}{\theta_D}\right) \quad (3)$$

burada ρ_0 ve ρ' sırasıyla residual (artık) özdirenç ve sıcaklık özdirenç katsayısıdır. Titanyum diborür için $\rho_0 = 15\mu\Omega.cm$ Formül (3)'de n değişeni iletkenler için $n = 5$ değerini alır. Formülden görüldüğü gibi özdirenci hesaplamak için (1) ifadesindeki $J_5\left(\frac{T}{\theta_D}\right)$ Bloch-Gruneisen fonksiyonun hassas hesaplanması gerekir. Bu çalışmada hesaplamalarda $J_5\left(\frac{T}{\theta_D}\right)$ Bloch-Gruneisen fonksiyonu için aşağıdaki analitik ifade kullanılmıştır [13]:

$$J_5\left(\frac{T}{\theta_D}\right) = 120\zeta(5) - \sum_{k=1}^{\infty} e^{-ky}\left(y^5 + \frac{5y^4}{k} + \frac{20y^3}{k^2} + \frac{60y^2}{k^3} + \frac{120y}{k^4} + \frac{120}{k^5}\right. \quad (4)$$

Burada $y = \frac{T}{\theta_D}$ ve $\zeta(p)$ Riemann zeta fonksiyonu olup aşağıdaki gibi tanımlanır:

$$\zeta(p) = \sum_{k=1}^{\infty} k^{-p} \quad (5)$$

Bu çalışmada önerilen yaklaşımlar geniş sıcaklık aralığında geçerli olup Titanyum diborürün elektrik iletkenliği ayrıntılı olarak inceleme imkânı sağlamaktadır. Titanyum diborürün iletkenliğinin sıcaklığın farkı değerlerinde hesaplama ve kaynak sonuçlar karşılaştırmalı olarak Tablo 1'de verilmiştir.

3. Tartışma ve sonuçlar

Titanyum diborür giriş kısımda belirtildiği gibi teknolojinin farklı alanlarında geniş kullanım alanına sahiptir. Bu çalışmada Titanyum diborürn elektrik iletkenliği sıcaklığın farklı aralıklarında değişmesi Bloch-Gruneisen ve klasik yaklaşıma göre incelenmiştir. Hesaplama sonuçları geniş sıcaklık aralığında Tablo 1'de verilmiştir. Alınan sonuçlara göre önerilen yöntem genel olup sıcaklığın tüm aralıklarında doğru sonuçlar vermektedir

Tablo 1. Titanyum diborürün elektrik iletkenliğinin sıcaklığa göre değişmesinin karşılaştırmalı sonuçları ($\theta_D = 1217K, \rho_{01} = 1\ \mu\Omega.cm, \rho_0 = 15\mu\Omega.cm, \rho' = 0.0572\ \ \mu\Omega.cm, \alpha = 0.0038K^{-1}$)

$T\ (K)$	Kaynak [3]	Denklem (2)	Denklem (3)
301.141	0.0473	0.0647	0.0929
375.665	0.0419	0.0507	0.0641
471.483	0.0381	0.0397	0.0457
673.764	0.0282	0.0272	0.0287
774.905	0.0264	0.0235	0.0243
870.722	0.0242	0.0209	0.0213
966.54	0.0215	0.0187	0.0189
1067.681	0.0212	0.0169	0.0170
1269.962	0.0178	0.0141	0.0141
1365.779	0.0167	0.0131	0.0131
1472.243	0.0157	0.0122	0.0121

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Kabakyatak intruzyonunun (Kürtün/Gümüşhane) tüm-kayaç jeokimyasal özellikleri

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Özet **–** Bu çalışmada, Doğu Pontid Kuzey Zonu'nda yer alan Kabakyatak intruzyonunun (Kürtün/Gümüşhane) jeokimyasal özellikleri detaylı bir şekilde incelemiş, intruzyonunu oluşturan kayaçların köken magmasının muhtemel kaynağı ele alınmıştır. İnceleme alanındaki en yaşlı birim Geç Kretase yaşlı Çatak Formasyonu'dur. Bu formasyon Eosen yaşlı Kabaköy Formasyonu tarafından uyumsuz olarak örtülmekte olup, tüm birimler Kabakyatak intruzyonunun da içinde yer aldığı Orta Eosen yaşlı plutonik kayaçlar tarafından kesilmiştir. Kabakyatak intruzyonunu oluşturan kayaçlar, I-tipi yüksek potasyumlu kalk-alkalen ve metalümin özellikte olup, yüksek silis içeriği gösterirler. Ana ve iz element değişimleri dikkate alındığında, artan SiO_2'ye karşı K_2O, Na_2O, Ba, Rb, Yh, Nb, La ve Pb arasında pozitif bir ilişki görülürken; MgO, CaO, Fe_2O_3, TiO_2, Al_2O_3, P_2O_5, Sr, Ni ve Y arasında negatif bir ilişki gözlemlenmektedir. Kayaçlarda hafif nadir toprak elementler ve büyük iyon yarıçaplı litofil elementlerce zenginleşme görülür. Kondirite göre normalleştirilmiş nadir toprak element desenleri konkav şekilli olup, negatif Eu anomalisi gösterirler. Elde edilen jeokimyasal veriler ışığında, Tüm veriler, incelenen Kabakyatak intruzyonuna ait kayaçların kayaçların ana magmasının litosferik mantodan türediğini, kabuksal kayaçların katkısının nispeten az olduğunu göstermektedir.

Anahtar Kelimeler – Gümüşhane, Doğu Pontidler, Kabakyatak intruzyonu, Tüm-kayaç jeokimyası

I. GİRİŞ

Alpin-Himalaya orojenik kuşağı, geniş bir alana yayılmış ve farklı jeolojik süreçlerin etkisiyle oluşmuş kompleks bir yapıdır. Bu kuşağın önemli bir parçasını oluşturan Doğu Pontidler (KD Türkiye), plütonik ve volkanik kayaçların yaygın olarak gözlemlendiği bir bölgedir [1], [2], [3], [4], [5], [6], [7], [8], [9]. Bu çalışmada, Doğu Pontidler'deki plütonik kayaçların jeolojik dağılımı ve jeokimyasal özellikleri incelenerek bölgenin magmatik tarihine ışık tutulması amaçlanmıştır.

Doğu Pontidler'de Permo-Karboniferden Eosen sonuna kadar değişen yaşta ve boyutta plütonik kayaçlar yer alır ve bileşimleri gabrodan granite kadar geniş bir yelpazede değişkenlik gösterir. Bölgede en yaygın olarak görülen plütonik kayaçlar ortaç ve asidik bileşimli kayaçlardır. Gabrolar ise nispeten daha az yayılıma sahiptir. Doğu Pontidler'deki plütonik kayaçlar, jeokimyasal özellikleri bakımından da çeşitlilik gösterir. Kayaçların ana ve iz element konsantrasyonları, köken magmalarının bileşimi ve oluşum koşulları hakkında bilgi verir. Bu element konsantrasyonları analiz edilerek kayaçların tektonik ortamı ve magma kaynağı hakkında yorumlar yapılmaktadır.

İnceleme alanı cıvarındaki Orta Eosen yaşlı plutonlar ile ilgili detay çalışmalar [10] yapılmış olmasına rağmen, Kabakyatak intruzyonu üzerine yapılmış bir çalışma yoktur. Bu çalışmada Kürtün (Gümüşhane) yöresinde yer alan Kabakyatak intruzyonunun jeokimyasal özellikleri incelenmiştir.

II. MATERYAL VE YÖNTEM

Çalışma alanından toplanan ayrışmamış veya çok az ayrışmış kayaç örneklerinin ana, iz ve REE analizleri Sample Solution Analitik Teknoloji Laboratuvarında (Çin) yaptırılmıştır. Tüm-kayaç ana element analizleri için RIGAKU (Japonya) tarafından üretilen Zsx Primus II dalga boyu dağılımlı X-ışını floresan spektrometresi (XRF) kullanılmıştır. Tüm kayaç iz element (NTE analizleri dahil) analizleri ise Agilent 7700e ICP-MS üzerinde gerçekleştirilmiştir. Analiz tekniğinin detayları [10]'de yer almaktadır.

III. BULGULAR VE TARTIŞA

A. *Bölgesel Jeoloji*

Türkiye, [11] tarafından Pontidler, Toridler, Anatolidler ve Kenar Kıvrımları olmak üzere dört tektonik bloğa ayrılmıştır (Şekil 1a). [12] jeolojik yapı ve coğrafi olarak Pontidleri Batı, Orta ve Doğu Pontid'ler olarak üç kısıma bölmüşlerdir. Bazı araştırmacılar [13], [14], [15]. Doğu Pontidler'de Geç Kretase yaşlı birimlerin, kuzey ve güney bölgelerinde farklılık göstermeleri nedeniyle, kuzey zon ve güney zon olarak iki alt birliğe ayırmış olup, bu görüş genel kabul görmüştür (Şekil 1b). [16], [17] ise Doğu Pontidler'i kuzey zonu, güney zonu ve eksen zonu şeklinde üç alt birime ayırmıştır.

Sakarya Zonu'nun kuzey kesimi olarak da bilinen Doğu Pontidler'de temel kayaları Variskan öncesi şistler ve gnayslar oluşturur [18]. Bu birimler Silüriyen-Devoniyen yaşlı metagranitler ve Orta-Geç Karbonifer yaşlı plutonlar tarafından kesilmiştir [19], [20], [21], [22], [23], [24], [25], [26], [27], [28]. Erken-Orta Jura yaşlı volkano-tortul istif, bu temel kayaçlarını uyumsuz bir şekilde örterler [29], [30], [31], [32], [33] ve Erken-Geç Jura yaşlı intrüzyonlar [34], [35], [36], [37] tarafından kesilirler. Geç Jura-Erken Kretase dönemi, yoğun bir karbonat çökelimi ile karakterize edilir (Berdiga Formasyonu, [38]. Bu birimler Geç Kretase yaşlı volkanik kayaçlar tarafından uyumlu olarak örtülmüş olup [39], [40], [41], [42], [43], [44], Geç Kretase yaşlı plütonik kayaçlar tarafından kesilmişlerdir [3], [4], [45], [46], [47], [48], [49], [50], [51], [52], [53]. Bölgede Geç Kampaniyenden Maastrihtiyen sonuna kadar devam eden yüksek-K'lu magmatizma gözlenir [54], [55]. [56] ve [57]'ya göre Anatolid-Torid bloklarının çarpışması Geç Paleosen ila Erken Eosen döneminde meydana gelmiştir. Bölgede Erken Eosen yaşlı adakitik kayaçların varlığı [58], [59], [60], [61], [62], [63], yay-kıta çarpışmasının son evresini ifade eder. Doğu Pontidlerde Eosen yaşlı birimler volkanik ve volkanoklastik kayaçlardan, bazik ila orta dereceli piroklastik kayaçlardan, lav akıntılarından ve dayklardan oluşmuş olup [1], [5], [64], [65], [66], [67], aynı yaştaki kalk-alkalen plutonlar tarafından kesilmişlerdir [2], [6], [63], [68], [69], [70], [71], [72], [73], [74]. Bölgede Eosen sonrasında Geç Miyosen-Pleyistosen yaşlı volkanik ve kırıntılı kayaçlar ile Neojen yaşlı volkanik kayaçlar (alkalen karakterli) yaygın olarak gözlenir [1], [56], [64], [75], [76]. Doğu Pontidler'in en yaşlı kayaçlarını Kuvaterner yaşlı traverten, alüvyon ve yamaç molozları oluşturur.

B. *İnceleme Alanının Jeolojisi*

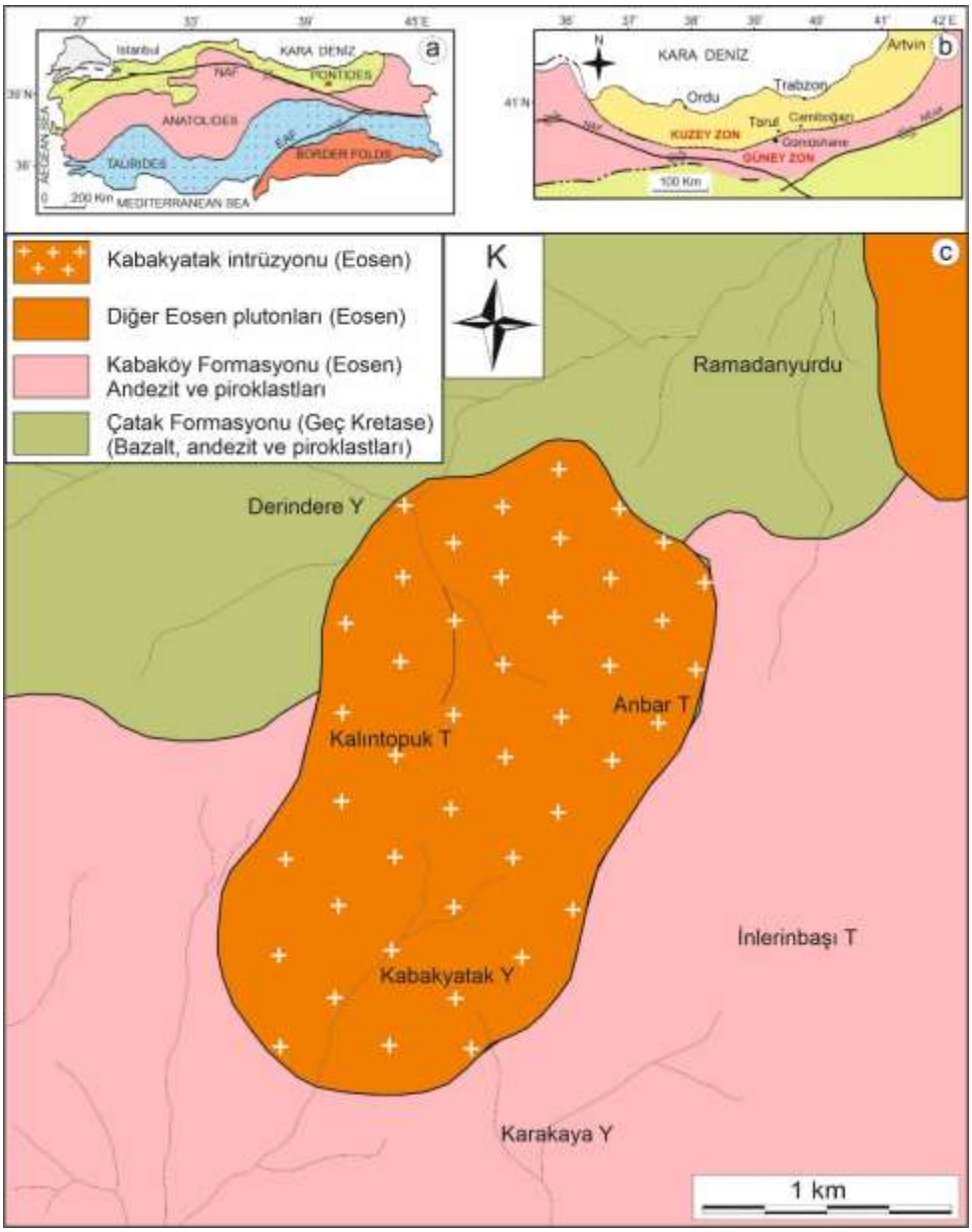
İnceleme alanı Doğu Pontidler'in kuzey zonunda yer alır. Yörede, Geç Kretase ve Eosen yaşlı birimler yüzeylenmektedir (Şekil 1).

Çalışma alanındaki en yaşlı kayaçları bazalt, andezit ve piroklastlardan oluşan Geç Kretase yaşlı Çatak Formasyonu oluşturur. Bu birimler üzerine uyumsuz olarak Eosen yaşlı Kabaköy Formasyonu gelir ve bu formasyon başlıca andezit ve piroklastlarından oluşur. Tüm bu birimler Orta Eosen yaşlı Kabakyatak intruzyonu ve aynı yaşlı diğer plutonlar tarafından kesilmişlerdir.

Kabakyatak intruzyonu yaklaşık elips şekilli olup, uzun ekseni KD-GB istikametinde uzanım göstermektedir (Şekil 1c). İntrüzyon kuzey sınırlarında Geç Kretase yaşlı Çatak Formasyonu ile dokanak

halinde iken, güney kısımlarda Eosen yaşlı Kabaköy Formasyonu ile dokanak oluşturur. Ayrıca, inceleme alanının kuzeydoğusunda Orta Eosen yaşlı plutonik kayaçlar yer alır (Şekil 1c).

Kabakyatak intrüzyonu inceleme alanında başlıca Kabakyatak Yaylası olmak üzere, Kalıntopak Tepe ve Anbar Tepe civarında yayılım gösterir (Şekil 1c). İntrüzyon genelde granodiyorit bileşimli olup, kenar kısımlarda tonalit bileşimlerine de rastlanır. Tonalitler açık gri-pembe renklerde gözlenirken, granodiyoritler ise genellikle gri, açık gri renklerde görülürler. Kayaçlar da gözle görülebilen feldispat, kuvars ve koyu renkli mineralleri yer alır.

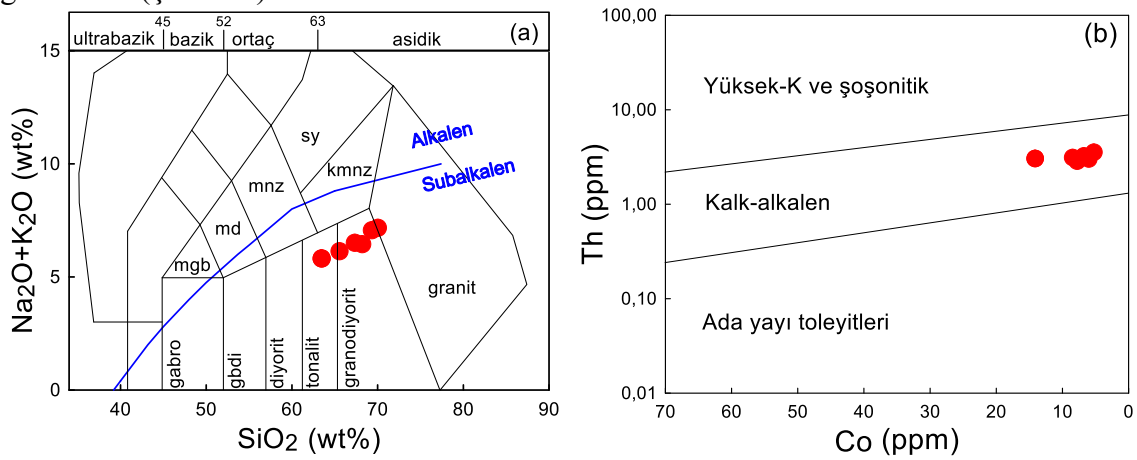


Şekil 1. (a) Türkiye ve çevresinin tektonik yapısı [11]'dan değiştirilerek); (b) Doğu Pontid orojenik kuşağının (EPOB) ana yapıları; (c) İnceleme alanının jeolojik haritası

C. *Tüm Kayaç Jeokimyası*
Ana ve iz elementler

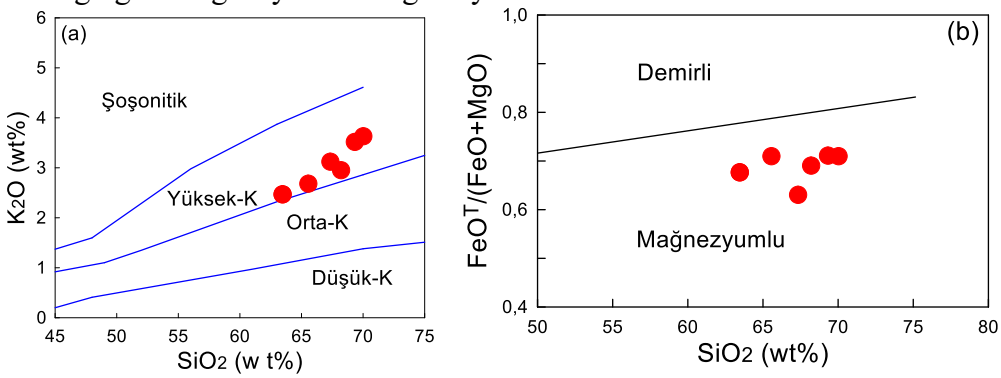
Kabakyatak intruzyonunu oluşturan kayaçlara ait jeokimyasal analiz sonuçları SiO_2'ye karşı (Na_2O+K_2O) diyagramında büyük çoğunlukla granodiyorit alanına, az oranda da tonalit alanına düşerler ve subalkalen

karakter sunarlar (Şekil 2a). Th'a karşı Co diyagramında [77] subalkalen örneklerin tümü kalk-alkalen karakter gösterirler (Şekil 2b).



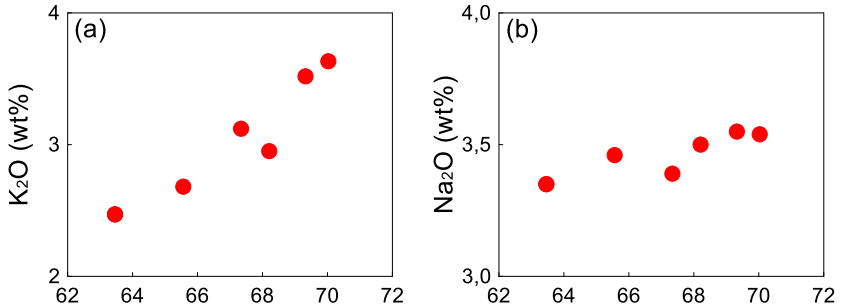
Şekil 2. Kabakyatak intruzyonunu oluşturan kayaçların, (a) SiO_2'ye karşı (Na_2O+K_2O) diyagramı [78], (b) Th'a karşı Co diyagramındaki [77] konumları

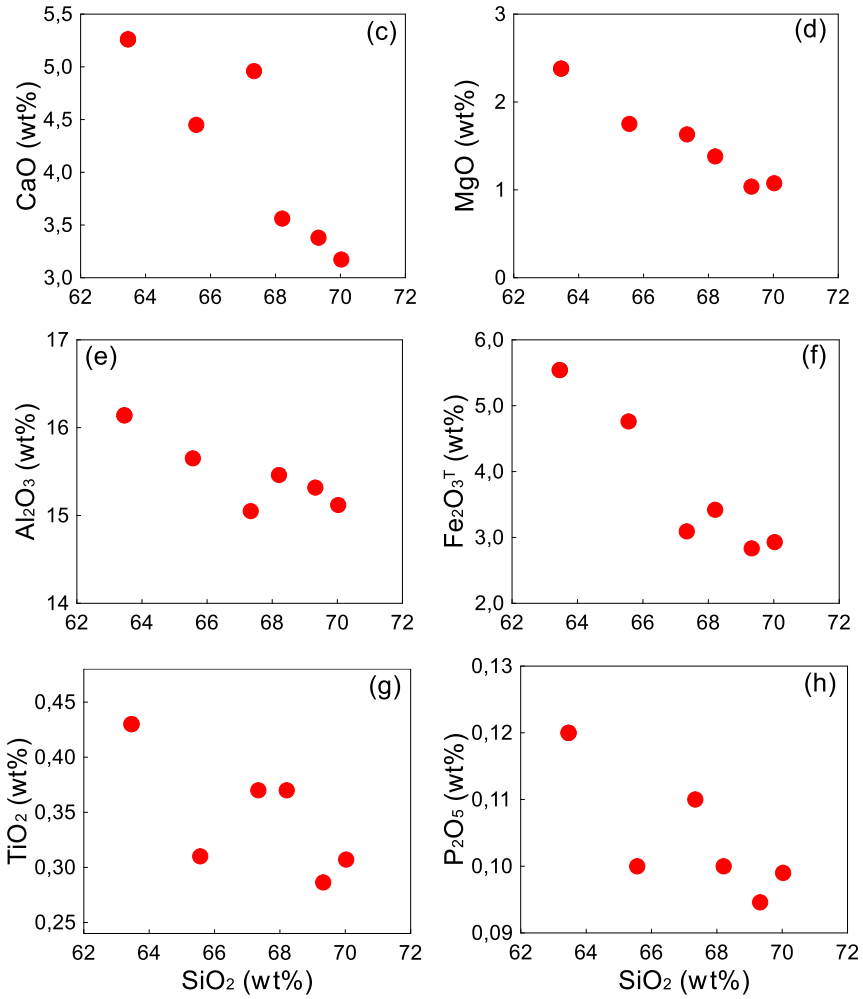
SiO_2'ye karşı K_2O diyagramında tüm örnekler yüksek-K'lu kalk-alkalen karakter sunarlar (Şekil 3a) ve Şekil 3b'de görüldüğü gibi mağnezyumlu bölgede yer alırlar.



Şekil 3. Kabakyatak intruzyonu kayaçlarına ait örneklerin (a) SiO_2'ye karşı K_2O diyagramı [79], (b) $FeO^t/(FeO^t+MgO)$ - SiO_2 (%) diyagramındaki [80] konumları

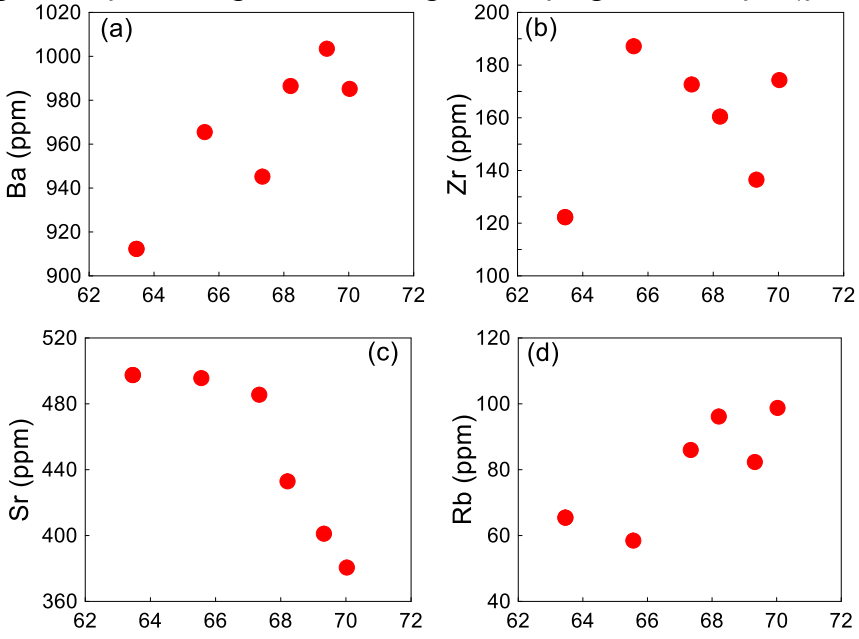
İncelenen örneklerin yer aldığı SiO_2'ye karşı ana elementler değişim diyagramlarında (Şekil 4), örneklerin SiO_2 değerleri ile CaO, MgO, $Fe_2O_5^T$, Al_2O_3, P_2O_5 ve TiO_2 değerleri negatif bir korelasyon gösterirken, K_2O ve Na_2O değerleri pozitif bir ilişki sunarlar.

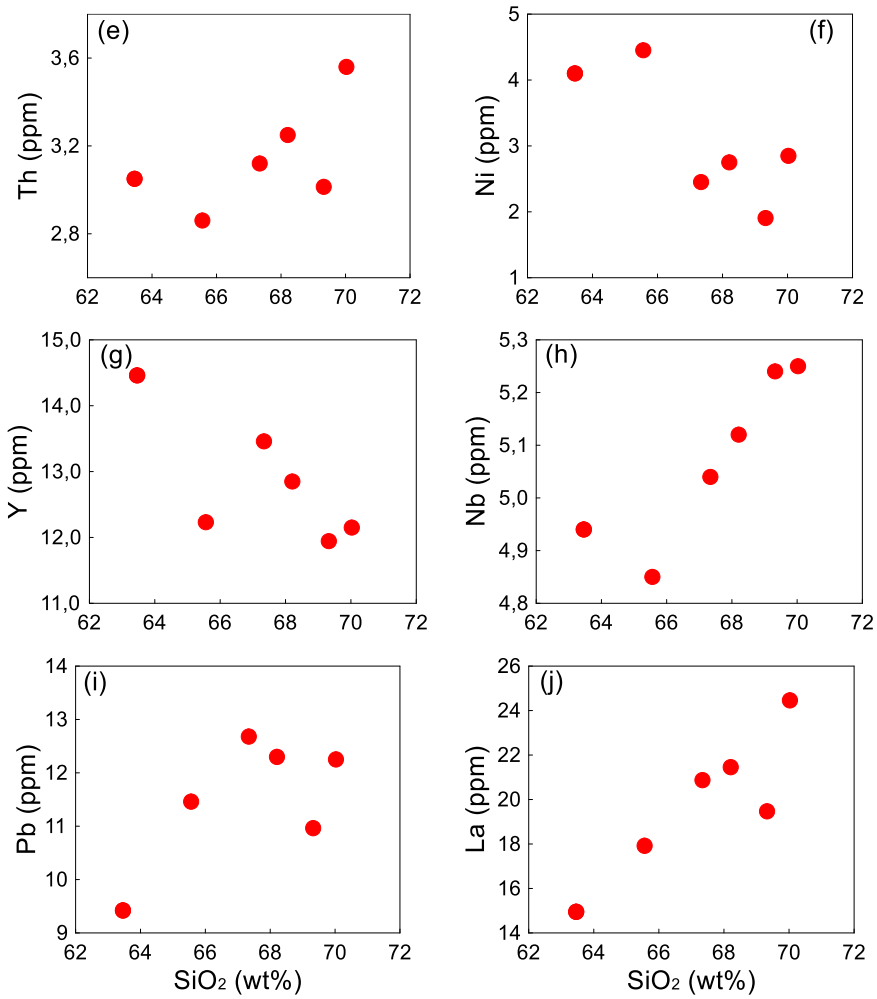




Şekil 4. Kabakyatak intruzyonu kayaçları örneklerinin SiO_2'ye karşı ana element değişimi diyagramları

İncelenen örneklerin yer aldığı SiO_2'ye karşı iz elementler değişim diyagramlarında (Şekil 5), kayaçların SiO_2 değerleri arttıkça Sr, Ni ve Y değerleri negatif bir ilişki gösterirken; Rb, Ba, Th, Nb, Pb ve La değerleri pozitif bir korelasyon göstermiştir. Zr değerleri ise belirgin bir ilişki göstermemiştir (Şekil 5).

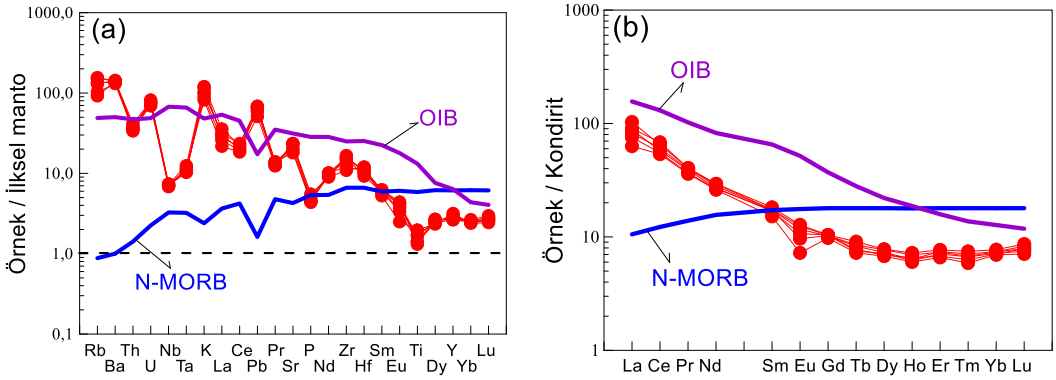




Şekil 5. İncelenen kayaç örneklerin SiO_2'ye karşı iz element değişimi diyagramları

İlksel (primitif) mantoya göre normalleştirilmiş iz element dağılım diyagramları (normalleştirme değerleri [81]'dan alınmıştır) (Şekil 6a), incelenen örneklerde genel bir zenginleşme eğilimini göstermektedir. Bu zenginleşme, Nb, Ta, P ve Ti gibi elementlerde negatif anomaliler ve Pb gibi elementlerde ise pozitif anomali şeklinde kendini göstermektedir.

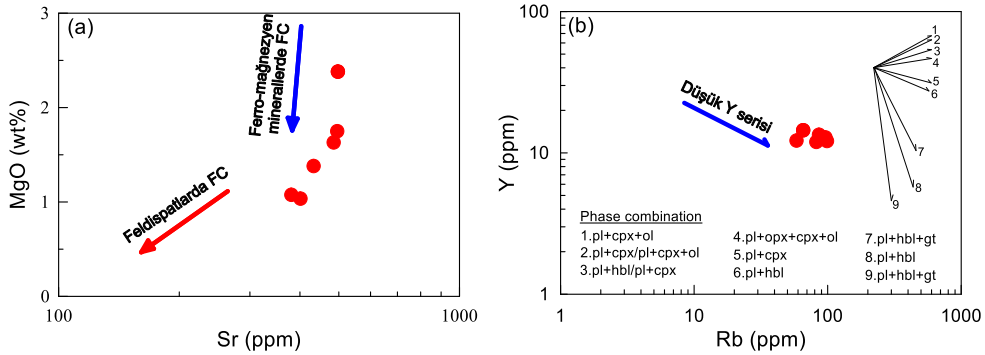
Kondrite göre normalleştirilmiş NTE diyagramları (normalleştirme değerleri (normalleştirme değerleri (Taylor and McLennan, 1985a)'den alınmıştır) (Şekil 6b), örneklerin genel olarak hafif NTE'lerde (LREE) daha belirgin olmak üzere NTE'ler bakımından zenginleştiğini göstermektedir. Bu zenginleşme, kayaçların oluşum ortamında magmatik fraksiyonel kristalleşme süreçlerin sonucudur. LREE'lerde gözlenen zenginleşme, örneklerin magmatik kaynaklı olduğunu ve kayaç oluşum ortamında fraksiyonel kristalleşmeye maruz kaldıklarını göstermektedir. Ağır NTE'lerde (HREE) gözlenen nispeten düz eğilim ise kayaçların ilkel mantodan türemiş magmatik kayaçlarla jeokimyasal benzerlik gösterdiğini işaret etmektedir. Örneklerdeki Eu_N değerleri 1'den küçük olup, negatif Eu_N anamolisi gösterirler (Şekil 6b).



Şekil 6. Kabakyatak intruzyonu örneklerinin normalleştirilmiş dağolımları, (a) ilksel mantoya göre, (b) Kondrite göre

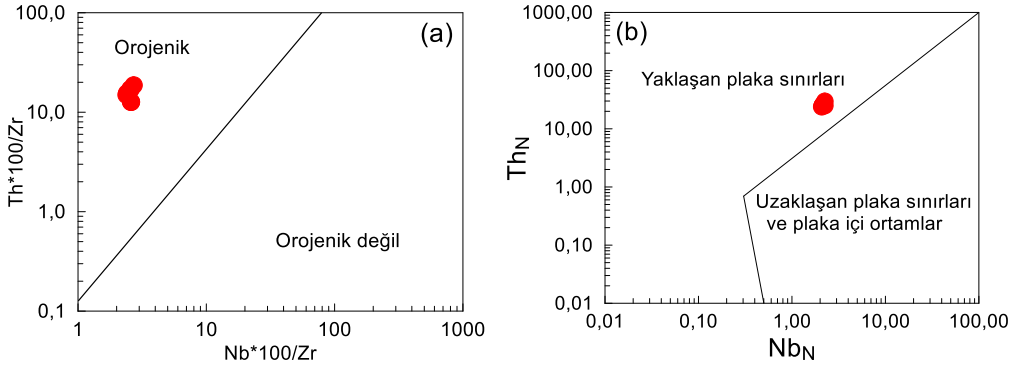
Tektonik konum ve petroloji

Kabakyatak intruzyonuna ait örnekler MgO'ya karşı Sr diyagramında (Şekil 7a) daha ziyade ferromagnezyen minerallerinde gözlenen fraksiyonlaşma trendi gösterirler. Y'a karşı Rb diyagramında tüm örneklerdüşük-Y serisi eğilimine sahip olup, plajiyolas ve hornblend fraksiyonlaşması gösterirler (Şekil 7b).



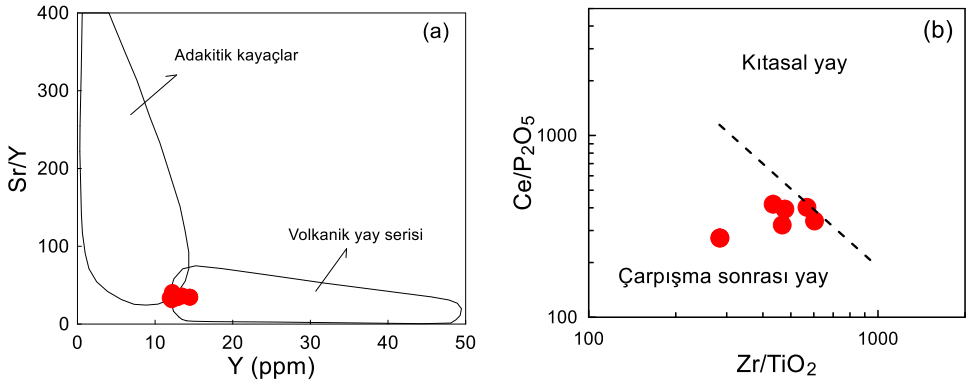
Şekil 7. Kabakyatak intruzyonu kayaçlarına ait örneklerin, (a) MgO-Sr diyagramındaki, (b) Y-Rb diyagramındaki konumları

Th/Zr'a karşı Nb/Zr ve Th_N'e karşı Nb_N diyagramlarında (Şekil 8a ve b), tüm örnekler orojenik alanda yer alırlar.



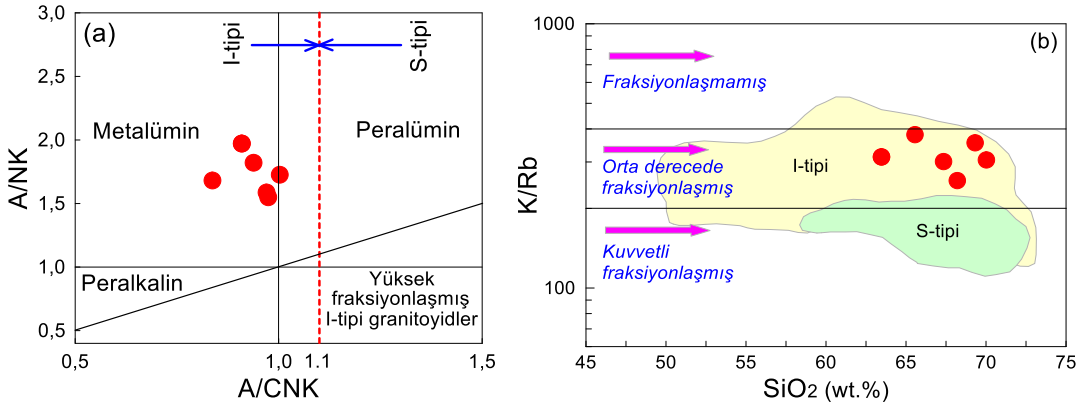
Şekil 8. Kabakyatak intruzyonu kayaçlarına ait örneklerin, (a) Th-Zr diyagramındaki, (b) Th_N-Nb_N diyagramındaki [80] konumları

Örnekler Sr/Y'a karşı Y diyagramında adakitik özellik göstermeyip, volkanik yay serisi alanında bulunurlar (Şekil 9a). Ce/P_2O_5 – Zr/TiO_2 diyagramında (Şekil 9b) ise çarpışma sonrası yay alanında yer alırlar.



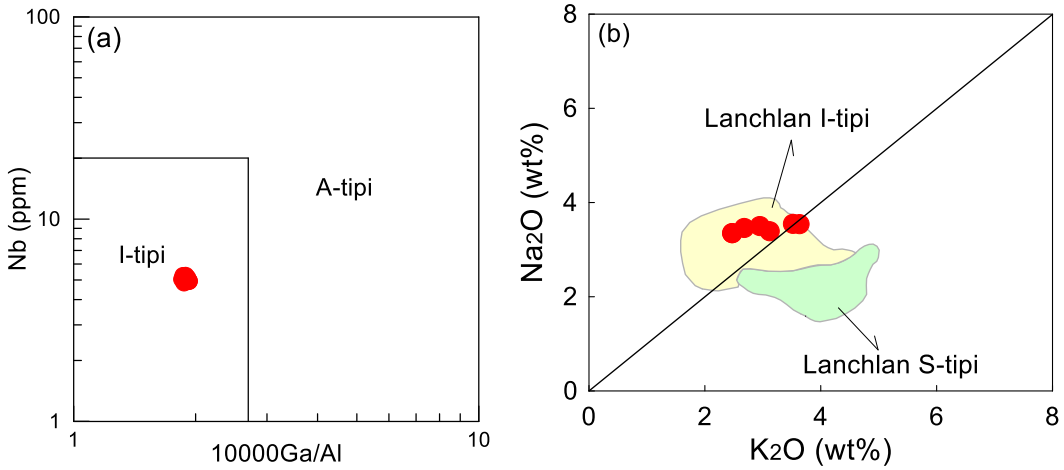
Şekil 9. Kabakyatak intruzyonu kayaçları örneklerinin, (a) Sr/Y'a karşı Y [83], (b) Ce/P_2O_5 - Zr/TiO_2 diyagramındaki konumları

Örneklerin A/CNK (molar olarak $Al_2O_3/(CaO+Na_2O+K_2O)$ içerikleri 1.1'den düşük olup, A/CNK – A/NK diyagramda (Şekil 10a) metalümin karakter gösterirler. SiO_2'ye karşı K/Rb diyagramında, tüm örnekler I-tipi bölgede yer alıp, orta derecede fraksiyonlaşma gösterirler (Şekil 10b).



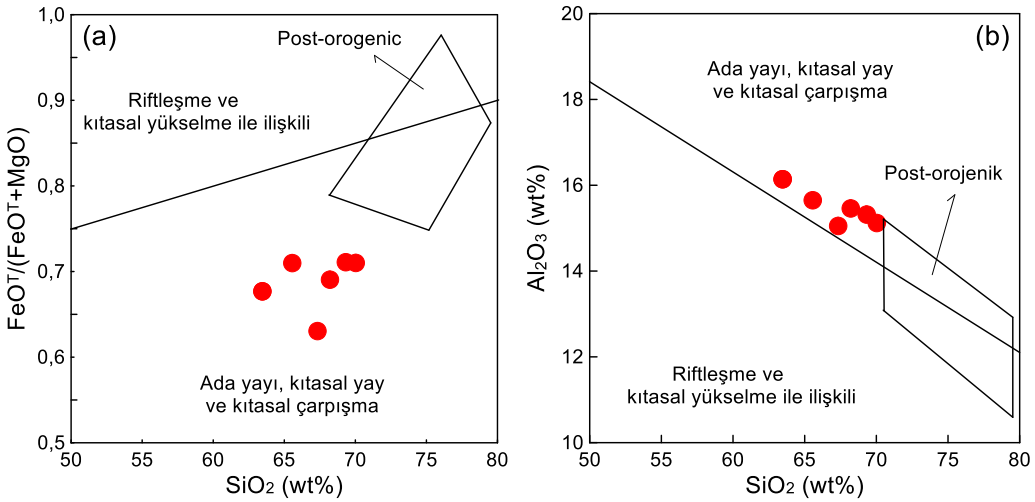
Şekil 10. Kabakyatak intruzyonu kayaçlarına ait örneklerin, (a) molar A/NK'ya karşı molar A/CNK diyagramındaki [84], (b) SiO_2'ye karşı K/Rb diyagramındaki konumları

Örneklerdeki I-tipi karakter Nb'ye karşı Ga/Al diyagramında (Şekil 11a) da gözlenmekte olup, Na_2O – K_2O diyagramında Lanchlan I-tipi granit alanında yer alırlar (Şekil 11b).



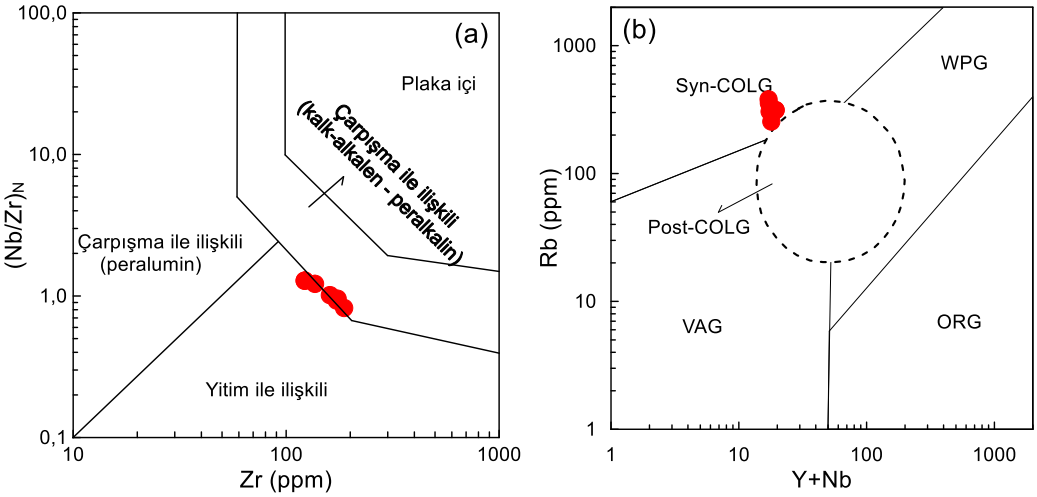
Şekil 11. Kabakyatak intruzyonu kayaçlarına ait örneklerin, (a) Nb'ye karşı 10000Ga/Al [85], (b) Na_2O-K_2O (%) [86] diyagramlarındaki konumları

İncelenen örnekler genelde çarpışma ile ilişkili bölgede yer alırlar (Şekil 12 a ve b).



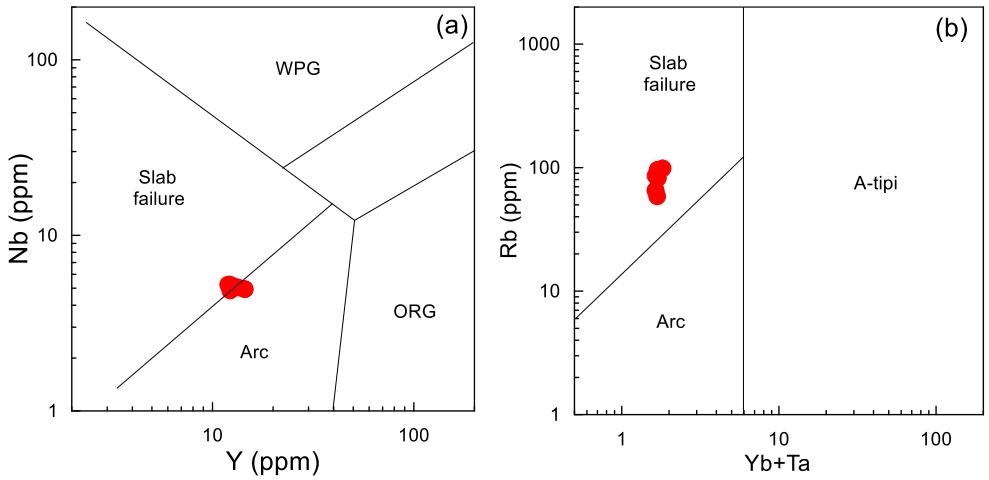
Şekil 12. Kabakyatak intruzyonu kayaçlarına ait örneklerin, (a) $FeO^T/(FeO^T+MgO)$, (b) Al_2O_3 – SiO_2 diyagramlarındaki konumları

Nb/Zr'a karşı Zr ile Rb'a karşı (Y+Nb) diyagramlarında (Şekil 13 a ve b), tüm örnekler çarpışma ve çarpışma sonrası alanlarda yer alırlar.



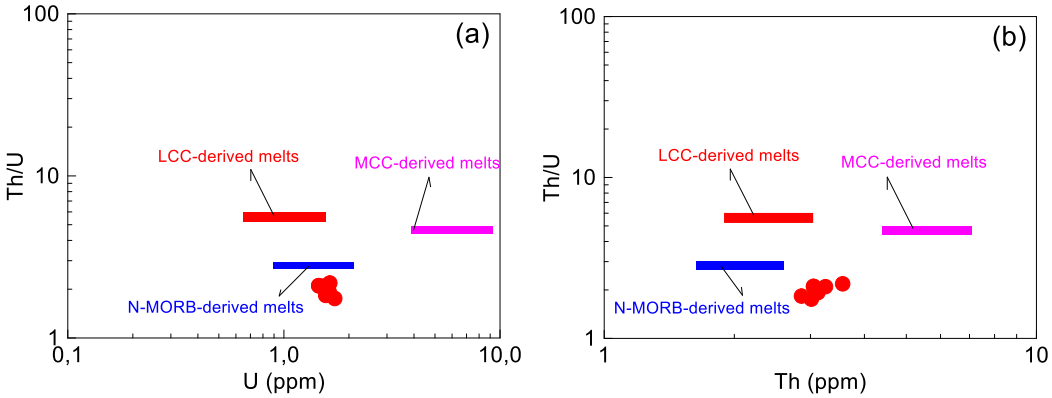
Şekil 13. Kabakyatak intruzyonu kayaçlarına ait örneklerin, (a) $(Nb/Zr)_N$ – Zr [87], (b) Rb – (Y+Nb) diyagramındaki [88] konumları

İncelenen örnekler Nb – Y diyagramında (Şekil 14a) slab ve yay (arc) dokanağında yer alırken, Rb – (Yb+Ta) diyagramında (Şekil 14b) yay değil de slab alanında yer alırlar.



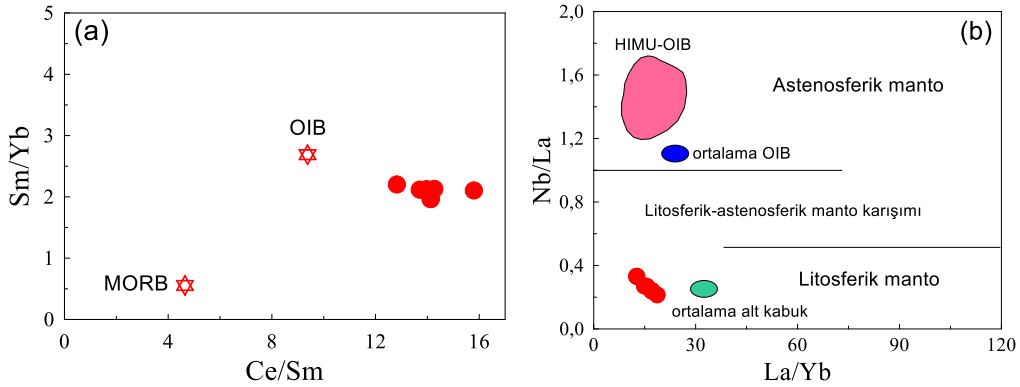
Şekil 14. Kabakyatak intruzyonu kayaçlarına ait örneklerin, (a) Nb – Y [88], (b) Rb – (Yb+Ta) [88] diyagramları

İncelenen örnekler Th/U – U ve Th/U - Th (Şekil 15a ve b) kabuktan ziyade, MORB alanlarında yer alırlar.



Şekil 15. Kabakyatak intruzyonu kayaçlarına ait örneklerin, (a) Th/U'a karşı U, (b) Th/U'a karşı Th diyagramları. LCC ve MCC değerleri [89]'den, MORB değerleri [90]'den alınmıştır

İncelenen örnekler Sm/Yb – Ce/Sm diyagramında (Şekil 16a) zenginleşmiş bölgede yer alırlar. Nb/La – La/Yb diyagramında (Şekil 16b) düşük Nb/La oranları ile litosferik manto bölgesinde yer alırlar.



Şekil 16. Kabakyatak intruzyonu kayaçlarına ait örneklerin, (a) Sm/Yb – Ce/Sm, (b) Nb/La – La/Yb diyagramlarındaki konumları. (a) MORB ve OIB değerleri [91]'den, (b) Litosferik manto, astenosferik manto ve karışım cizgi değerleri [92], HIMU-OIB alan değerleri [93]'den alınmıştır.

IV. SONUÇLAR

1. Çalışma alanında başlıca Geç Kretase yaşlı Çatak Formasyonu, Eosen yaşlı Kabaköy Formasyonu ve bu formasyonları kesen Orta Eosen yaşlı plutonik kayaçlar yer alır.

2. İncelenen Kabakyatak intruzyonuna ait kayaçlar yaygın olarak granodiyorit, az oranda da tonalit bileşimindedir. Tonalitler intrüzyonun kenar kısımlarında yer alırlar.

3. Kabakyatak intruzyonuna ait kayaçlar, jeokimyasal analizler ışığında genel olarak I-tipi, yüksek-K'lu kalk-alkalen ve metalümin özellik göstermektedir.

4. Tektonik yerleşim diyagramlarına yapılan analizler sonucunda, Kabakyatak intruzyonuna ait kayaçların çarpışma ile ilişkili jeokimyasal ve petrolojik özellikleri gösterdiği belirlenmiştir.

5. Kabakyatak intruzyonuna ait kayaçların jeokimyasal analizleri, kayaçların köken magmasının zenginleşmiş bir litosferik manto kaynağı olabileceğini göstermektedir

.

TEŞEKKÜR

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Derinoba-Kayadibi Plütonlarının kökensel ilişkisinin jeoistatistiksel İrdelenmesi

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Özet – Bu çalışmanın amacı, mevcut jeokimyasal verilerin jeoistatistiksel yaklaşımlarla değerlendirilerek farklı kayaçların birbirleriyle kökensel ilişkisinin irdelenmesi/tanımlanmaya çalışılmasıdır. Bu amaçla Doğu Pontidlerin Kuzey zonunda yüzlek veren Derinoba ve Kayabidi (GB Trabzon, Türkiye) granitlerinin tüm kayaç analiz sonuçları değişik istatistiksel yaklaşımlarla değerlendirilmiştir. Çalışma için Derinoba granitine ait 15 ve Kayadibi granitine ait 5 adet tüm kayaç analizi işleme tabi tutulmuştur. İncelemeye konu veri setinin elaman sayısı (özellikle Kayadibi graniti) sınırlı sayıda olduğu için analizlerde parametrik olmayan istatistiksel yöntemlerin tercih edilmiştir. Çalışma kapsamında iki granit kütlesinin tanımlayıcı istatistik parametreleri hesap edilmiştir. Böylelikle jeokimyasal verilerin merkezi dağılım parametreleri belirlenmiş ve veri setinin genel karakteri anlaşılmaya çalışılmıştır. Bu çalışma akabinde ise ilgili veri setlerine Mann Whitney U testi uygulanmış ve bu iki granit kütlesinin birbirleri ile kökensel ilişkileri irdelenmiştir. Çalışma sonucunda Derinoba ve Kayadibi granitlerinin SiO_2, Gd, Tm, Er, Rb/Sr, La_{CN}/Lu_{CN}, La_{CN}/Yb_{CN}, ASI parametrelerince sig. %1 ve/veya %1-3 aralığında aynı kökensel kaynağı sahip temsil ettiği, SiO_2 dışındaki diğer ana oksitlerce ve Sr, Ta, Nb, Hf, Zr, U, Ga, La, Ce, Pr, Nd, Sm, Eu, Tb, Dy, ve Ho elementlerince ise %95 (1-sig.) güven aralığında aynı/benzer kökene sahip olduğu görülmüştür. Elde edilen sonuçlar bahse konu granitlerin kökeni yönelik yapılan konvansiyel çalışma sonuçları teyit etmiştir.

Anahtar Kelimeler – Doğu Pontidler, Tanımlayıcı İstatistik, Mann Whitney U testi, Derinoba graniti, Kayabidi granati, Trabzon, Türkiye

I. GİRİŞ

İstatistiksel yaklaşımlar yerbilimlerinde özellikle de maden aramaya yönelik jeokimya çalışmalarında 1900'lerin başlarından beri önemli yer tutmaya başlamıştır. Bu çalışmaların yaygınlığı ile birlikte de jeoistatistik kavramı literatürde önemli yer bulmuştur. Günümüzde de başta maden yatakları ve jeokimya anabilim dalı almak üzere bir çok yerbilimci istatistiksel prensiplerden yararlanmaktadır [1], [2], [3], [4], [5]. Jeolojik amaçlı çalışmalarda elde edilen birçok sayısal verinin toplu olarak değerlendirilmesinde ve çıkarımlar yapılmasında başta tanımlayıcı istatistik olmak üzere, t-testi (bağımsız tek örnek t-testi, bağımsız iki örnek t-testi, bağımlı iki örnek t-testi), varyasyon (ANOVA) analizleri ve faktör analizleri kullanılmaktadır. Özellikle t-testi ve ANOVA testi, duruma göre de bunların nonparametrik eşlenikleri petrolojik çalışmalarda kayaçların kökensel benzerliklerinin karşılaştırılmasında kullanıma uygun jeoistatistiksel yöntemlerdir.

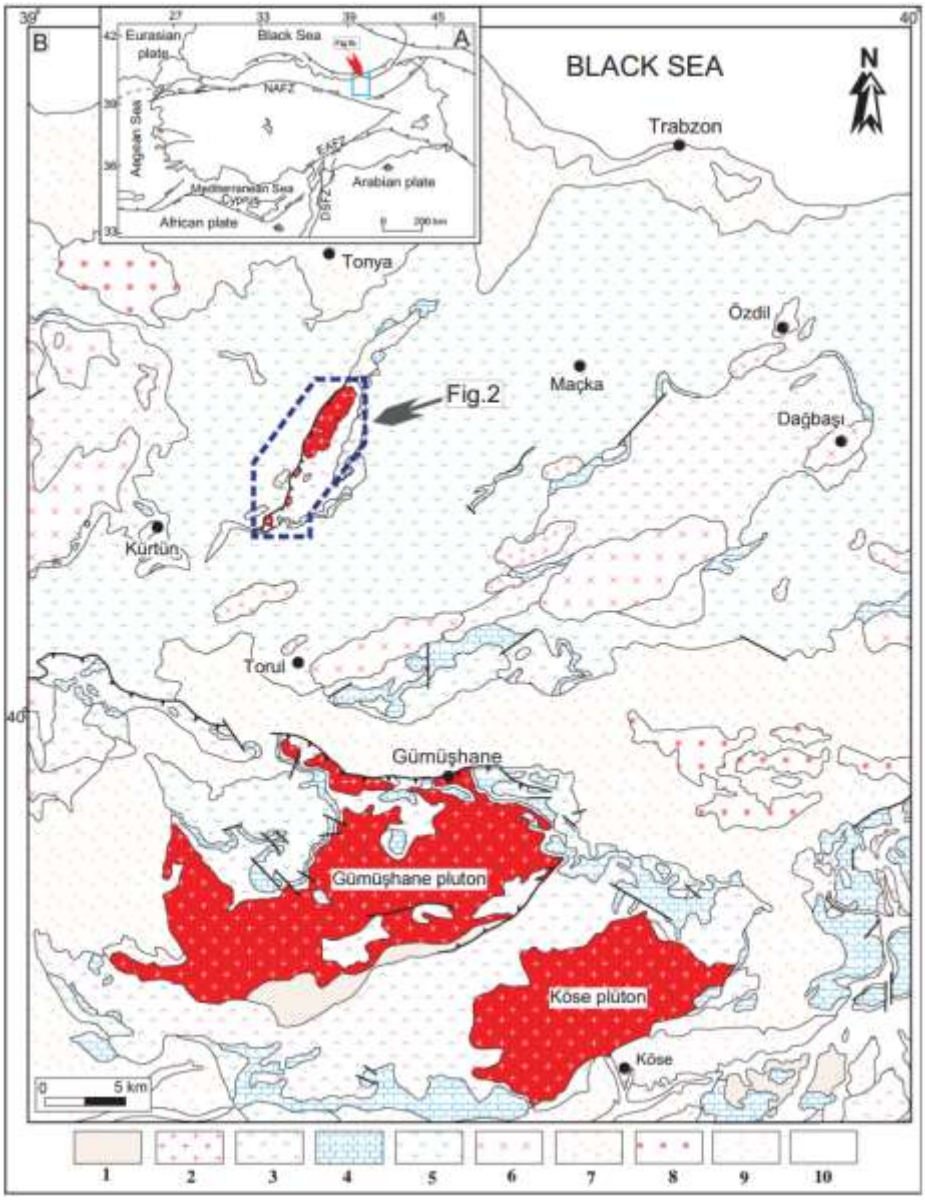
Pontid tektonik birliği bölgesel ölçekte pek çok magmatik kayacı içerir [6], (Şekil 1A). Bunların çoğunluğu Avrasya-Gondwana kıtalarının yaklaşan/çarpışan sınırları ile ilişkili kayaçlardır. Bölgenin

zengin jeolojik özellikleri ve ilişkili maden yatakları potansiyeli araştırmacıların dikkatini çekmiş ve yerbilimleri bağlamında geçmişten günümüze birçok çalışma gerçekleştirilmiştir [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19]. Bölgedeki magmatik kayaçlar geniş bir yaş aralığına sahip olup [20], [21], [22], [23], [24], [25], [26], [27], benzer yaşta ve kökene sahip, farklı lokasyonlarda da irili ufaklı bir çok magmatik kütle de yapılan çalışmalarla ortaya konmuştur [28], [29], [30], [31]. Bölge kayaçlarının bileşimi düşük-K, yüksek-K kalk-alkalin metalümina-peralümina granitoyidlerden alkalin siyenitlere kadar değişim göstermektedir (Yılmaz and Boztuğ, 1996; Kaygusuz et al., 2008, 2010, 2016, 2024). Bölgedeki Paleozoyik temel kayaçlarının büyük çoğunluğu granitoyidlerdir. Bunların birbirleriyle kökensel ve yaş ilişkilerine yönelik çalışmalar özellikle son zamanlarda yoğunluk kazanmaya başlamıştır. Değişik jeolojik-jeokimyasal ve izotop (duraylı-radyojenik) çalışmalarıyla bu ilişkiler ortaya konulmaya çalışılmıştır. Bu ilişkilerin sayısal verilerinin jeoistatistiksel irdelenmesine ise genellikle yapılan çalışmalarda çok yer verilmemiştir. Bu çalışmada jeokimyasal verilerin jeoistatistiksel yaklaşımla değerlendirilmesi ve böylelikle kayaçların kökensel ilişkilerinin jeoistatistiksel değerlendirilmesinin yapılması amaçlanmıştır. Örnek çalışma olarak Kaygusuz vd. [28] tarafından Derinoba ve Kayadibi granitlerinin jeokimyasal parametreleri kullanılmıştır. Verilerin genel değerlendirilmesi tanımlayıcı istatistik parametreleri ile gerçekleştirilmiş olup, verilerin azlığı dikkate alınarak jeoistatistiksel yöntem olarak da Mann Whitney U testi kullanılarak kökensel değerlendirme yapılmaya çalışılmıştır.

II. BÖLGESEL JEOLOJİ

Doğu Pontidler yapısal ve litolojik özellikleri de dikkate alınarak, genel manada kuzey ve güney zon olarak bölümlenmiştir [34], [35]. Güney zonda ağırlıklı olarak Paleozoyik'ten Neojen'e kadar volkanik, plütonik, sedimanter ve metamorfik kayalar yer alırken, kuzey zonda ise Karbonifer'den Neojen'e kadar volkanik (yer yer tortul ara katkılı) ve plütonik kayalar baskın durumdadır (Şekil 1 A) [17], [36], [37], [38], [39], [40], [41], [42].

Doğu Pontidler'de temel kayaları Variskan öncesi şistler ve gnayslar [43] ile bunları kesen Silüriyen-Devoniyen yaşlı metagranitler ve Orta-Geç Karbonifer yaşlı plutonlar oluşturur [21], [28], [44], [45], [46], [47], [48], [49], [50]. Bu temel kayaçlar Erken-Orta Jura yaşlı volkano-tortul istif tarafından uyumsuz olarak örtülürler [51], [52], [53], [54], [55] ve Erken-Geç Jura yaşlı intrüzyonlar [56], [57], [58], [59] tarafından kesilirler. Geç Jura-Erken Kretase aralığında yoğun bir karbonat çökelimi yer alır (Berdiga Formasyonu, [60]). Bu birimler Geç Kretase yaşlı volkanik kayaçlar tarafından uyumlu olarak örtülürler [29], [31], [61], [62] ve Geç Kretase yaşlı plütonik kayaçlar tarafından kesilirler [26], [63], [64], [65], [66], [67], [68]. Bölgede Geç Kampaniyenden Maastrihtiyen sonuna kadar devam eden yüksek-K'lu magmatizma yer alır [69]. Anatolid-Torid bloklarının çarpışması Geç Paleosen ila Erken Eosen döneminde meydana gelmiştir [70], [71]. Bölgede Erken Eosen yaşlı adakitik kayaçların varlığı [72], [73], [74], [75], [76], [77], yay-kıta çarpışmasının son evresini ifade eder. Doğu Pontidlerde Eosen yaşlı birimler volkanik, volkanoklastik, piroklastik, lav akıntıları ve dayklardan oluşmuş olup [15], [78], [79], [80], [81], [82], aynı yaştaki kalk-alkalen plutonlar tarafından kesilmişlerdir [39], [83], [84], [85], [86], [87], [88], [89], [90], [91], [92]. Bölgede Geç Miyosen-Pleyistosen yaşlı volkanik ve kırıntılı kayaçlar ile Neojen yaşlı alkalen volkanik kayaçlar yaygın olarak gözlenir [16], [35], [80], [93]. Bölgenin en genç birimleri Kuvaterner yaşlı yamaç molozu, traverten ve alüvyonlardır [94], [95]..



Şekil 1. A. Türkiye ve yakın çevresinin tektonik haritası [33]'den değiştirilmiştir. B. Plütonik ve volkanik kayaçların dağılım. (1) Palezoyik metamorfik kayaçlar, (2) Paleozoyik plutonlar, (3) Liyas-Dogger volkanik kayaçlar, (4) Malm-Alt Kretase sedimanter kayaçlar, (5) Üst Kretase volkanik kayaçlar, (6) Üst Kretase plutonlar, (7) Paleojen-Neojen kalkalkalin volkanik kayaçlar (8) Paleojen-Neojen alkalin volkanik kayaçlar, (9) Eosen plutonlar, (10) Alüvyon, NAFZ: Kuzey Anadolu Fay Zonu, EAFZ:Doğu Anadolu Fay Zonu Haritanın orjinali için bakınız: , [28].

III. JEOİSTATİSTİKSEL DEĞERLENDİRME

Bu çalışmada toplamda 20 örneğe ait jeokimyasal veriler değerlendirmeye alınmıştır. Örneklerden 15 tanesi Derinoba granitine ait olup, 5 tanesi ise Kayadibi granitine ait aittir. Verilerle ilgili detaylı bilgiler Kaygusuz vd. [28]'da görülebilir. Tanımlayıcı istatistiksel yaklaşımlar bilimsel araştırmalardaki verilerin toplu olarak değerlendirilmesindeki güçlükleri aşmada yaygın olarak kullanılmaktadır. Örneğin verilerin ortalamaları, ortalama etrafındaki dağılım karakterleri, ortalamadan sapmaları verilerin değerlendirilmesini anlamlı hale getirmektedir. Tanımlayıcı istatistik kategorisinde ortalama, medyan, mod değerleri, standart sapma ve varyans gibi parametreler yer almaktadır. Tüm bu veriler değerlendirilirken bir diğer önemli kavram ise istatistiksel önem, anlamlılık düzeyi veya olasılık kavramıdır. Bu kavram genel olarak P ile gösterilir. $P \leq 0.05$ veya $P > 0.05$ gibi ifadelerle önem seviyeleri ile ilgili bilgi verilir. P değeri %95 güven aralığını temsil eder ve genel olarak istatistiksel değerlendirmelerde "sig." olarak ifade edilir. Bu çalışmada

daha çok ortalama (mean), standard sapma (Std.Deviation), standard hata (Std. Error Mean) parametreleri dikkate alınarak değerlendirme yapılmıştır.

Mann Whitney U testi bağımsız iki örnek t-testinin parametrik olmayan alternatifidir. Bağımsız iki örnek t-testinden farkı ise bu yöntemde grupların ortalama değerleri yerine medyan değerlerinin karşılaştırılmasına dayanır. Bizim verilerimizin istatistiki olarak az sayıda olması nedeniyle bu test yöntemi tercih edilmiştir [96].

IV. BULGULAR

A. Arazi gözlemleri ve petrografik özellikler

Sahada 4 ayrı granit kütlesi mevcut olup (Derinoba, Kayadibi, Şahmelik ve Kızılağaç), bu çalışmada Derionaba ve Kayadibi granitleri değerlendirmeye alınmıştır. Çalışmaya konu intrüzyonlar yaklaşık KD-GB yönelimli kütlelerdir ve bölgede yüksek kodları temsil etmektedirler. Bu kayaçlar genellikle Jura öncesi volkanik ve piroklastiklerle sınırlandırılmıştır.

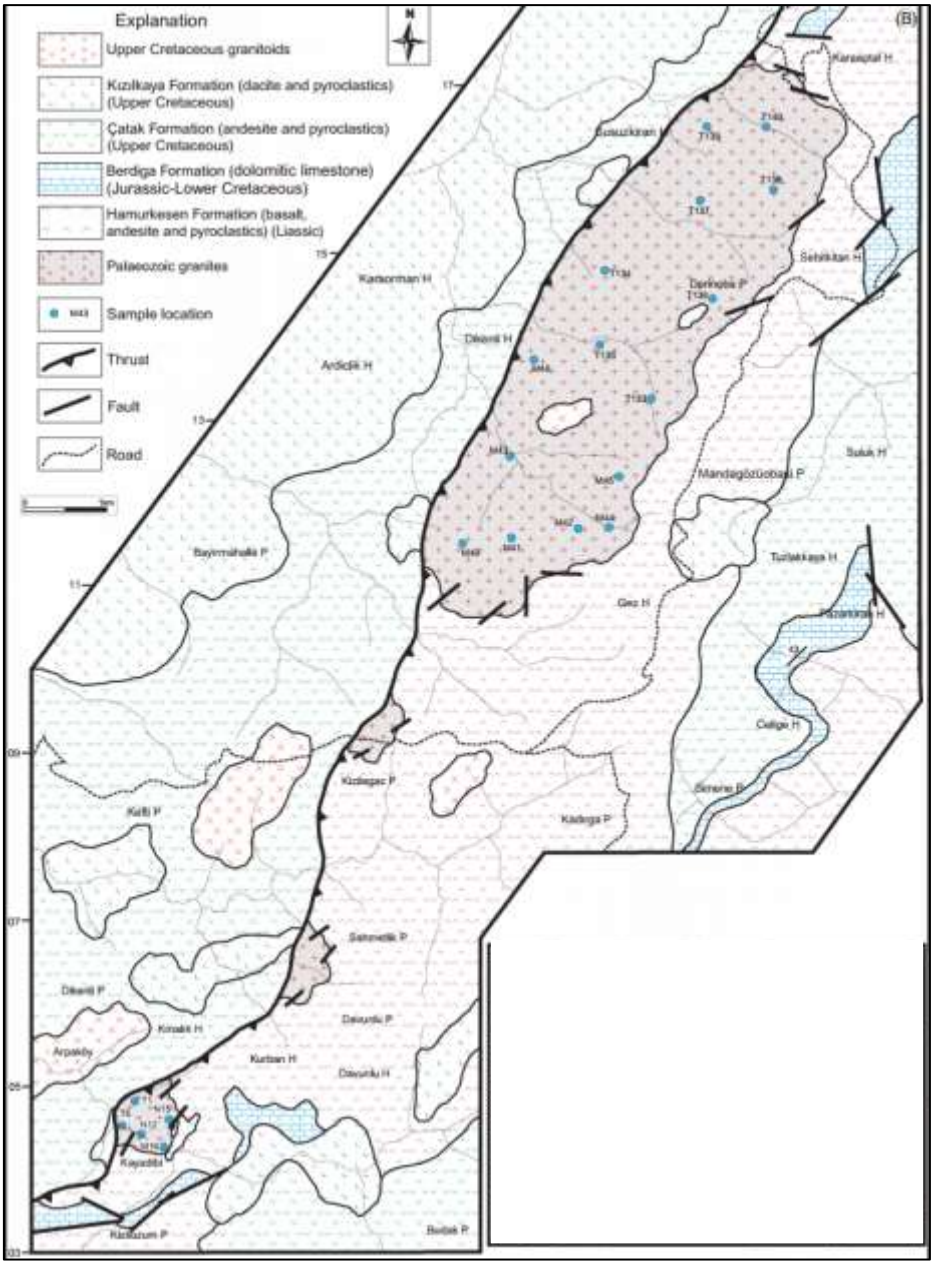
Derinoba graniti Trabzon'un 65 km güneybatısında yer almaktadır. Derinoba graniti yoğun alterasyon ve günlenmeye maruz kalmıştır. Kayabidi graniti ise elipsoid şeklinde daha küçük kütle şeklinde olup, 1 km^2'lik bir alanda yüzeylenmektedir ve Derinoba granitinin güney batısında yüzeyleme vermektedir (Şekil 2).

Granitlerin genel karakteri orta-kaba taneli monzogranit karakterindedir. Mineralojik olarak eş taneli K-feldispat, kuvars, plajiyoklas, biyotit minerallerinden oluşmaktadır. Aksesuar olarak ise zirkon, apatit, allanit, manyetit mineralleri rapor edilmiştir. Alterasyon ürünü mineraller ise serizit, klorit, epidot, kil mineralleri, karbonatlar ve beyaz mika mineralleridir.

B. Jeoistatistiksel Değerlendirmeler

Derinoba ve Kayadibi granitlerinin tanımlayıcı istatistikleri Tablo 1'de verilmiştir. Tanımlayıcı istatistik değerleri incelendiğinde ana oksitlerin ortalama (Mean) değerlerinin birbirine yakınlığı dikkat çekicidir. Standart sapma değerlerinin düşüklüğü verilerin normal dağılımına işaret etmekle birlikte aradaki farkların (sig. 0.05) kayaçların benzerliğinin (dolayısıyla kökensel ilişkisinin yakınlığı bağlamında) daha detaylı test edilmesi gerekliliğini doğurmaktadır.

Kökensel değerlendirmelerde dikkate alınan parametreler için benzerliğin tespit edilmesi amacıyla Mann Whitney U Testi dikkate alınmıştır (Tablo 2 ve 3). Verilerin Rank değerlerinin düşük olanları ilgili parametre için de elde edilen sonuçların düşük olduğuna işaret eder. Örneğin SiO_2 için Kayadibi granitinin değerinin düşük olduğu, TiO_2 için ise Derinoba granitinin ilgili değerinin düşük olduğu ifade edilir.



Şekil 2. Çalışma sahası jeolojik haritası ve örnek alım yerleri [28]'den alınmıştır.

Tablo 1. Derinoba ve Kayadibi granitlerinin bazı parametrelerine ait tanımlayıcı jeoistatistik parametreleri (kayaçlar için ortalamaların belirlenmesinde ortalama+standard hata değerlerinin dikkate alınmalıdır, tabloda ilgili bölümler koyu işaretlenmiştir)

Jeokimyasal Parametreler		Örnek Sayısı	**Mean**	**Std. Error Mean**
SiO_2	Derinoba Plütonu	11	**75.56**	**0.18**
	Kayadibi Plütonu	5	**74.46**	**0.24**
TiO_2	Derinoba Plütonu	11	**0.10**	**0.01**
	Kayadibi Plütonu	5	**0.13**	**0.02**
Al_2O_3	Derinoba Plütonu	11	**12.73**	**0.13**
	Kayadibi Plütonu	5	**12.94**	**0.19**
$Fe_2O_3^T$	Derinoba Plütonu	11	**1.40**	**0.08**
	Kayadibi Plütonu	5	**1.90**	**0.26**
MnO	Derinoba Plütonu	11	**0.03**	**0.00**
	Kayadibi Plütonu	5	**0.03**	**0.01**
MgO	Derinoba Plütonu	11	**0.37**	**0.04**
	Kayadibi Plütonu	5	**0.51**	**0.07**
CaO	Derinoba Plütonu	11	**0.65**	**0.16**
	Kayadibi Plütonu	5	**1.14**	**0.18**

Na_2O	Derinoba Plütonu	11	**3.28**	**0.06**
	Kayadibi Plütonu	5	**3.40**	**0.16**
K_2O	Derinoba Plütonu	11	**3.95**	**0.12**
	Kayadibi Plütonu	5	**4.28**	**0.24**
P_2O_5	Derinoba Plütonu	11	**0.03**	**0.00**
	Kayadibi Plütonu	5	**0.04**	**0.01**
Sr	Derinoba Plütonu	11	**45.90**	**3.02**
	Kayadibi Plütonu	5	**81.28**	**10.71**
Ta	Derinoba Plütonu	11	**1.18**	**0.13**
	Kayadibi Plütonu	5	**0.88**	**0.17**
Nb	Derinoba Plütonu	11	**13.01**	**0.43**
	Kayadibi Plütonu	5	**11.42**	**1.60**
Hf	Derinoba Plütonu	11	**4.51**	**0.47**
	Kayadibi Plütonu	5	**5.32**	**0.38**
Zr	Derinoba Plütonu	11	**134.11**	**10.92**
	Kayadibi Plütonu	5	**146.70**	**8.94**
Y	Derinoba Plütonu	11	**27.63**	**1.36**
	Kayadibi Plütonu	5	**39.20**	**1.72**
Th	Derinoba Plütonu	11	**13.89**	**1.23**
	Kayadibi Plütonu	5	**20.96**	**0.95**
U	Derinoba Plütonu	11	**3.05**	**0.21**
	Kayadibi Plütonu	5	**3.76**	**0.91**
Ga	Derinoba Plütonu	11	**16.61**	**0.38**
	Kayadibi Plütonu	5	**15.72**	**1.13**
La	Derinoba Plütonu	11	**32.83**	**1.27**
	Kayadibi Plütonu	5	**30.24**	**4.02**
Ce	Derinoba Plütonu	11	**64.64**	**3.17**
	Kayadibi Plütonu	5	**69.90**	**7.98**
Pr	Derinoba Plütonu	11	**7.38**	**0.31**
	Kayadibi Plütonu	5	**7.76**	**0.87**
Nd	Derinoba Plütonu	11	**29.45**	**1.44**
	Kayadibi Plütonu	5	**29.96**	**3.08**
Sm	Derinoba Plütonu	11	**5.29**	**0.16**
	Kayadibi Plütonu	5	**5.98**	**0.25**
Eu	Derinoba Plütonu	11	**0.64**	**0.10**
	Kayadibi Plütonu	5	**0.75**	**0.04**
Gd	Derinoba Plütonu	11	**4.80**	**0.50**
	Kayadibi Plütonu	5	**7.52**	**0.41**
Tb	Derinoba Plütonu	11	**0.99**	**0.11**
	Kayadibi Plütonu	5	**1.30**	**0.04**
Dy	Derinoba Plütonu	11	**5.01**	**0.40**
	Kayadibi Plütonu	5	**6.41**	**0.24**
Ho	Derinoba Plütonu	11	**1.25**	**0.12**
	Kayadibi Plütonu	5	**1.48**	**0.05**
Er	Derinoba Plütonu	11	**3.27**	**0.27**
	Kayadibi Plütonu	5	**4.51**	**0.12**
Tm	Derinoba Plütonu	11	**0.49**	**0.03**
	Kayadibi Plütonu	5	**0.67**	**0.04**
Yb	Derinoba Plütonu	11	**3.30**	**0.20**
	Kayadibi Plütonu	5	**4.63**	**0.06**
Lu	Derinoba Plütonu	11	**0.46**	**0.02**
	Kayadibi Plütonu	5	**0.62**	**0.02**
La_{CN}/Lu_{CN}	Derinoba Plütonu	11	**7.53**	**0.48**
	Kayadibi Plütonu	5	**5.17**	**0.79**
La_{CN}/Sm_{CN}	Derinoba Plütonu	11	**3.92**	**0.14**
	Kayadibi Plütonu	5	**3.19**	**0.41**
Gd_{CN}/Lu_{CN}	Derinoba Plütonu	11	**1.26**	**0.09**
	Kayadibi Plütonu	5	**1.52**	**0.08**
La_{CN}/Yb_{CN}	Derinoba Plütonu	11	**7.01**	**0.54**
	Kayadibi Plütonu	5	**4.43**	**0.62**
Tb_{CN}/Yb_{CN}	Derinoba Plütonu	11	**1.24**	**0.08**
	Kayadibi Plütonu	5	**1.20**	**0.02**
Eu_{CN}/Eu^*	Derinoba Plütonu	11	**0.37**	**0.05**
	Kayadibi Plütonu	5	**0.34**	**0.01**
Mg#	Derinoba Plütonu	11	**20.98**	**2.23**

	Kayadibi Plütonu	5	**21.19**	**1.11**
ASI	Derinoba Plütonu	11	**1.18**	**0.03**
	Kayadibi Plütonu	5	**1.06**	**0.03**
K_2O/Na_2O	Derinoba Plütonu	11	**1.21**	**0.05**
	Kayadibi Plütonu	5	**1.26**	**0.04**
Rb/Sr	Derinoba Plütonu	11	**2.97**	**0.35**
	Kayadibi Plütonu	5	**1.42**	**0.28**
Sr/Y	Derinoba Plütonu	11	**1.72**	**0.18**
	Kayadibi Plütonu	5	**2.14**	**0.40**
Nb/Ta	Derinoba Plütonu	11	**12.05**	**1.08**
	Kayadibi Plütonu	5	**13.99**	**1.73**
Zr/Hf	Derinoba Plütonu	11	**31.83**	**2.81**
	Kayadibi Plütonu	5	**27.68**	**0.74**
Th/U	Derinoba Plütonu	11	**4.66**	**0.38**
	Kayadibi Plütonu	5	**7.02**	**1.79**

Mann Whitney U test istatistikleri için ise Asymp. Sig değeri dikkate alınır. Şayet sig. değeri <0.05 ise granitik kayaç için ilgili parametreler açısından %5 önemlilik değerinde farklılığın olduğu ifade edilir. Bu değer %5'ten büyük ise ilgili parametreler için iki kayaç grubu arasında (%95 olasılıkla) anlamlı bir farkın olmadığı belirtiler. Sig. değerinin 0.01 değeri için ise benzer durum bu değerin küçüklüğüne göre %1 önemlilik düzeyinde incelenen kayaç grupları için ilgili parametre bağlamında bir farklılığın olduğu şeklinde yorumlanır. %1-%5 aralığında ise %99 olasılıkla kayaçların ilgili parametreler için benzer kökene sahip olduğu ifade edilir.

Bu açıklamalar ışığında Derinoba ve Kayadibi granitleri değerlendirldiğinde; Y, Th, Yb ve Lu elementlerince granitlerin farklılığa sahip olduğu gözlenmiştir (Sig. <0.01). SiO_2, Gd, Tm, Rb/Sr parametrelerine göre %1 önemlilik değerinde (%99 güven aralığında) Derinoba ve Kayadibi granitlerinin benzer kökene sahip olduğu tespit edilmiştir. Benzer bulgular Er, La_{CN}/Lu_{CN}, La_{CN}/Yb_{CN}, ASI parametreleri için de söz konusu olup, ortak kaynağa işaret etmektedir. Bunun dışındaki incelenen diğer parametreler de %95 güven aralığında Derinoba ve Kayadibi granitleri için ortak kaynağa işaret etmektedir. Dolayısıyla kayaçların kökensel ortaklığı jeoistatistiksel olarak da tespit edilmiş olup, Kaygusuz vd. [28] bulguları jeoistatistiksel olarak da teyid edilmiştir.

Tablo 3. Mann Whitney U Testi test istatistikleri

	Mann-Whitney U	Wilcoxon W	**Asymp. Sig. (2-tailed)**
SiO_2	4.00	19.00	**0.01**
TiO_2	13.50	79.50	**0.11**
Al_2O_3	17.00	83.00	**0.23**
$Fe_2O_3^T$	13.00	79.00	**0.10**
MnO	20.50	86.50	**0.42**
MgO	16.50	82.50	**0.21**
CaO	11.00	77.00	**0.06**
Na_2O	20.50	86.50	**0.43**
K_2O	17.50	83.50	**0.26**
P_2O_5	16.50	82.50	**0.20**
Sr	3.00	69.00	**0.01**
Ta	21.00	36.00	**0.46**
Nb	18.00	33.00	**0.28**
Hf	21.00	87.00	**0.46**
Zr	20.00	86.00	**0.40**
Y	1.00	67.00	**0.00**
Th	1.00	67.00	**0.00**
U	22.50	88.50	**0.57**
Ga	17.00	32.00	**0.23**
La	27.50	42.50	**1.00**
Ce	18.00	84.00	**0.28**
Pr	20.00	86.00	**0.40**
Nd	26.00	92.00	**0.86**
Sm	10.00	76.00	**0.05**
Eu	27.00	93.00	**0.95**

Gd	5.00	71.00	**0.01**
Tb	13.50	79.50	**0.11**
Dy	13.00	79.00	**0.10**
Ho	20.00	86.00	**0.40**
Er	8.00	74.00	**0.03**
Tm	6.00	72.00	**0.01**
Yb	0.00	66.00	**0.00**
Lu	2.00	68.00	**0.00**
La_{CN}/Lu_{CN}	8.00	23.00	**0.03**
La_{CN}/Sm_{CN}	16.00	31.00	**0.19**
Gd_{CN}/Lu_{CN}	11.00	77.00	**0.06**
La_{CN}/Yb_{CN}	9.00	24.00	**0.04**
Tb_{CN}/Yb_{CN}	21.00	36.00	**0.46**
Eu_{CN}/Eu^*	17.50	32.50	**0.25**
Mg#	25.00	40.00	**0.78**
ASI	8.50	23.50	**0.03**
K_2O/Na_2O	22.00	88.00	**0.53**
Rb/Sr	3.00	18.00	**0.01**
Sr/Y	15.00	81.00	**0.16**
Nb/Ta	25.00	91.00	**0.78**
Zr/Hf	25.00	40.00	**0.78**
Th/U	15.00	81.00	**0.16**

V. SONUÇLAR

Bu çalışma kapsamında, Doğu Pontidlerin kuzey zonunda yeralan Derinoba ve Kayadibi granitlerinin (GB Trabzon, Türkiye) belli başlı jeokimyasal parametreleri jeoistatistiksel yaklaşım ve yöntemlerle incelenmiş ve kökensel olarak ilişkisi ortaya konmaya çalışılmıştır. Çalışılan granitler birbirine komşu olup, Derinoba graniti Trabzon'nun 65 km güney batısında yeralmakta, aynı istikamette ve devamında ise Kayadibi granit yüzeylenmektedir. Bu çalışmada granitlerin belli başlı jeokimyasal parametrelerinin tanımlayıcı istatistik parametreleri yardımıyla genel karakterleri ve aralıkları tespit edilmiştir. Akabinde ise Mann Witney U testi ile Derinoba ve Kayadibi granitlerinin kökensel benzerliği istatiksel olarak irdelenmiştir. Yapılan çalışma sonucunda Derinoba ve Kayadibi granitlerinin SiO_2 içeriklerinin >%70, TiO_2 içeriklerinin >%0.1, Al_2O_3 içeriklerinin >%12, $Fe_2O_3^T$ içeriğinin >%1.40, toplam alkali içeriklerinin >%6, olduğu tespit edilmiştir. La_{CN}/Lu_{CN}, La_{CN}/Sm_{CN}, Gd_{CN}/Lu_{CN}, La_{CN}/Yb_{CN}, Eu_{CN}/Eu^*, Mg# ve ASI değerlerinin ise sırasıyla, >5, >3, >1, >4, >1, >0.3, >20 ve >1 olduğu tespit edilmiştir. Derinoba ve Kayadibi granitlerinin kökensel olarak ilişkili olup olmadıkları jeoistatistiksel olarak Mann Whitney U Testi ile irdelendiğinde; Y, Th, Yb ve Lu elementlerince granitlerin aynı kökensel kaynağı sahip olduğu belirlenememiştir. SiO_2, Gd, Tm, Rb/Sr, Er, La_{CN}/Lu_{CN}, La_{CN}/Yb_{CN}, ASI parametreleri açısından aynı kökensel kaynağa sahip olduğu (sig. %1 ve/veya sig. %1 -%5 aralığında), söylenebilir. Derinoba ve Kayadibi kayaçları bunun dışındaki diğer incelenen parametreler açısından ise %95 güven aralığında kayna kökensel kaynağa sahip oldukları tespit edilmiştir. Jeoistatistiksel olarak ulaşılan bu sonuçlar Kaygusuz vd. [28]tarafından ulaşılan sonuçları teyid etmiştir.

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Water quality and organic pollution in Fierza Lake

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Abstract **–** This study shows analytical data regarding the physical-chemical parameters and organic pollutant levels in water samples of Fierza Lake which is the largest artificial lake in Albania. It is formed by the flows of White Drin River (Peja, Kosovo) and Black Drin River (Lake Ohrid, Struga, North Macedonia) which join together near Kuksi city, North-East Albania. This transboundary ecosystem has a large water basin area that lies in Kosovo, North Macedonia and Albania and for that, this waterbody could be affected by the pollution from the human activities. Water samples from Fierza Lake were taken in May 2024 at 10 different stations. The physical-chemical parameters that were determined in the water samples from this station were: temperature, pH, DO, BOD_5, COD, conductivity, turbidity, TDS, TSS, Nutrients (nitrates, nitrites, ammonium ions, N-total, phosphates, P-Total), the main ions (sulfates, chlorides, calcium and magnesium ions). Organochlorine pesticides, PCB, PAH and BTEX were organic pollutants that were also evaluated in this lake. Water quality in Fierza Lake for this study period can be classified from moderately good to good. This fact was supported by presence of organic pollutants almost in all analyzed samples. This could be related with intense human activity in its water basin. Urban pollution, agricultural activity and transport are the main sources that cause the decrease of water quality in this ecosystem. The physical-chemical parameters and organic pollutant should be analyzed continuously from respective institutions in order to have a complete assessment of the environmental problems in the lake.

Keywords – Water quality, Water analyzes, Physical-Chemical parameters, Organic pollutants, Fierza Lake

I. INTRODUCTION

Fierza Lake is the largest artificial lake in our country. It was built to generate electricity. The Fierze Dam on the Drin River has a length of 70 kilometers and a maximum area of 7,000 hectares, of which 5,000 hectares are used for raising and cultivating fish. This lake has a height of 167 meters, a water surface area of 72.5 km², a maximum depth of 128 meters, and a volume of 2.7 billion cubic meters of water. The total area of the watershed is 11,829 km² [1, 2]. Fierza Lake is formed by the River Drin, one of the largest rivers in our country. It is formed near the city of Kukës by the confluence of its two main branches: The White Drin River (*alban*. Drini i Bardh) and the Black Drin River (*alban*. Drini i Zi).

The White Drin River originates near Peja, Kosovo, in Radavc. It crosses the Dukagjin Plain and flows into Fierza Lake. It is 160 km long; however, together with its longest branch, the river reaches a length of

335 km. The Black Drin River originates in Struga, North Macedonia, from the northern part of Lake Ohrid, which is supplied with water from Lake Prespa.

The catchment area of the Drin, including its two main branches, spans several countries (Kosovo, Albania, North Macedonia, and Greece), thereby raising the possibility of pollution in Fierza Lake, which collects water from these rivers [1, 2, 3]. Some of the main sources of pollution in Fierza Lake include spills of liquid/solid urban waste, agriculture, industrial waste, transport, and mechanics. Anthropogenic sources of water pollution are divided into two groups: point and non- point sources.

Point sources include discharges of urban liquid waste (wastewater) and livestock farms, industrial waste discharges, leaching water from solid waste disposal sites, and more. Non-point sources include agricultural land drainage water discharges, polluted rainfall, wastewater pipe leaks, etc. These wastes directly affect the values of pH, nutrients, different ions, and the presence of various organic pollutants, which are reflected in the quality of the waters, making them suitable or unsuitable for the organisms living there. It must be noted that fish is grown in Fierza Lake and consumed by the residents of the area [3-9].

Therefore, the purpose of this research was to evaluate the water pollution of the Fierze lake, whose water is used for drinking but also for fishing. Knowing these data, we can see how endangered the population is from using this water, either for drinking or through food chain.

II. Materials and Method

A. Water sampling in Fierza Lake

Water samples from Fierza Lake were collected in May 2024. At 10 stations, samples with volumes of 2.5 liters were taken in Teflon containers. The sampling was realized according to the ISO 5667- 14:2016 methodology. Transport and storage before analytical analysis in the laboratory were at a temperature of +4°C. Field measurements of various physico-chemical parameters, such as temperature, pH, conductivity, turbidity, TDS, and DO, were measured in the field at each sampling station using a Hanna model portable multimetric device. In the figure 1 are sampling sites for Fierza Lake:

Fig 1. Sampling stations in Fierza Lake.

B. Determination of Physical-Chemical parameters

pH, conductivity, DO (dissolved oxygen), TDS, turbidity and temperature were determined in field (for each station) by using Hanna Multiparameter meter portable equipment (HI98194 Model). VELP brand automatic sensors (respirometers) were used to estimate the 5-day (BOD_5) in water [10]. Pre-prepared SPEC COD digestion tubes with mercury sulfate were used for determination of COD assisted by thermo-reactor ECO 16 and a PF-3 spectrophotometer suitable for COD analysis [10]. The UV-VIS measurements of nutrients (nitrates, nitrites ammonium, N-Total, Phosphates and P-Total) and sulfate ions were carried out in the UV 31 SCAN ONDA model spectrophotometer as follows: The analysis of nitrates (NO_3) in water is based on the ISO 7890-3: 1988; the analysis of nitrites (NO_2) in water is based on the ISO 6777: 1984 method; the analysis of ammonium (NH_4^+) in water is based on the ISO 7150/1:1984 method; N-total was determined using complete disaggregation of the sample. All forms of nitrogen are oxidized and measured as NO_3 (Screening Method). P-total was determined using the disaggregation method, which aims to oxidize all forms of phosphorus into PO_4 ions and further make their determination using the spectrophotometer method at 880 nm. The analysis of sulfates in water is based on method 9038 for the determination of sulfates by the turbidimetry method at a wavelength of 420 nm [2, 6, 10]. Chloride ions were determined in water samples using the argentometric method (4500-Cl^- B, Argentometric Method, known as the Mohr method). The data obtained for chloride ions in water were used to calculate the salinity of the samples. The concentration of calcium and magnesium ions in water was realized by using the titration method with EDTA in the presence of different indicators [6, 10]. Finally, the analysis of TSS was based on their determination by the gravimetric method [10].

C. Determination of organochlorine pollutants in water samples

For the determination of organochlorine pesticides (OCPs) and polychlorbifenils (PCBs) in water samples was used liquid-liquid extraction. After extraction, the organic phase was dried with anhydrous sodium sulphate and a florisil column was used for the sample clean-up procedure. After concentration, the samples were injected in GC/ECD technique. OCPs and PCBs were analyzed simultaneously using Rtx-5 capillary column (30m x 0.25mm x 0.25µm) in a Varian 450 GC gas chromatograph equipped with PTV injector and ECD detector. Helium was used as the carrier gas (1 ml/min) and nitrogen as make-up gas (24 ml/min). Manual injection was done in splitless mode at 300°C. The detected pesticides were: DDT (p,p-DDE, p,p-DDD, p,p-DDT), HCHs (a-, b-, γ- and d-isomers), Heptachlor (Heptachlor and Heptachlorepoxide); Chlordanet (alpha and gamma isomers); Aldrins (Aldrin, Dieldrin, Endrin and their derivatives) and Endosulfans (Endosulfan alfa, Endosulfan beta and Endosulfan sulfate). PCB analysis was

based on the determination of seven markers (PCB IUPAC No. 28, 52, 101, 118, 138, 153 and 180). Quantification of pesticides and PCB was based on the external standard method [4, 16-28].

D. Determination of Polyaromatic hydrocarbures (PAHs) in water samples

Two steps liquid-liquid extraction (LLE) was used for extracting PAHs from water samples. Dichloromethane (first step LLE) and n-hexane (second step LLE) were used as extracting solvents. After extraction, the organic phase was dried with anhydrous sodium sulfate (Na_2SO_4) for water removing. Extracts were concentrated and then were injected in GC/FID apparatus. Gas chromatographic analyzes of PAH in water samples were performed with a Varian 450 GC apparatus equipped with a flame ionization detector and a PTV injector. Capillary column VF-1 ms (30m x 0.33mm x 0.25μm) was used for the separation of 13 PAH according to EPA Method 525. Helium was used as carrier gas at 1ml/min. The FID temperature was maintained at 280°C. Nitrogen was used as carrier gas (24 ml/min). Hydrogen and air were the flame detector gases at 30 ml/min and 300 ml/min, respectively. The EPA 525 standard mixture was used for qualitative and quantitative PAH analysis. Acenaphthylene, Fluorene, Phenanthrene, Anthracene, Pyrene, Benzo [a] anthracene, Chrysene, Perylene, Fluoranthene, Benzo [b] fluoranthene, Indeo [1,2,3-cd] pyrene, Dibenzo [a, b] anthracene and Benzo [g, h, i] perylene were determined in water samples. PAH quantification is based on the external standard method [15-32].

E. Determination of BTEX by using HS-SPME Method

Determination of benzene, toluene, ethylbenzene and xylene (BTEX) in water samples was realized using solid phase micro-extraction in static head space mode (HS/SPME) followed by GC/FID technique. 5 ml of water (2 g of sediment) sample was put in a 10 ml head space vial. 100 um PDMS fiber was used to extract BTEX from water samples. Adsorption process was realized in 50^{o}C (using a water bath) for 45 minutes. Desorption process (30 seconds in 280^{o}C) was realized in a PTV injector (HS mode was selected) of a Varian 450 GC instrument. VF-1 ms capillary column (30 m x 0.33 mm x 0.25 μm) was used for separation of Benzene, Toluene, Ethyl benzene and Xylene isomers. Helium was used as carrier gas with 1 ml/min. FID temperature was held at 280°C. Nitrogen was used as the make-up gas (25 ml/min). BTEX Mixture was used for their qualitative and quantitative analyse based on external standard method [4, 28].

III. RESULTS

In this study, water samples from Fierza Lake were analyzed at 10 different stations in May 2024. These samples were used to analyze the physico-chemical parameters important for assessing the water quality of this significant ecosystem, which collects the waters of the White Drin and Black Drin rivers. These rivers have a wide catchment area spread over several states. The physico- chemical parameters determined in the water samples were: temperature, pH, DO, BOD_5, COD, conductivity, turbidity, TDS, TSS, NO_3^-, NO_2^-, NH_4^+, N-total, orthophosphates, P-Total, sulfates, chlorides, calcium, and magnesium ions.nTemperature, pH, conductivity, turbidity, TDS, and DO were determined directly in the water for each station using a

Hanna model portable multimetric apparatus, while other parameters were determined in the laboratory. BOD was determined with automatic sensors. Standard tubes pre- prepared with mercury sulfate and a spectrophotometer PF-3 with suitable wavelengths for COD analysis were used to determine the chemical oxygen demand. The UV 31 SCAN ONDA device was used for measurements of nutrients and sulfates. Cl^-, Ca^{2+}, and Mg^{2+} ions were determined by the titration method. The analysis of TSS was based on their determination by the gravimetric method. The measurements were carried out after the calibration of the equipment and the evaluation of the methods used in these analyses, as recommended by national and international norms [10-17]. The average measurement data for the 10 stations of Fierza Lake are shown in Table 1.

Table 1. Statistical data for physico-chemical parameters from Fierza Lake

Physical-Chemical parameters	Mean	Min	Max	Median	STDEV
PH	7.85	7.45	8.24	7.74	0.24
Temperature (oC)	24.25	22.86	24.90	11.57	0.63
DO (mg/l)	8.47	7.25	1036	8.51	0.74
BOD 5 (mg/l)	42.31	26.38	71.20	44.36	7.25
COD (mg/l)	72.13	48.61	110.34	71.35	8.21
Conductivity (us/cm)	539.27	486.32	695.74	540.32	18.36
Turbidity (FNU)	27.36	18.27	55.26	28.51	5.39
TDS (mg/l)	189.36	152.24	240.38	192.34	11.35
TSS (mg/l)	21.25	11.24	42.31	22.04	4.21
NO3 (mg/l)	8.20	3.28	16.35	8.52	2.39
NO2 (mg/l)	0.02	0.00	0.05	0.02	0.01
NH4 (mg/l)	0.05	0.00	0.11	0.05	0.02
N-total (mg/l)	3.14	0.85	5.32	3.36	0.74
PO4 (mg/l)	1.15	0.54	2.65	1.20	0.42
P-total (mg/l)	0.62	0.38	0.91	0.64	0.22
SO4 (mg/l)	26.38	15.36	53.65	27.15	7.22
Cl- (mg/l)	28.53	18.24	41.28	29.33	2.15
Ca+2 (mg/l)	74.26	44.28	116.32	75.11	8.26
Mg+2 (mg/l)	24.18	22.35	28.10	25.17	3.28

The analysis of organic compounds was based on the determination of 21 chlorogenic pesticides and their degradation products according to EPA 8081B, 7 marker PCBs, 13 PAHs according to EPA 525 Method, and BTEX. The analysis of these micropollutants in the water samples was carried out using the gas chromatography technique. The ECD detector was used for qualitative/quantitative analysis of organochlorinated pollutants (OCPs and PCBs), while the FID detector was used for the identification of PAHs and BTEX. Liquid-liquid extraction was used for the isolation of OCPs, PCBs, and PAHs from water samples, while the HS-SPME technique was used for volatile compounds (BTEX). The summarized data for the classes of pesticides, tracer PCBs, PAHs, and BTEXs are given in Table 2.

Table 2. Statistical data for organic pollutants in Fierza Lake

Organic pollutants	Mean	Min	Max	Median	STDEV
∑HCHs	0.19	0.00	0.58	0.13	0.22
∑Heptachlors	0.20	0.01	0.46	0.16	0.16
∑Chlordanes	0.21	0.01	0.61	0.16	0.22
∑Aldrines	0.39	0.02	1.21	0.23	0.43
∑DDTs	0.25	0.01	0.97	0.14	0.33
∑Endosulfanes	0.37	0.00	1.78	0.12	0.56
∑OCPs	1.55	0.05	5.45	0.90	1.86
∑PCBs	1.93	0.21	7.55	0.74	2.65
∑PAHs	0.67	0.00	4.39	0.11	1.40
∑BTEX	0.36	0.01	1.14	0.27	0.39

IV. DISCUSSION

In this study, the highest physico-chemical parameters for the water ecosystem of Fierza Lake were analyzed. From the data obtained, we see that the highest temperature of the lake water at the time of collection was about 24.3°C, which is normal for the month of May. The average value for pH of water samples was 7.9. This value may result from the discharge of urban waters along the entire length of the White Drin and Black Drin rivers. The average value for dissolved oxygen in the lake water was 8.5 mg/l, which is higher than the norm (> 5 mg/l), classifying its water as suitable for aquatic life. The BOD measured over five days had an average value of 42.3 mg/l, classifying the waters of Fierza Lake as moderately polluted. The average chemical oxygen demand (COD) value was 72.1 mg/l, indicating the presence of chemicals in the lake water from urban discharges, agriculture, mechanics, industry, transport, mining, etc. This COD value classifies the lake water as moderately good, supported by the conductivity value of 539.3 µS/cm. The average turbidity was 27.4 FNU, with a large fluctuation (18.3 - 55.3 FNU) depending on the stations where the measurements were taken, particularly differing between the area where the waters of the Drin River flow and the dam. The average TSS value was 21.3 mg/l, with significant differences across different stations. This value classifies the water as good.

The average concentration of NO_3 in water was 7.67 mg/l, a high value compared to previous studies (1, 2, 3, 4), classifying the water as moderately good. The large amounts of nitrates can be a consequence of urban discharge waters and agricultural fertilizer use. The average nitrite concentration in the water was 0.02 mg/l, with a maximum value of 0.03 mg/l. The average NH_4^+ concentration was 0.05 mg/l, while the total nitrogen (N) had an average value of 3.1 mg/l, likely influenced by urban discharge waters and agriculture. The average PO_4^{3-} concentration was 1.2 mg/l, and the average total phosphorus (P) was 0.6 mg/l, both higher than previous studies for surface waters in Albania (1, 3, 4, 5). These nutrient values classify the water of Fierza Lake as moderately good. The average sulfate concentration was 26.4 mg/l, related to natural urban pollution and anthropogenic influences in the catchment area. The average chloride concentration was 36.17 mg/l, a high value for surface waters due to urban spills (hygiene and water chlorination products). The presence of calcium (74.3 mg/l) and magnesium (24.2 mg/l) ions is related to the natural background and geological areas not only of the lake but also of the rivers and effluents supplying it.

Organochlorine pesticides (OCPs) were detected in almost all water samples from Fierza Lake. The total concentration of OCPs ranged from 0.005 μg/l (Fierza dam) to 5.45 μg/l (Kuksi 2 station), possibly due to previous use and new arrivals by the White Drin and Black Drin rivers. The average level was 1.55 μg/l. The wide catchment area of the two main rivers supplying Fierza Lake, which includes many agricultural areas, contributes to the presence of pesticides in the water samples. Soil leaching and the high stability of these substances also influence their presence. The pesticide profile in Fierza Lake was as follows: Aldrines > Endosulfanes > DDTs > Chlordanes > Heptachlors > HCHs. The distribution of average values of organochlorine pesticides was as follows: Total HCHs (α-, β-, γ-, and δ-isomers of Hexachlorocyclohexane) ranged from 0 - 0.4 μg/l, with an average of 0.2 μg/l; Heptachlors (Heptachlor and Heptachlorepoxide) ranged from 0.01 μg/l to 0.46 μg/l (average 0.2 μg/l); Chlordanes (alpha and gamma-Chlordanes) ranged from 0.01 μg/l to 0.6 μg/l (average 0.2 μg/l); Aldrins (Aldrin, Dieldrin, Endrin, Endrin aldehyde, and Endrin ketone) ranged from 0.02 μg/l to 1.2 μg/l (average 0.4 μg/l); DDT-related chemicals (o,p- DDE, p,p-DDE, p,p-DDD, p,p-DDT) ranged from 0.01 μg/l to 1.0 μg/l (average 0.3 μg/l); and Endosulfanes (Endosulfan alpha, Endosulfan beta, and Endosulfan sulfate) ranged from N.D. (not detected) to 1.8 μg/l (average 0.4 μg/l). Degradation products of active substances used as pesticides were found in most samples, likely due to their previous uses.

PCB markers were detected in all analyzed samples from Fierza Lake, with total concentrations ranging from 0.2 μg/l to 7.6 μg/l (average 1.9 μg/l). Their presence may be related to mechanical activity and repair of turbines used for electricity production, atmospheric deposition, and new arrivals from rivers and/or effluents. The presence of volatile PCBs supports this fact. Oil discharges from some mechanical businesses in the Kuksi area could be terrestrial sources of PCBs in water samples. Heavy PCBs were also found in

some stations of Fierza Lake. PAHs were detected in 60% of the water samples analyzed, with an average value for 13 PAHs according to the EPA 525 Method of 0.7 μg/l, ranging from N.D. to 4.4 μg/l. BTEX average levels were 0.4 μg/l, with a range from 0.01 μg/l to 1.1 μg/l. The main reasons for the presence of hydrocarbons could be mechanical businesses near Kuksi and other areas within the water basin of Fierza Lake, motorist transport, possible hydrocarbon accidents, and massive fires near these areas. The presence of PAHs was a combination of non-pyrogenic PAHs (gas station discharges/accidents, hydrocarbon spillage, mechanical activities, etc.) and pyrogenic PAHs (forest and urban waste burning, transport emissions, industrial activities, etc.). Benzene and toluene were found in higher concentrations than other derivatives, supporting this fact.

V. CONCLUSION

The aim of the study was to evaluate the physico-chemical parameters and the presence of organic pollutants in the water samples from Fierza Lake. This important water ecosystem gathers the waters of the White Dri and Black Drin rivers, with water basins spread over several Balkan states. This wide spread and other effluents are the main reasons for the pollution of the waters of this lake. From the analysis of these parameters, we can conclude that the water in this area has a slightly basic pH due to urban water discharge at various points in the area. The average values for DO, BOD_5, and COD indicate that the lake water is suitable for the growth of organisms in this area. The high value for COD is mainly related to the presence of chemicals from urban discharge water, agriculture, and mining. The levels found for nutrients (NO_3, N-total, PO_4, and P-total) were higher than in previous reports for this area. Urban discharge wastwater and agriculture are the main factors influencing these levels. Interestingly, nitrite and ammonium ions were not detected in most of the analyzed stations. The presence of sulfates is mainly related to urban pollution and mining spills. Concentrations of ions (Cl^-, Ca^{2+}, and Mg^{2+}) can also be related to the natural background and geology of the lake area and the riverbeds that supply it with water. The levels found in the water of Fierza Lake classify these waters as moderately good. Pesticides, PCBs, and PAHs were detected in water samples from Fierza Lake. Their presence could be due to ship/motorist transport, elevated activity near port areas, new arrivals from rivers, water currents, point sources, accidents, etc. Pesticide degradation products were found in high concentrations because of their previous use. The presence of PCBs and PAHs can be related to transport, industrial/mechanical activity, atmospheric deposition, and water currents. Analyses of the physico-chemical parameters in the water of the lake and not only (this should also be extended to rivers and its effluents) should be periodically conducted by the laboratories of the responsible institutions because there are tendencies to damage the quality of these waters mainly from anthropogenic activity. Continuous analysis of organic pollutants is recommended using GC/MS/MS and LC/MS/MS technique.

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Evaluation of Erosion Resistance of Fine-Grained Soils in The Context of Clay Factor Affecting Cohesion Intercept

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Abstract – One of the factors that causes embankment dams to fail is internal erosion. Internal erosion transports soil particles through seepage and pressurized pipe flow. Forms of internal erosion are seen in cohesive and non-cohesive soils. While Backward Erosion (piping) and Suffusion/Suffosion are seen in cohesionless soils, Concentrated Leak Erosion (CLE) and Contact Erosion occur in cohesive soils. Concentrated Leak Erosion is the transportation of particles with pressurized pipe flow in cracks and gaps. The erosion rate and critical shear stresses determine the resistance of fine-grained soils to Concentrated Leak Erosion. Some geotechnical properties of soils also determine this erosion resistance. In this study, Based on the results obtained from past research, the effect of molecular attraction forces, one of the components of the cohesion intercept value, on the erosion resistance of fine-grained soils is evaluated and discussed while taking into account the clay factor that affects the erosion resistance and cohesion intercept value. As a result, it has been determined that the clay ratio and mineralogy affect the cohesion intercept value in non-dispersive soils, and as the cohesion intercept value increases, the erosion resistance of fine-grained soils increases.

Keywords – Cohesion intercept, Cohesive soil, Concentrated leak erosion, Embankment dam, Internal erosion

I. INTRODUCTION

The increase in the world's population and people's efforts to sustain their economic gains have greatly increased the number of dams built in recent years. Again, with the increase in the world population, urban areas have expanded and increased. With the rise in the number of dams and residential areas, many metropolitan areas and economic activity areas have remained in the downstream region of these dams. One of the disasters that will threaten the downstream regions, where residential areas and financial activities are located, will undoubtedly be the collapse of these dams. The erosion resistance of fine-grained soils used due to their impermeability properties in water-retaining structures such as embankment dams is an important factor in ensuring the safety of these structures.

Failure in dams is defined by ICOLD [1] as the inability to retain water in the reservoir due to the collapse of dam structures or deterioration of their stability. 78% of the total dams in the world are embankment dams [2]. The causes of failure of embankment dams were listed as overtopping, internal erosion (piping), and sliding. It was revealed that 46.1% of embankment dams collapsed due to internal erosion [3]. As seen in many cases in the past, the loss of life and property due to the collapse of embankment dams and the wasted investments have revealed that the issues related to the safety of these dams need to be investigated. One of these safety points is that embankment dams are exposed to the danger

of internal erosion. Internal erosion is not a cause of collapse that can be analyzed entirely with numerical formulas or models. It is necessary to have sufficient data about the dam and to know the erosion resistance of the soil to be eroded [4].

The most effective factors that cause embankment dams to collapse are overtopping and internal erosion. Surface erosion occurs on upstream and downstream slopes of embankment dams due to overtopping and slope protection defects. If the upstream slopes are not protected with a suitable covering material such as riprap, collapse may occur due to overtopping along with the scours. Erosion develops when the shear stresses created by the overhead flow exceed the critical shear stresses that enable the transport of the embankment material, and the breach, which initially forms a V (triangle), takes the shape of an inverted trapezoid over time [5]. Water leaks occurring in the fill and foundation cause internal erosion. CLE, one of the internal erosion modes, occurs in fine-grained plastic soils containing clay. CLE is defined by USACE (US Army Corps of Engineers) as the erosion of soils due to transverse cracks in embankment dams and gaps formed along conduits and spillways [4].

Different test equipment was used to investigate fine-grained soils' resistance against surface and internal erosion. In this paper, evaluations will be made on the fact that cohesion intercept is a basic factor affecting the erosion resistance of fine-grained soils, considering the clay factor that affects cohesion intercept and erosion resistance in previous studies.

II. CONTROL PARAMETERS OF CONCENTRATED LEAK EROSION

Internal erosion is the movement of soils in the filling and foundations of embankment dams by seepage and pressurized pipe flow. Internal erosion manifests itself as water leakage in structures that store water. The statistics regarding dam failures show no uniform internal erosion mechanism in embankment dams. In addition, the concept of piping, which is one of the types of internal erosion, was used instead of internal erosion in the statistics given. ICOLD (The International Commission on Large Dams) and USACE stated that internal erosion occurs in five modes: backward erosion (piping), concentrated leak erosion (CLE), global backward erosion, contact erosion, and suffusion [4]. CLE and backward erosion (piping) modes are confused [6]. In both of them, a pipe-like channel is formed due to erosion. However, this channel expands due to soil erosion in the existing crack due to the effect of pressurized flow in CLE. In backward erosion, this channel develops and grows due to the material carried downstream to upstream under the seepage's influence. While CLE occurs in cohesive soils, Backward erosion, on the contrary, develops in cohesionless soils.

Factors affecting the formation of CLE can be examined under three main headings: material properties, hydraulic factors, and crack/gap properties. Material and crack properties are the factors that determine the potential for CLE to occur. Hydraulic factors like hydraulic gradient must be large enough for this potential to turn into CLE. Material properties are parameters that affect the erosion resistance of fine-grained soils. One of these material properties is clay ratio and mineralogy. Transverse cracks extending in the upstream-downstream direction must occur for CLE. Differential settlements, longitudinal arching, insufficient compression and lack of kneading between layers, drying cracks, local compressions, slides, and tectonic movements affect the formation of transverse cracks [7]. In addition, CLE can also be observed due to the erosion of the core material in the gaps formed on the surfaces where the filling materials come into contact with the spillway wall and conduit pipe [8]. CLE can also be seen as a result of hydraulic fracturing [9]. With these cracks, CLE can also occur due to gaps created by tree roots and burrows created by animals [10].

The geometric parameters that control the initiation and progression of CLE determine the magnitude of the hydraulic gradient and shear stresses. For CLE caused by pressurized flow to occur, a closed

environment, such as cracks and voids, is required. As the shear stresses due to flow on the walls of these cracks or gaps increase, the amount of material carried by erosion also increases. The reservoir water height above the crack/gap where the pressurized flow occurs, and the width of the crack affect these shear stresses. According to the basic principles in pipe hydraulics, shear stresses increase as the reservoir water height above the crack/gap increases and the width of the crack decreases. As the crack/gap length increases, the hydraulic gradient decreases, and the amount of material carried by erosion decreases.

III. COHESION INTERCEPT IN SOILS

Soils are divided into two cohesive and non-cohesive soils in soil mechanics. If the particles are connected and adhered to each other, it is defined as cohesive soil; if not, it is cohesionless soil. Cohesionless soils are granular soils. They are soils with a high sand and gravel ratio. Cohesive soils are fine-grained soils. They are soils with high clay and silt content and show plastic deformation behavior. The "cohesion" mentioned here is the soil particles influenced by molecular attraction forces.

The shear strength (τ) of soils is generally determined by the internal friction angle (φ) and cohesion intercept (c) components, as shown in equation (1), according to the Coulomb failure theory.

$$\tau = c + \sigma.\tan(\varphi) \quad (1)$$

The angle of internal friction depends on the normal stresses (σ) applied to the soil. It is caused by the interaction of soil particles with each other (friction, locking, etc.).Cohesion intercept, unlike the cohesion described above, is a mathematical parameter. It is independent of the normal stresses applied to the soils. When σ = 0, the shear strength of the soil is equal to the cohesion intercept.

Cohesion intercept includes intermolecular forces of attraction (true cohesion), capillary forces, and cementation [11]. Intermolecular forces of attraction consist of van der Waals and electrostatic attraction forces, primary valence bonding, ionic lattice attraction, and cation linkage. Negative pore water pressure is effective in the formation of capillary forces in partially saturated soils. Suction pressures developing due to negative pore water pressures are another component that provides the shear strength of soils without affecting stress and is also defined as "apparent cohesion". When soils are completely saturated with water, apparent cohesion becomes zero. Carbonates, aluminates, silicates, iron oxide, and organic substances carry out cementation by causing the particles to bond chemically in fine-grained soils [12].

IV. DETERMINATION OF EROSION RESISTANCE OF FINE-GRAİNED SOILS

In order to evaluate the effect of cohesion intercept on the erosion resistance of fine-grained soils in the context of clay factor, the results obtained from erosion tests performed in the past using different test equipment and materials were considered. Erosion resistance of fine-grained soils is measured by the "critical shear stress", which includes the flow velocity at which erosion begins, and the "erosion rate", which shows the amount of material transported over time. As critical shear stresses increase and/or erosion rate decreases, erosion resistance of fine-grained soils increases. Critical shear stress and erosion rate can be determined by surface erosion and internal erosion tests. Surface erosion tests include laboratory flume erosion tests [13], rotating cylindrical erosion tests [14], and jet erosion tests [15]. Internal erosion tests include the hole erosion test [16], slot erosion test [17], and pinhole test [18]. The pinhole test is insufficient to determine fine-grained soils' critical shear stresses [19]. With the test equipment developed by Topçu and Tosun [20], critical shear stresses of dispersive soils can be compared qualitatively, while erosion rates can be determined quantitatively. Based on the internal erosion problems experienced in embankment dams, Sherard [21] determined the erosion resistance of non-dispersive soils. He categorized well-compacted cohesive soils with a plasticity index greater than 15 as having the highest erosion resistance. However, uniform fine sands with a plasticity index of less than 6 will have the lowest erosion resistance. According to the ICOLD [22], the erosion resistance of soils classified as dispersive soil based on a pinhole

test and silty sands with a fine content greater than 30% is very low. On the contrary, high plasticity clays with a liquid limit (LL) value greater than 65 have very high erosion resistance.

V. EFFECT OF CLAY RATIO AND MINERALOGY ON EROSION RESISTANCE

It is known that the cohesion intercept value in fine-grained soils can be measured with the help of triaxial and shear box tests. The findings of the internal and surface erosion tests were compared and evaluated, with the tests determining the shear strength and considering the clay ratio and mineralogy that affect the molecular attraction forces, one of the components of the cohesion intercept value.

One of the most important parameters affecting the behavior of fine-grained soils is the clay mineralogy and ratio that the soils contain. Warkentin and Yong [23] performed a shear box test on fully saturated, disturbed, fine-grained soil consisting entirely of clay. The strength component determined from shear strength tests performed on fine-grained soils consisting entirely of clay and fully saturated with water is true cohesion. It is only under the influence of molecular attraction forces. In such soils, cementation and capillary forces, components of cohesion intercept, are not observed due to disturbance and are fully saturated. In soils with the same NaCl concentration in the pore fluid, the strength value of Montmorillonite clay soil, when the void ratio (n) is approximately eight, is the same as the strength value of kaolinite clay soil when n = 2.2. It is seen that the strength value decreases as the void ratio increases. Accordingly, the montmorillonite clay soil's strength was higher than the kaolinite clay soil at the same void ratios (Fig. 1).

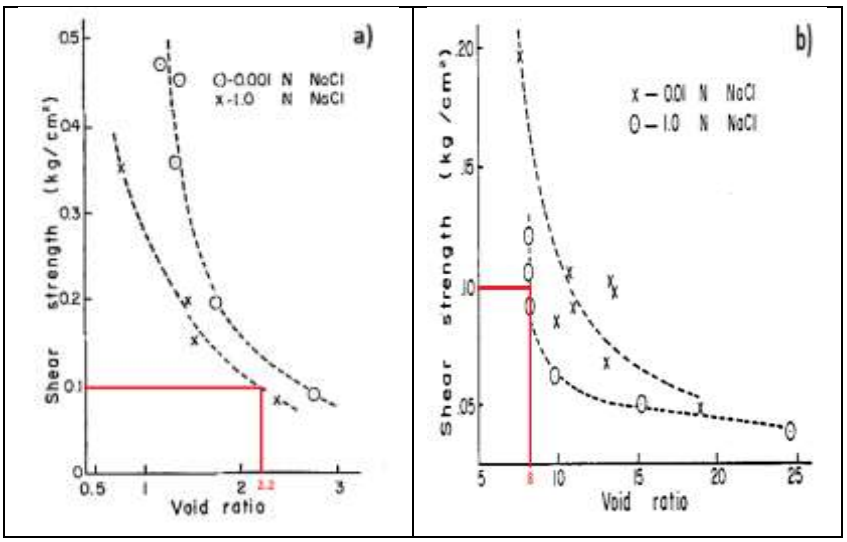

Fig. 1 Shear strength of entirely of clay soils a) Kaolinite b) Montmorillonite

Arulanandan and Perry [24] showed that the critical shear stresses of soils containing montmorillonite are greater than kaolinite soils, based on the dielectric dispersion index in their rotating cylindrical and flume test on fully saturated fine-grained soils (Fig. 2). As the dielectric dispersion index increases, critical shear stresses increase. Especially in conditions where physical testing is not possible, the erosion resistance of soils can be evaluated with this index value, which reflects the electrical properties of the pore fluid of soil.

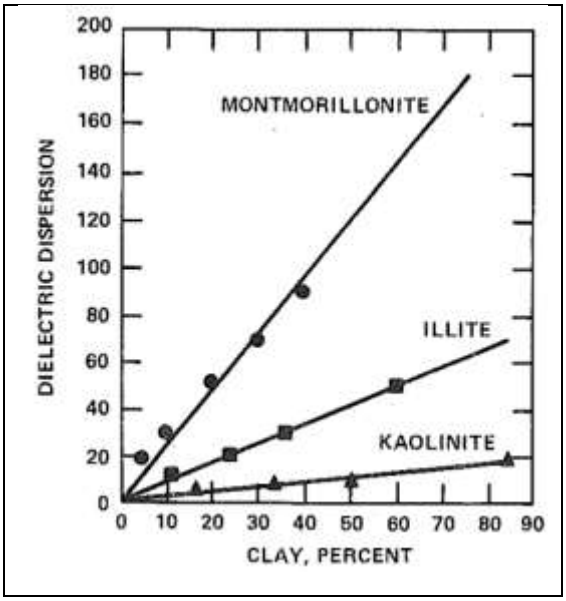

Fig. 2 Effect of clay mineralogy on dielectric dispersion

Djarwadi et al. [25] determined that the cohesion intercept value increased as the clay ratio increased in the undrained, unconsolidated (UU) triaxial test performed on fine-grained soils with different clay ratios that were partially saturated. However, in hole erosion tests conducted on unsaturated fine-grained soils, critical shear stresses increase as the clay ratio increases [26], as shown in Fig. 3.

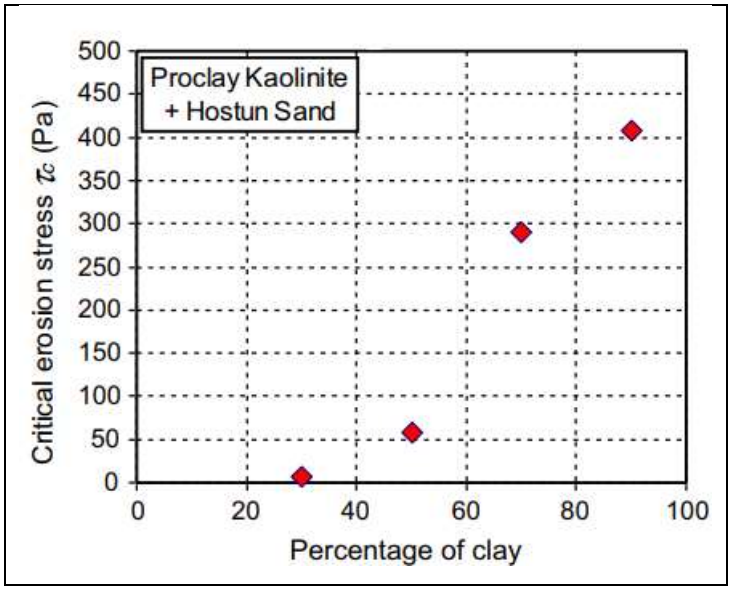

Fig. 3 Effect of clay ratio on critical shear stresses

VI. CONCLUSION

Based on the results obtained from previous studies, the effect of molecular attraction forces, one of the components of the cohesion intercept value in non-dispersive soils, on the erosion resistance of fine-grained soils is evaluated and discussed, taking into account the clay factor. Accordingly, the cohesion intercept value of montmorillonite clays is greater than that of kaolinite clays under the same conditions. At the same time, the erosion resistance of montmorillonite clays is higher than that of kaolinite clays. Likewise, cohesion intercept value and erosion resistance increase as the clay ratio increases. As a result, the erosion resistance of fine-grained soils increases as the cohesion intercept value increases in the context of clay factor (clay ratio and mineralogy) in non-dispersive soils.

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Role of 24-EBL on Pollen Germination and Pollen Tube Growth in Blackberries

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Abstract – Fertilization biology is one of the most essential factors used to select potential genotypes and varieties. Plant sexual reproduction relies heavily on pollen germination and pollen tube growth. It has been observed that the coordinated action of hormones secreted in the ovary during pollination or fertilization controls fruit set and development. A healthy pollen is used for pollen germination in vitro and in vivo because it has the same nutritional storage and composition as a seed. Nevertheless, the nutrients in pollen are usually inadequate for pollen tubes to reach the seed drafts. As a result, the use of nutrients in the stigma helps to promote the formation of pollen tubes after a certain stage. Pollens from six wild-grown blackberry plants in Atabey/Isparta were used in this study, Turkey, to investigate pollen germination and pollen tube length in several bioregulators. Considering our prior findings, the control germination medium for the study was adopted consisted of 0.5% agar agar + 15% sucrose + 5 ppm boric acid. Brassinolide (24-epibrassinolide-24-EBL) (0.1 ppm, 0.01 ppm and 0.001ppm) was added to the control medium and incubated at 20^0C. The development of pollen germinaion tubes was examined using an ocular micrometer 24 hours after germination. The statistical analyses were carried out using SPSS 22.0. Adding 0.1 ppm 24-EBL to the media resulted in the greatest pollen germination rate and longest pollen tube length across all genotypes (N6 pollen germination rate: 78.65%; tube growth: 185.34 µm). As a consequence, 0.1 ppm 24-EBL is an appropriate dosage for promising genotype N6 and other genotypes.

Keywords – Brassinolide, Rubus canescens, bioregulators, fertilization biology, berries

I. INTRODUCTION

Turkey is positioned at the junction of three phytogeography areas. Turkey's flora contains 11,466 plant species, while Europe as a whole has over 12,000 species. The Rosaceae family includes thorny and trailing plants that are seldom green and can be shrub or tree. This family includes 115 genera and around 3200 species worldwide. Turkey has 35 genera and 318 species belonging to the Rosaceae family.

Blackberry bushes feature long, thorny canes that arch and trail across the ground. Some cultivars have been created withless thorniness to make harvesting simpler.

The blackberry plant's blossoms produce blackberries. As the fruit ripens, it converts from green to crimson, deep purple, and black. Blackberry harvest season varies by area, but normally occurs from May to August, depending on climate [1]

Flowering branches are erect, 15-40 cm long, angled, pubescent to slightly tomentose, and armed like turions. Sepals are ovate to oblong, acute, hairy, and tomentose. They reflex after blooming. Petals are white (drying pale yellowish), obovate-oblong (occasionally wider), and measure 5-8 (-10 mm). Fruits are around 1 cm in size and a red-purple tint. drupelets are black, tiny, and glabrous [2]. It's a plant that is half light and half dark. It is resistant to both cold and heat. It prefers wetness but may also thrive in arid environments. The fruit juice can be used as a mouthwash to treat tonsil irritation [3]. Plants' fertilization

success depends on progamic processes [5;6]. Fruit tree fertilization success relies heavily on pollen germination and tube development [7]. Pollen ingredients contained in pollen tubes are often insufficient to reach the seeds. As a result, pollen tubes go from one stage to the next, with future growth occurring in the stigma as nutrients are used. These compounds contain sucrose. Pollen germination and tube development are valuable study materials for several disciplines, including morphology, physiology, biotechnology, ecology, evolution, biochemistry, systematics, and molecular biology. Boron, calcium, potassium, and particular mineral components like magnesium are essential for pollen germination and tube growth. Boron, an inorganic substance, plays an important role in pollen germination and tube growth in the form of boric acid and borate. The first plant growth regulator found in steroid structure was isolated from brassinosteroid rapeseed pollen (*Brassica napus* L.) shown to be effective at extremely low concentrations, may be used safely on plants and may have promising future results [8]. 24-epibrassinolide (EBL) is a molecule created during BL biosynthesis that promotes plant metabolism, including carbon absorption, nucleic acid biosynthesis, ROS metabolism, and light harvesting. In plants, EBL promotes enzyme activity during photosynthesis [9]. Brassinolide and 24-epibrassinolide (24-EBL) are the most stable and bioactive among the 60 discovered brassinosteroids. On the steroidal side, all BRs have a 22R and 23R-diol structure. Compounds with 22R and 23R-hydroxyls are much more active than synthetic counterparts with 22S and 23S-hydroxyls. However, in the original 22R and 23R configurations Brassinolide promotes plant cell elongation, vascular bundle development, photomorphogenesis, fruit quality, and gene expression [10].

In this research, we attempted to investigate the effect of various dosages of Brassinolide (24-epibrassinolide-24-EBL) on *in vitro* pollen germination studies in blackberries.

II. Materials and Method

Pollen was collected from the blooms of six wild blackberries plants (N1, N2, N3, N4, N5, and N6) during the balloon stage. The 50 flowers on the balloon stage were picked. The flowers were immediately sent to the laboratory. Anthers were eliminated. Store in a dark-colored container to aid in dehiscence at ambient temperature [11].

For germination tests, the "agar in plate" method [12]. was used, Control germination medium and optimal germination temperatures recorded previously were provided for the same genetypes. which contained 0.5% agar agar + 15% sucrose + 5 ppm boric acid and added Brassinolide (24-epibrassinolide-24-EBL) (0.1 ppm, 0.01 ppm, and 0.001 ppm) to the control medium and incubated at 20^0 C [13]. Tree different concentrations of 24-EBL were tested in the germination medium for the *in vitro* germination test.

I. Control: 0.5% agar agar + 15% sucrose + 5 ppm H_3BO_3 (Boric Acid)
II. 0.5% agar agar + 15% sucrose + 5 ppm H_3BO_3+**0.1 ppm 24-EBL**
III. 0.5% agar agar + 15% sucrose + 5 ppm H_3BO_3+ **0.01ppm 24-EBL**
IV. 0.5% agar agar + 15% sucrose + 5 ppm H_3BO_3+**0.001ppm 24-EBL**

Pollen tubes were classified as "germinated" if they were at least twice as long as broad [14]. The length of the pollen tube was measured using an ocular micrometer under a 40X light microscope. Four Petri plates were utilized for the germination and polen tube studies. Four independent microscope fields, each with 100-150 pollen grains, were counted on a separate petri plate. SPSS 22.0 was used for the statistical analysis, with a significance level of 0.05. Duncan's multiple range test was used to analyze the mean ranges.

III. RESULTS

Our investigation demonstrated that varied dosages of 24-EBL, a brassinosteroid from the new generation hormone group, had statistically significant impacts on pollen germination and tube development ($p<0.05$).When the average application dosages were examined, the medium that boosted pollen germination the most compared to the control group and obtained the greatest germination rate was

the medium with 0.1 ppm 24-EBL (45.60%). All 24-EBL dosages enhanced pollen germination rates relative to the control group for all genotypes. Although 0.01 and 0.001 ppm dosages of 24-EBL boosted pollen germination more than the control group, they were statistically comparable (35.64% and 34.49%) respectively. Once the genotypes were examined for pollen germination rate, the N6 genotype had the highest rate at 58.89%. This was followed by N5 (44.77%) and N1 (51.73%).

Table 1. Effects of different doses of 24-EBL *in vitro* pollen germination of six blacberry genotypes (%)

	Control	**0.1ppm 24-EBL**	**0.01ppm 24-EBL**	**0.001ppm 24-EBL**	**Mean**
N1	45.17	62.51	51.00	48.27	**51.73b^{y}**
N2	11.74	29.86	24.16	24.03	**22.44d**
N3	10.03	24.12	20.78	21.36	**19.07de**
N4	14.20	20.32	17.35	18.67	**17.63de**
N5	30.94	58.19	44.60	45.38	**44.77c**
N6	51.73	78.65	55.97	49.23	**58.89a**
Mean	**27.30c^{x}**	**45.60a**	**35.64b**	**34.49b**	

^{x,y}The difference between values shown in different letters in the same row and column is statistically significant ($p<0.05$)

Table 2 shows pollen tube lengths determined using an ocular micrometer 24 hours after pollen sowing. The longest pollen tubes (147.26 µm) were measured in the germination media supplemented with 0.1 ppm 24-EBL, similar to pollen germination rates. The control condition produced the shortest pollen tube, measuring 122.30 µm. The N6 genotype had the longest pollen tube length (171.26 µm) among the assessed genotypes. The N4 genotype's pollen tube length was measured to be 150.63 µm, whereas the N5 genotype's was 141.09 µm. The N3 genotype had the shortest pollen tubes, measuring 101.22 µm.

Table 2. Effects of different doses of 24-EBL *in vitro* pollen tube growth of six blacberry genotypes (µm)

	Control	**0.1ppm 24-EBL**	**0.01ppm 24-EBL**	**0.001ppm 24-EBL**	**Mean**
N1	96.87	113.28	99.71	100.61	**102.61e^{y}**
N2	105.36	124.39	108.31	108.62	**111.67d**
N3	93.58	121.20	96.01	94.12	**101.22e**
N4	140.20	177.69	143.63	141.02	**150.63b**
N5	133.27	161.68	135.52	133.91	**141.09c**
N6	164.56	185.34	166.92	168.22	**171.26a**
Mean	**122.30cd^{x}**	**147.26a**	**125.01b**	**124.41b**	

^{x,y}The difference between values shown in different letters in the same row and column is statistically significant ($p<0.05$)

III. DISCUSSION

Pollen tubes play a crucial part in fertilization and have been used to research the biology and biochemistry of polarity and tip development. This has helped identify key actors in the cell polarity machinery. Inorganic ions and proteins are two examples of factors that are known to influence pollen tube development or directionality. Brassinosteroids (BRs) promote cell elongation, and some BR synthesis or perception mutants have severe dwarf phenotypes[15]. BR signaling affects the development and establishment of reproductive organs, among other physiological responses.. BRs increase the quantity of ovule primordia in female plants, leading to more seeds. The pollen particles contain a large amount of vitamins,hormones, and amino acids as well. They rarely require an external source of such substances for germination and tube growth.

Several studies have shown that auxins, gibberellins, and cytokinins enhance germination and tube development. These hormonal substances strongly enhance pollen germination and pollen tube growth. Brassinosteroids, like other plant hormones, have an impact on cell elongation and division, DNA, RNA, and protein synthesis, organ enlargement and development, senescence, and stress [16;17]. All 24-EBL

concentrations tested in our study, particularly 0.1 ppm, increased pollen germination and tube development compared to the control group. Parallel to our results Research has shown that BRs improve pollen germination and development in *Prunus avium, Prunus dulcis* [18], tomato [16] and rice [19]. However, in tobacco, the growth-promoting effects of BRs on pollen are inconsistent. Also brassinosteroids increased in vitro pollen tube growth and pollen germination" A. Thaliana [20]. Furthermore, *Prunus avium, Camellia japonica*, and *Prunus dulcis* have been demonstrated to enhance pollen germination and pollen tube growth in response to brassinosteroids [21]. Brassinosteroids improved pollen germination and fruit set in rice, as well as pollen viability and loss during heat stress [22]. The researchers inveatigated that gibberellic acid, followed by epibrassinolide, had an inciting impact on grapevine pollens [23]. Also showed that adding individual growth regulators to the growth medium improved pollen germination in Cabernet Sauvignon and Merlot (*Vitis vinifera* L.) [24]. Similarly our results 0.1 ppm 24-EBL situmulated pollen germination and pollen tube growth in two currant species [25]. Pollen germination and tube development serve as useful research tools for changing morphology, biological, biotechnological, ecologically sound, progressive biochemical, organized, and molecular studies. Also, evaluating pollen performance may be important for fruit growth of genetic progeny for breeding reasons, particularly in choosing which cultivars should be applied by researchers and producers. *In vitro* pollen germination is important for determining the physiological and biochemical parameters required for pollen germination and tube development. In vitro pollen germination may be used to evaluate pollen conditions such as reserved food material, membrane conditions, and conversion rates. *In vitro* germination studies are beneficial for researching the genetic, physiological, biochemical, and cytochemical features of different plant species. These studies are also an excellent predictor of in vivo pollen behavior, but only throughout the autotrophic period, when style nutrients, carbohydrates, and plant growth regulators have little effect on the early stages of pollen germination and pollen tube extension. *In vitro* assessments aid in breeding program selection and can forecast sterility issues in commercial orchards [26].

IV. CONCLUSION

In comparison to the control group, both bioregulators provide beneficial effects at all dosages in terms of pollen germination and tube development.0.1 ppm of 24-eBL gave the highest results pollen germination and pollen tube lenght. In vivo research on fertilization biology should be pursued. Standardizing optimal conditions can improve the accuracy and ease of in vitro pollen germination. We anticipate that these findings will be valuable to scholars and producers for future breeding studies.

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Değerli maden üretiminde insan güvenilirlik analizleriyle risklerin değerlendirilmesi

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Özet – İnsan güvenilirlik analizi , insandan kaynaklı risklerin incelenmesi ve iyileştirilmesi için kullanılan bir yöntemdir. Kazaya sebep olabilecek fiziksel, bilişsel, içsel ve dışsal faktörler üzerinde çalışmaların yapıldığı çeşitli yöntemler mevcuttur. Özellikle iş kazalarının birçoğunun insandan kaynaklandığını düşünürsek çalışmanın tehlikeli iş kolları sınıfında yer alan tüm işyerlerinde yapılması gerekmektedir. Çalışma değerli maden üretimi (trabzon hasırı) gerçekleştirilen bir firmada yapılmıştır. Trabzon hasırının en önemli özelliği insan işçiliği ile üretiliyor olmasıdır. Tel halindeki altın, örücüler tarafından iğne yardımıyla örülür. Örme işlemi biten yarı mamul atölyeye gönderilir. Kuyumculukta üretilen takılar, kullanıma bağlı olarak zamanla yüzey kalitesini yitirerek yüzeyinde kirli veya oksitli katmanlar oluşur. Bu katmanların temizlenebilmesi ve altının renginin bozulmaması için belli başlı işlemlerden geçmektedir. İşlemler esnasında birçok kimyasal madde kullanılmaktadır. Ayrıca makine ve ekipmanlar tehlike barındırdığından çalışma için bu alan seçilmiştir. Yöntemler arasında SPAR-H (Standartlaştırılmış Tesis Analizi Risk-İnsan Güvenilirliği Analizi) yöntemi uygulanmıştır. Bunun için atölyedeki tüm görevler tanımlanır. Her görev için operatörlerin performanslarını etkileyen faktörlerin seviyesi belirlenir. Bu faktörler yöntem için belirlenen faktörlerin dışında bizim tarafımızdan probleme özgü de belirlenebilmektedir. Faktör seviyeleri çarpılarak görevlerin insan hata olasılığı belirlenir. Alınması gereken güvenlik önlem ve tedbirleri firmaya bildirilir. İnsan güvenilirlik analizi, insandan kaynaklanabilecek olası hataları tespit etme ,önleme ve olasılıklarını düşürme fırsatı verir. SPAR-H yöntemi SCOPUS veri tabanında tarandığında değerli maden üretiminde bir çalışma yapılmadığını gördük. Türkiyede ise çalışmaların sınırlı olduğu, yapılan çoğu çalışmanın ise denizcilik ile ilgili olduğu gözükmektedir. Bu çalışma sayesinde literatüre değerli madenlerin işlenmesi alandaki bir çalışmanın SPAR-H yöntemi ile uygulanabilir olduğunu göstermiş olacağız.

Anahtar Kelimeler – İnsan Güvenilirlik Analizi, SPAR-H, Değerli Maden, İnsan Hata Olasılığı

I. GİRİŞ

Sanayi devriminden sonra yaşanan kazalarda ilk hedef noktası olarak teknik hatalara yoğunlaşılmaktaydı. İlerleyen yıllarda bu durum yerini, insan kaynaklı hatalara odaklanmaya bıraktı ve bu hataların çok ciddi sonuçlara yol açtığı tespit edildi. Uzmanlar insan performansını ölçmeye, performansı etkileyen nedenlere yöneldi. Böylece insan hatası olasılığını hesaplamak için çok sayıda yöntem de gelişmeye başladı.. Yapılan literatür taramasında ülkemizde konuyla ilgili fazla bir çalışmaya rastlamadık. Değerli maden üretimi (trabzon hasırı) yapan bir firmada bu yöntemler ile risk analizi yapılmıştır. Tel halindeki altın örülerek atölyeye geldikten sonra bir çok kimyasal maddenin kullanımı ile son halini almaktadır. Yöntemler arasında SPAR-H yöntemi uygulanmıştır. Bunun için atölyedeki tüm görevler tanımlanır. Her bir görev için operatörlerin performanslarını etkileyen faktörlerin seviyesi belirlenir. Bu faktörler yöntem için belirlenen faktörlerin dışında probleme özgü de belirlenebilmektedir. Risk analizi sonucunda en riskli görev ortaya çıkmaktadır.

Günümüzde halen popülaritesi devam etmekte olan Trabzon hasırının en önemli özelliği insan işçiliği ile üretiliyor olmasıdır. Bu da ürünü daha da değerli kılmaktadır. Altının işlenmesi esnasında kullanılan kimyasal maddeler ve makineler sebebiyle değerli olduğu kadar da tehlikelidir. İnsan emeği ve gücü ile ortaya çıkan bu ürün müşterilere sunulmadan önce hasır atölyesinde bir takım temizleme ve kaplama işlemlerinden geçmektedir.

Kuyumculukta üretilen takılar, kullanıma bağlı olarak zamanla yüzey kalitesini yitirerek (çizilme, kirlenme vb.) yüzeyinde kirli veya oksitli katmanlar oluşur. Bu katmanların temizlenebilmesi ve altının renginin bozulmaması için bir takım kimyasal maddeler kullanılmaktadır [1] . İmalat yapılan ve kimyasal maddelerin sıklıkla kullanıldığı sektörlerde tehlike ve riskler göz ardı edilemez. İnsanın olduğu her yerde kazaya sebebiyet verecek durumlar yaşanabilmektedir. Tüm bunlar düşünüldüğünde hasır atölyesinde insan güvenilirlik analizi ihtiyacını ortaya çıkmıştır. İnsan güvenilirlik analizi yöntemleri incelendiğinde SPAR-H yöntemi uygulanması tercih edilmiştir.

II. LİTERATÜR TARAMASI

SCOPUS veritabanında yapılan tarama sonucu Tablo 1de verilmiş olup insan güvenilirlik analizlerinden SPAR-H yöntemi 146 makale bulunmuştur bunlardan erişime açık olan 40 tanesi incelenmiştir. SPAR-H yöntemi en çok nükleer santralde daha sonra denizcilik çalışmalarında kullanıldığı görülmüştür.

Tablo 1. SCOPUS veritabanında literatür taraması

Aranan kelimeler	**Bulunan Çalışma Sayısı**
SPAR-H	160
human reliability analysis AND SPAR-H	146
precious AND metal AND human AND reliability AND analysis	8
precious AND metal AND SPAR-H	0

Jahangiri ve diğerleri (2016) İran'da bir kimya fabrikasında ki insan hata olasılığını hesaplamak için SPAR-H metodunu kullanmışlardır. Ortalama insan hatası olasılığını 0,11 olarak en yüksek insan hata olasılığı olan görevin olasılığını ise 0,50 olarak tespit etmişlerdir. Hata olasılıklarını azaltıcı tedbirler sunulmuştur. [2]

Zhao ve diğerleri (2017) Nükleer santral içindeki digital kontrol sistemi için insan güvenilirlik analizi yapmışlar. SPAR-H yöntemini uygularken Görev Karmaşıklığının buradaki kazalarda önemli yer tuttuğunu belirttiler. Karmaşıklık faktörünü PSFlerden ayırarak insan hata olasılığı hesaplamışlardır. Geliştirilmiş yöntemin standart yönteme göre daha iyi sonuç verdiğini ifade ettiler. [3]

Eyvazlou ve diğerleri (2018) İran'da bir jeneratör üretim tesisinde insan hatası olasılığını ölçmek için SPAR-H yöntemini kullanmışlardır. Görevler için 8 adet PSF'ye (performans şekillendiren faktör) göre değerlendirildi. En yüksek ve en düşük insan hata olasılığının olduğu görevler belirlendi. Bu olasılıkların azaltılması için stresin azaltılması, prosedürlerdeki eksiklerin tamamlanması, insan makine uyumunun artırılması operatörlerin tecrübeli kişilerden seçilmesi gibi önlemlerde bulunmuşlardır [4].

Zhan ve diğerleri (2019) Metro Hattı kapı operasyonları için SPAR-H yöntemini kullandılar. Standart 8 PSF için seviyelerini belirlediler. Çalışmalarının neticesinde personelin deneyim/eğitim seviyesinin iyileştirilmesinin, çalışma güvenilirliğini önemli ölçüde artıracağını öngördüler. [5]

Najafi ve diğerleri (2022) bir Nükleer Santralin ana buhar hattı kesintisi üzerine çalışma yapmıştır. İnsan hatası olasılığılını hesaplarken SPAR-H yöntemi ile olasılık değerleri tahmin edilmiştir. Çalışmanın sonuçlardan biri de kullanılabilir sürenin operatör için yetersiz olduğudur. [6]

He ve Diğerleri (2024) Çin'de labaratubar kazalarının sık sık yaşanması ve ciddi sonuçlar doğurmasından kaynaklı, bir üniversite labaratuvarında insan güvenilirlik analizi yapmışlardır. İnsan güvenilirlik metodlarından CREAM ve SPAR-H kullanmışlardır. CREAM yöntemi ile psikolojik faktörler dikkate alınarak hesaplama yapılmıştır. Çalışamının sonucunda önleyici tavsiyeler verilmiştir. [7]

III. MATERYAL VE YÖNTEM

Çalışmayı yaparken kullanılan materyalleri ve yöntemleri ayrıntılı olarak açıklayın. Farklı kaynaklardan yaptığınız alıntılar referanslarda verilmeli ve kaynak gösterilmelidir.

A. İnsan Güvenilirlik Analizi

İnsan güvenilirlik analizi yöntemleri farklılıklarından dolayı üç nesil olarak tanımlamıştır: ilk nesil 1975'ten 1990 yılına kadar , ikincisi 1990'dan 2005 yılına kadar üçüncüsü ise 2005'ten günümüze kadar devam etmektedir. Bir operasyonda tanımlı olan alt görevler için insan hatası olasılıklarını vurgulayanlar birinci nesil yöntem olarak adlandırılır. Birinci nesil teknikler, daha sofistike yöntemlerin yerini almasına rağmen, birçok endüstriyel uygulamada hala kullanılmaktadır İkinci nesil yöntemler ise, Performansı Şekillendiren Faktörleri (PSF'ler) (çalışanın bilişsel süreçlerini de içine katarak) tanımlamaktadır. Üçüncü nesil yöntemler ise bu faktörler arasındaki etkileşimlerin açıklanmasını içermektedir [8].

Catelani ve ark. (2021) çalışmasına göre, birinci nesil yöntemler genellikle görevi yapan kişilerin performanslarını başarılı veya başarısız olarak neticelendirmek üzere puanlar. İkinci nesil yöntemlerde kullanılan PSF'ler genellikle çalışanların iş yükü, stres, toplumsal sorunlar, psikolojik sorunlar, hastalık, çevresel etkiler gibi çalışma performanslarını etkileyen içsel ve dışsal faktörleri içermektedir. İnsan hatalarının nedenlerini ve ne sıklıkta gerçekleştiğini dikkate alır. Yaklaşık 20 yıl önce tanıtılan üçüncü nesil yöntemler ise, insan performansını şekillendiren faktörler arasındaki dinamik ilişkiler ve bağımlılıklarla ilgilenmektedir [9].

İnsan güvenilirlik analizi yöntemlerden bazıları aşağıdaki gibidir;

THERP: İnsan Hata Oranı Tahmini Tekniği , 1983 yılında Swain ve Guttmann tarafından geliştirilen bir HRA yöntemidir. "Olay ağacı" yaklaşımı, eylemler ve hatalar arasındaki bağımlılığın nicel modellemesine izin verir. Ortaya çıkan olay ağacı, olayların gerçekleşme sırasını ve her düğümde oluşabilecek olası hataları ifade eder [8].

SLIM: Başarı Olasılık İndeksi Yöntemi (SLIM), Embrey ve arkadaşları tarafından 1983 yılında tanıtılan ve ABD Nükleer Düzenleme Komisyonu'nun sponsorluğunda geliştirilen bir tekniktir. Bir süreçteki alt görevlerin başarı veya başarısızlık olasılığını değerlendirmeyi amaçlar; SLIM uygulamasında, PSF'ler önemlerine göre ağırlıklandırılır. PSF etkisinin doğru ölçeklendirilmesi, SLIM analizinin kritik bir yönüdür[8].

HEART: İnsan Hatası Değerlendirme ve Azaltma Tekniği (HEART) 1986 yılında Williams tarafından tanımlanmıştır. HEART tekniği, nükleer endüstri, havacılık, demiryolu, tıp ve kimya gibi çeşitli endüstrilerde yaygın olarak uygulanmaktadır. HEART tekniği, ortak görev türleri ve Hata Üreten Koşullar (EPC'ler) ile ilgili bir anket içerir. Yönteme göre, ortak görev türleriyle ilgili otuz sekiz hata üreten koşul ve dokuz insan hata olasılığı değeri vardır. İnsan güvenilirliği göreve bağlı olarak değerlendirilir [8].

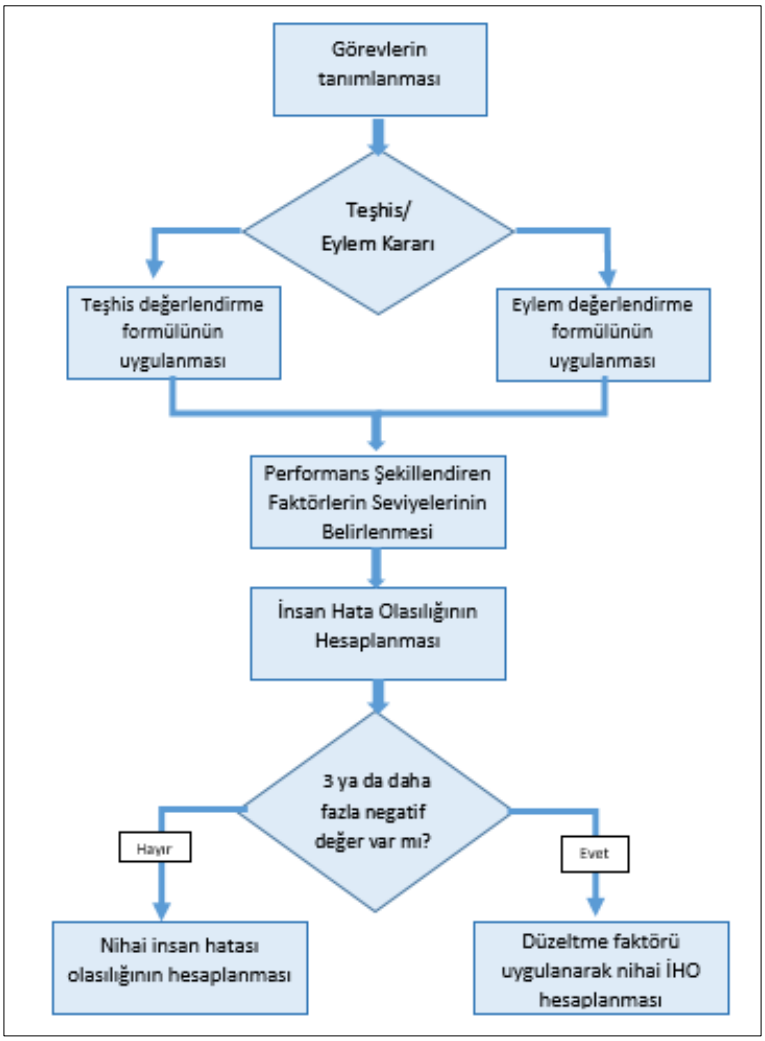
SHERPA: Sistematik İnsan Hatası Azaltma ve Tahmin Yaklaşımı , Embrey (1986) tarafından geliştirilmiştir ve ilk olarak nükleer enerji üretim endüstrisinde uygulanmıştır. Genel bir süreci alt görevlere dönüştürür ve olası hata modlarını belirlemek için bir sınıflandırma sistemi sağlar [8].

CREAM: Bilişsel Güvenilirlik ve Hata Analizi Yöntemi, 1998 yılında Eric Hollnagel tarafından önerilmiştir. CREAM'in insan hatası değerlendirme teknikleriyle karşılaştırıldığında temel avantajları, zihinsel süreçlerin insan performansındaki önemini belirlemek için bilişsel bir modelin dahil edilmesi; ve her adımda hem ileriye dönük hem de geriye dönük olarak analiz etme yeteneği [8].

B. SPAR-H Yöntemi

SPAR-H (standartlaştırılmış tesis analizi risk-insan güvenilirliği analizi) tekniği, ABD nükleer düzenleme komisyonu tarafından 1994 yılında tanıtıldı ve 1999'da son halini aldı. Yöntemin amacı, insan güvenilirliği açısından bir tesisteki belirli görevler için hata olasılığını, nominal hata oranını, Performans Şekillendirme Faktörünü ve görevler arasındaki hata bağımlılığını hesaplamaktır. SPAR-H yöntemi birinci nesil ve ikinci nesil insan güvenilirliği analizi yöntemlerinin yetersiz kaldığı noktalarda, hepsini kapsayan ve araalrındaki etkileşimi açıklayan üçüncü nesil analiz yöntemidir [10].

SPAR-H yöntemi genel adımları aşağıdaki şekilde gösterilmiştir.



Şekil 1. SPAR-H yöntemi uygulama akış diyagramı

Adım 1. Görevler tanımlanır.

Adım 2. Görevlerin eylem mi teşhis mi olduklarına karar verilir.

Adım 3. PŞF seviyeleri belirlenir. SPAR-H insan hata olasılığını ölçmek için sekiz PŞF önermektedir. Bunlar;

- Kullanılabilir Zaman: PŞF'sinin değerlendirilmesinde ilgili görevi tamamlamak için gereken süre ile mevcut süre karşılaştırılır.
- Stres faktörü: aşırı ısı, gürültü, yetersiz havalandırma veya kimyasala maruz kalma gibi kişide stres yaratacak çevresel faktörlerdir.
- Karmaşıklık, görevin ne derece zor olduğunu ifade eder.
- Tecrübe ve eğitim için, göreve dahil olan operatör(ler)in tecrübe ve eğitimi seviyelendirilir. Operatör eğitim aldığı halde yetersiz geldiği durumlarda bu PŞF olumsuz seviye ile ilişkilendirilir.
- Prosedür, tanımlanan görevler için resmi bir işleyiş belgesinin varlığını ve kullanımını ifade eder.
- Ergonomi işin insana uyumudur. Sadece ekipmanlar değil bilgisayar yazılımı gibi bileşenler de de bu PŞF'ye dahildir. Göreve uygunluk, operatörün yaptığı işe bedenen ve zihnen uygunluğudur.
- İş Süreçleri, çalışanlar arasındaki iletişim, planlama, ve yönetim desteği dahil iş yapmanın tüm yönlerini ifade eder. [11]

Adım 4. İnsan hata olasılığı hesaplanır. Her bir hata türü için nominal hata olasılıkları (NİHO), sırasıyla teşhis için 0,01 ve eylem için 0,001 olarak tanımlanmıştır. Bir PŞF'nin insan performansı üzerinde etkisi yoksa nominal olarak yani çarpanı 1 olacak şekilde seviyelendirilir.

İHO= 0,01x her bir PSF seviyesi (1)

Eğer üç yada daha fazla olumsuz seviye varsa denklem 2 kullanılır.

$$\text{İHO}=\frac{N\text{İ}HO.PSF_{bileşen}}{N\text{İ}HO\ (\ PSF_{bileşen}-1)+1} \quad (2)$$

Tablo 2. Teşhisler için PSF Seviyeleri

PSFs	**PSF Seviyeleri**	**Teşhis için Çarpan**
Kullanılabilir Zaman	Yetersiz Zaman	100
	Yaklaşık yeterli zaman (≈ 2/3 x nominal)	10
	İdeal Zaman	1
	Ekstra Zaman (yarım saat 1 saat)	1
	Aşırı Zaman> 2 katı kadar	0.1
	Yetersiz Bilgi	
Stres	Aşırı	5
	Yüksek	2
	Nominal	1
	Yetersiz Bilgi	1
Karmaşıklık	Yüksek Karmaşıklık	5
	Orta Derecede	2
	Nominal	1
	Belirgin adımlar	0,1
	Yetersiz Bilgi	1
Tecrübe/Eğitim	Düşük	10
	Nominal	1
	Yüksek	0,5
	Yetersiz Bilgi	1
Prosedürler	Mevcut değil	50
	Eksik	20
	Mevcut ancak zayıf	5
	Nominal	1
	Mevcut ve yeterli	0,5
	Yetersiz Bilgi	1
Ergonomics/ İnsan Makine Uyumu	Eksik	50
	Zayıf	10
	Nominal	1
	İyi	0,5
	Yetersiz Bilgi	1
Göreve Uygunluk	Uygunsuz	100
	Bozuk Uygunluk Nominal	5
	Nominal	1
	Yetersiz Bilgi	1
İş Süreçleri	Zayıf	2
	Nominal	1
	İyi	0,8
	Yetersiz Bilgi	1

IV. UYGULAMA

Uygulama için Uğurlu Kuyumculuk Trabzon hasır atölyesi seçilmiştir. Altın telinin istenen uzunluk ve ölçüde örülmesinden sonra atölyeye gönderilir ve sırasıyla aşağıdaki işlemler uygulanmaktadır.

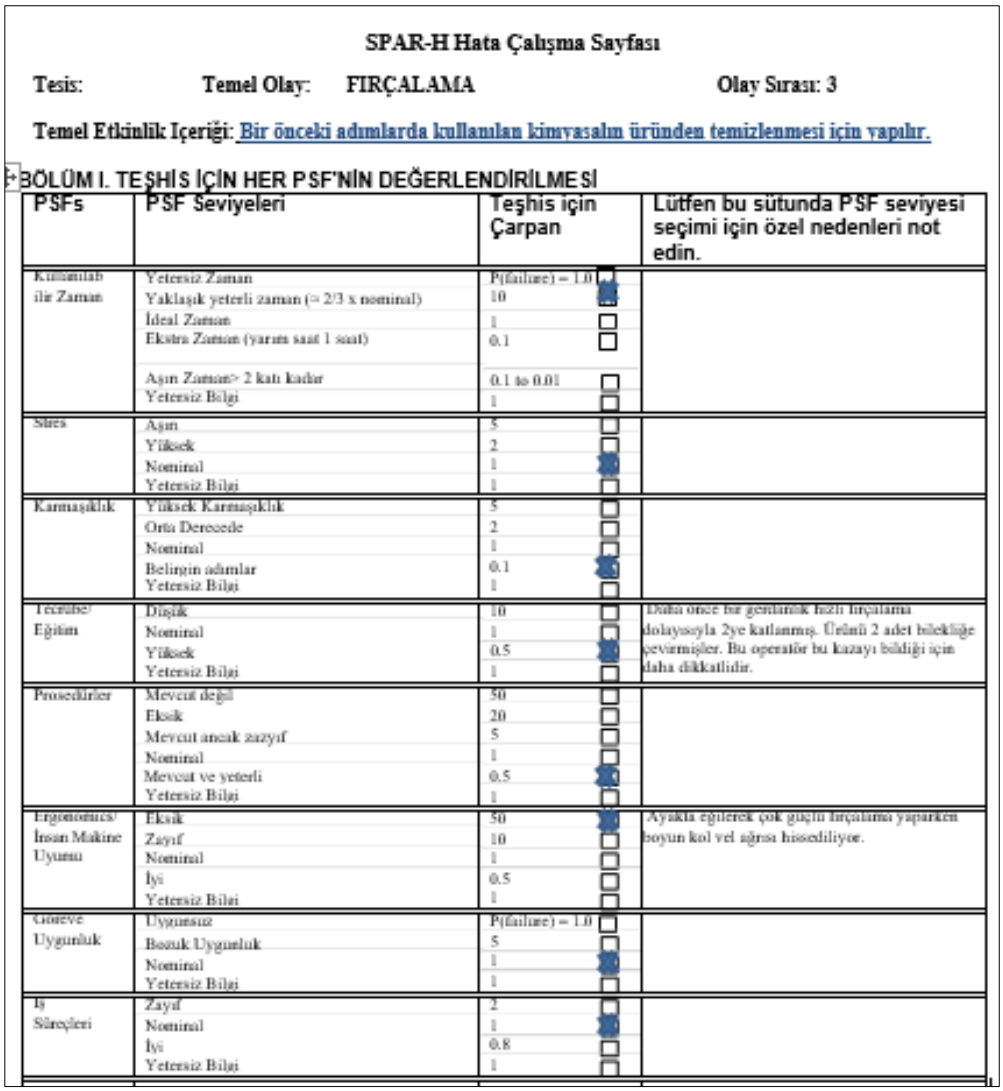
1. Tavlama : Altının yumuşaması istenilen yapıya gelmesi için yapılmaktadır.
2. Sıcak Zaç Yağı : Ateş gören altın kararır. Sülfirik asit ve su ile ürün temizlenir.
3. Patlatma: Hidrojen, siyanür ve sıcak su ile patlatma makinesine ürün yerleştirilerek üstündeki tüm pislik temizlenmektedir.
4. Fırçalama: Bir önceki adımlardan üzerinde kalan kimyasalı temizlemek için deterjan kullanılarak yapılır. Fırçalama işlemi basit gözükse de sürekli aynı yönde yapılması gereken kol kuvveti gerektiren bir işlemdir. Bu işlemde fırçanın sert olmasından dolayı ürünün hasar alma ihtimali yüksektir.
5. Cilalama: Ürünün parlaması için cila makinesi kullanılır. Ellerin makineye çok yakın olduğu parmakların sürtünmeden dolayı hasar alma olasılığı yüksek bir işlemdir.
6. Cırcır: Cila lekelerini temizlemek için kimyasal suya sabun katarak tekrar temizlik yapılır.
7. İslim: Basınçlı su buharı ile üründe kalan yabancı maddeler temizlenir.
8. Soğuk Zaç Yağı: Cırcırda kullanılan sabunun üründe kalmaması için bu suya batırılarak temizlenir.
9. Yaldızlama: Ürünün temizlik işlemi bittikten sonra, bakır teller yardımıyla sıcak kimyasal karışım için yapılan kaplama (renklendirme) işlemidir. Bu aşamada fosfat, sülfit, karbonat, siyanür, kezzap, tuz ruhu, kostik ve bir miktar toz altın kullanılmaktadır.Yaldızlama öncesi ve sonrası ürün renk değişimi aşağıdaki gibidir;

Şekil 2. Yaldızlama öncesi ve sonrası ürün rengindeki değişim

Ürünün renginde kızarıklık olması durumunda bu ürünün yeterince temizlenmediği anlamına gelir. Böyle bir durumda patlatma işlemine dönerek adımlar takip edilir.

V. BULGULAR

Her görev için PSF seviyeleri belirlendikten sonra Denklem 1 ve denklem 2 kullanılarak İHO değerleri hesaplanmıştır Teşhis için her performans faktörünün değerlendirilmesi aşağıdaki form örneğinde gösterildiği gibi doldurulmuştur. Örnekte “fırçalama” görevi gösterilmiştir . Hasır atölyesinde uygulanan SPAR-H yöntemi sonucunda insan hata olasılığı değerleri Şekil 4te verilmiştir. En yüksek görev 0,29 olasılık ile patlatma çıkmıştır. Ardından 0,20 olasılık ile yaldızlama, 011 insan hata olasılığı ile cilalama işlemi gelmektedir. Patlarma görevinin yüksek hata olasılığa sahip olmasının başlıca sebepleri; proesdür eksikleri ve işin insana uyumundaki eksiklerdir. Ayrıca bu görev için operatörün alduğı eğitim yetersiz gelmektedir. Operatör geçmişte patlatma makinesinde iş kazası meydana geldiğini de ifade etmiştir.



SPAR-H Hata Çalışma Sayfası

Tesis: Temel Olay: FIRÇALAMA Olay Sırası: 3

Temel Etkinlik İçeriği: Bir önceki adımlarda kullanılan kimyasalın üründen temizlenmesi için yapılır.

BÖLÜM I. TEŞHİS İÇİN HER PSF'NİN DEĞERLENDİRİLMESİ

PSFs	PSF Seviyeleri	Teşhis için Çarpan	Lütfen bu sütunda PSF seviyesi seçimi için özel nedenleri not edin.
Kullanılabilir Zaman	Yetersiz Zaman	P(failure) = 1.0	
	Yaklaşık yeterli zaman (= 2/3 x nominal)	10	
	İdeal Zaman	1	
	Ekstra Zaman (yarım saat 1 saat)	0.1	
	Aşırı Zaman> 2 katı kadar	0.1 to 0.01	
	Yetersiz Bilgi	1	
Stres	Aşırı	5	
	Yüksek	2	
	Nominal	1	
	Yetersiz Bilgi	1	
Karmaşıklık	Yüksek Karmaşıklık	5	
	Orta Derecede	2	
	Nominal	1	
	Belirgin adımlar	0.1	
	Yetersiz Bilgi	1	
Tecrübe/ Eğitim	Düşük	10	Daha önce bir geminin inişi fırçalama dolayısıyla 2ye katlanmış. Ürünü 2 adet bileklliğe çevirmişler. Bu operatör bu kazayı bildiği için daha dikkatlidir.
	Nominal	1	
	Yüksek	0.5	
	Yetersiz Bilgi	1	
Prosedürler	Mevcut değil	50	
	Eksik	20	
	Mevcut ancak zayıf	5	
	Nominal	1	
	Mevcut ve yeterli	0.5	
	Yetersiz Bilgi	1	
Ergonomics/ İnsan Makine Uyumu	Eksik	50	Ayakta eğilerek çok güçlü fırçalama yaparken boyun kol vel ağrısı hissediliyor.
	Zayıf	10	
	Nominal	1	
	İyi	0.5	
	Yetersiz Bilgi	1	
Göreve Uygunluk	Uyumsuz	P(failure) = 1.0	
	Bozuk Uygunluk	5	
	Nominal	1	
	Yetersiz Bilgi	1	
İş Süreçleri	Zayıf	2	
	Nominal	1	
	İyi	0.8	
	Yetersiz Bilgi	1	

Şekil 3. Fırçalama için PŞF değerlendirmesi

Görevler	Kullanılabilir zaman	Stres	Karmaşıklık	Tecrübe ve eğitim	Prosedür	Ergonomi	Göreve Uygunluk	İş süreçleri	Nihai İHO
Tavlama	1	1	1	0,5	5	1	1	1	0,03
Sıcak Zaçyağı	10	1	0,1	1	5	10	1	1	0,00
Patlatma	0,1	5	2	10	20	10	1	2	0,29
Fırçalama	1	1	0,1	10	5	10	1	1	0,01
Cilalama	10	5	0,1	1	5	50	1	1	0,11
Cırcır	10	1	0,1	1	5	0,5	1	1	0,03
İslim	0,1	1	0,1	1	5	0,5	1	1	0,00
Soğuk Zaçyağı	0,1	1	0,1	1	5	0,5	1	1	0,00
Yaldızlama	10	5	5	1	1	10	1	1	0,20

Şekil 4. Nihai insan hatası olasıkları

VI. TARTIŞMA

Ulusal tez merkezinde daha önce hasır atölyesinde SPAR-H ile yapılmış insan güvenilirlik analizi çalışmasına rastlanmamıştır. Ülkemizde sadece 2022 yılında sigortalı çalışanların 589.271 adeti iş kazası geçirmiştir. Bunların 1.520 tanesi ise ne yazık ki ölümle sonuçlanmıştır[12].

İş kazalarının sayısının her geçen yıl artması sebebiyle insan güvenilirlik analizinin önemi de artmıştır. Çalışma ortamının çok sayıda yanıcı ve yakıcı kimyasal barındırmaktadır. İnsan hata olasılığını artırdığını düşündüğümüz havalandırma , yorgunluk, ara ürün kalitedi gibi faktörlerin de PSFlere dahil edilmesi uygun olacaktır. Şekil 5'te görülen patlatma makinesinde çalışan operatörün daha önce iş kazası geçirdiği öğrenildi. Ürün atlama riskine karşı makineye bir cam kapak önerisinde bulunuldu. İçindeki maddelerin yanıcı etkisi bulunmakta olduğundan alınacak önlemler ile insan hata olasıkları azaltacaktır. İkinci en yüksek hata olasılığı çıkan görev ise yaldızlama aşaması olmuştur. Bu işlem esnasında iki elin sabit kalması gerektiğinden ergonomi seviyesi olasılığı artıran önemli bir faktör olmuştur. Ayrıca yaldızlama temizlik ve renklendirmenin son aşaması olduğundan genellikle bu görevdeki sürenin yetersiz olduğu ifade edilmiştir. Bu da insa hata olasılığını olumsuz anlamda etkilemiştir.

Şekil 5. Patlatma Makinesi

VII. SONUÇLAR

Bu çalışma ile ilk defa değerli maden üretiminde SPAR-H yöntemi kullanılmış olacaktır. Ayrıca ülkemiz madenler açısından çok zengin bir bölgeye sahiptir. İnsan hatası ciddi kazalara yol açabilmektedir. İnsan güvenilirliği analizi insan hata olasılığını hesaplayarak aslında bize daha önlenebilir riskleri göstermektedir. Bu yöntemin uygulanabilir olduğunu göstererek diğer alanlarda da güvenilirlik analizi yapılması için yol açmış olacağız. Çalışmanın birçok sektörde olduğu gibi değerli maden işlenen bu sektörde de iyi sonuçlar verdiği ortaya çıkmıştır. SPAR-H yönteminin avantajları kullanımının kolay olması ve kullanıcının uzman gerektirmemesidir.

Yöntem sekiz standart performans şekillendiren faktörü içermektedir. Çalışmayı probleme özgü farklı performans faktörleri ile geliştirebiliriz. Bunun için operatörler ile beyin fırtınası yaparak insan hatasına sebep olan faktörler belirlenerek insan güvenilirlik analizindeki diğer yöntemler ile de çalışmayı ele alabiliriz. Çalışmada faktörlerin eşit önem seviyesinde olduğu düşünülerek yapılmıştır. Uzman görüşü ile ağırlıklar değiştirilebilir.

Bilinen değerli metallerden biri olan altının işlendiği bu atölyede yaşanacak insan hatası, maddi ve manevi olumsuz sonuçlara yol açabilmektedir. Bu yüzden de hata olasılığının düşük olması önemlidir. SPAR-H yönteminin uygulandığı bu çalışma sektör için özgün bir çalışma olmuştur.

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HEART MONITORING DEVICE: Electrocardiography

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Abstract – This project aims to measure heart electrical activity and save lives through early diagnosis by making the final product widely accessible for everyone to own their own device. The electronic sensor used in the project accurately detects heart rate and transmits this data to a microcontroller. The microcontroller processes and displays the data in a user-friendly manner on screen, enabling users to easily monitor their own heart health. The latest version of the product has been successfully tested on five different users with positive results, demonstrating its reliability and effectiveness. Another crucial objective of our project is to ensure the product is affordable by minimizing costs, thus reaching a broader audience. This initiative will empower more individuals to identify and proactively address potential health risks through early diagnosis. Looking ahead, as this innovative approach gains traction in the healthcare industry, awareness and accessibility to heart health will continue to improve.

Keywords – heart electrical activity, electronic sensor, microprocessor, affordable healthcare.

I. INTRODUCTION

The heart is a fist-shaped organ located in the chest [1]. It has four chambers—two atria and two ventricles—that are responsible for the vascular circulation of blood throughout the body, making it one of the vital organs of the human body. The prevalence of cardiovascular diseases (CVDs) globally is linked to the failure of the heart's functioning. This underscores the critical need for accessible and efficient monitoring solutions as device, therefore an electrocardiography device called ECG [2].

An ECG, or electrocardiogram, is a medical test that measures and records the electrical activity of the heart over a period. This non-invasive test is commonly used to detect and monitor various heart conditions by recording the electrical impulses generated by the heart's natural pacemaker (the sinoatrial node) as they spread through the heart muscle.

Traditional ECG systems, while effective, often pose challenges in terms of cost, portability, and user-friendliness. This literature review explores recent advancements and existing technologies in portable ECG monitoring, aiming to highlight gaps that can be addressed by innovative solutions like the one proposed in this study.

Cosoli G. et al. [3] discusses the development of a portable ECG monitoring system utilizing wireless technology for real-time data transmission. It emphasizes the system's effectiveness in remote monitoring and its impact on improving patient compliance and outcomes. Tai Le; H. Han; T. Hoang; Vu C.N and C. K. N. discuss in "A low cost mobile ECG monitoring device using two active dry electrodes.” the use of two active dry electrodes is used as touch sensors. A buffer circuit is applied to remove the over-sensitivity effect of the electrodes, this showing the use of more components means a little bit more cost [4].

While existing studies have made significant strides in portable ECG monitoring, the proposed system in this study stands out in several ways: Leveraging the Arduino UNO board and AD8232 sensor, the system

is designed to be lightweight and easily deployable in various settings, making it accessible to a broader population. By utilizing open-source hardware and software components, the system aims to reduce manufacturing costs without compromising on functionality or accuracy. The graphical user interface (GUI) provides real-time visualization of ECG data, enhancing user interaction and facilitating proactive management of heart health. Integration of advanced signal processing algorithms ensures accurate parameter extraction, improving diagnostic capabilities and enabling timely intervention.

II. MATERIALS AND METHOD

The ECG monitoring system developed for this study integrates several key components to facilitate portable and effective cardiac monitoring.

Arduino UNO Board is the core of the system, handling data processing and user interaction then AD8232 Sensor is utilized for signal acquisition directly from the patient via electrodes, capturing cardiac electrical activity also electrodes are used for contact to the patient's skin to ensure optimal signal acquisition for ECG monitoring. Amplification Circuit is embedded within the AD8232 sensor sense the electrical activity of the heart and converts it into usable type of data, i.e digital data ,conditions and amplifies raw ECG signals to improve signal quality. Arduino UNO board is connected to Graphical Display Unit (PC) via USB port to provide real-time visualization of processed ECG signals using Arduino IDE's Serial Plotter. Finally as power supply, the used computer supplies necessary electrical power to all components of the system, ensuring continuous operation.

ECG signals are acquired using the AD8232 sensor connected to electrodes placed on specific body locations. The sensor's integrated amplification circuit ensures signals are conditioned to enhance quality and facilitate accurate parameter extraction. The sensor pin L0+ and L0- are connected to the digital pins D10 and D11, Ground pin and 3.3 V pins from the sensor are connected respectively to ground pin and 3.3 V pins of the Arduino board, finally we also connect the output pin of the sensor to analog pin A0 of the microprocessor[5]. The code will in the first time check with L0+ and L0- connection setup if there is leads-off connection, if not then reads analog input from A0 and send the value and finally delay for fourty seconds to prevent saturating serial data. Electrodes cconnected to the sensor’s board are attached to patient skin with gel(so wet electrodes), respectively according to Eindhoven triangle, right and left hand and then to roght leg as grounfd of the circuit[6].ECG signal are displayed are called electrocardiogram [7]. Processed ECG signals and extracted parameters are displayed in real-time on a graphical unit connected to the Arduino UNO board via Arduino IDE's Serial Plotter. This immediate visualization allows for real-time monitoring and assessment of the patient's cardiac activity. Signal processing algorithms implemented on the Arduino UNO board include digital filtering techniques to reduce noise and enhance the clarity of ECG waveforms. These algorithms are crucial for accurate parameter extraction, such as heart rate and rhythm analysis. The system's software is developed using the Arduino IDE, providing an integrated development environment for programming the Arduino UNO board. This environment supports the implementation of signal processing algorithms and real-time data visualization through its Serial Plotter feature.

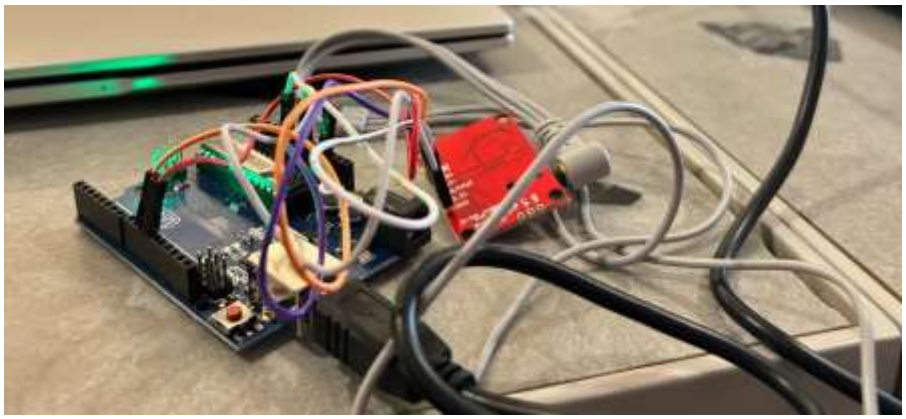

Fig. 1 connection between Arduino Uno Board and AD8232 Sensor

III. Results and Discussion

In summary, ECG monitoring system utilized in this study effectively acquired, processed, and visualized cardiac signals in real-time. It accurately extracted key parameters such as heart rate and rhythm, demonstrating high correlation with standard medical devices. While the system showed promising clinical feasibility and performance metrics, challenges such as signal artifacts require further refinement.

Future iterations could focus on improving signal processing algorithms to enhance noise reduction and incorporating wireless communication for seamless data transmission. Overall, this system represents a promising tool for early detection with implementation of Machine Learning tools for accurate, early and precise heart disease and continuous monitoring of cardiovascular health, with implications for improving patient outcomes and reducing healthcare costs.

Fig 2: Electrocardiogram displayed on Arduino IDE Serial Plotter [8].

IV. CONCLUSION

In conclusion, the development of a portable, cost-effective, and user-friendly ECG monitoring solution is essential to address the limitations of traditional bulky equipment, particularly in continuous monitoring outside clinical settings. Using Arduino Board and biosensor enable getting electrical signal from heart to proceed diagnosis. Further implementation of machine learning methods to this device will help with accuracy in diagnosis for healthcare.

Acknowledgment

We would like to acknowledge the invaluable contributions and support that made this study possible. Our sincere thanks go to:

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Yarn Design as an Influencing Factor on the Tensile Properties of Sports Materials

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Abstract – Sports physiology, a branch of sports medicine, studies how the body responds and adapts to physical activity. Coaches must understand modern scientific knowledge in sports and related disciplines to optimize training and care for athletes' health, while the sportswear must assist in the retaining of optimal comfort during the activity. Football jerseys, once simple garments for team distinction, have evolved into high-tech equipment designed for performance, breathability, and moisture management. Initially made of cotton, jerseys now use synthetic materials, transforming them into crucial tools for player comfort and advertising space for brands. In this study, tensile properties of different knitted fabrics produced of polymer yarns were tested. The results indicated that the inclusion of elastane increases the fabric's flexibility and stretch but results in a reduction in breaking strength. A fabric made of 100% polyester yarn exhibits the highest breaking strength, particularly in the wales direction. Adding elastane to polyester fabrics significantly enhances their elongation properties, making them more stretchable and durable under stress.

Keywords – yarn, fabric, material, polymer, tensile, properties

I. INTRODUCTION

Sports physiology is part of sports medicine (a branch of medicine that includes all types of sports and physical exercise), and deals with the study of the organism and body functions related to the response and adaptation to physical activity. In order for a coach to contribute in the best way to all aspects of leading and training a football team, he must be familiar with modern professional and scientific knowledge in the field of sports, as well as other related scientific disciplines. A good knowledge of the physiological processes related to sports training and competition enables the coach not only to better program the training process and better results, but also to take better care of the health of his athletes [1]. Usually, during a football match, a player finishes the game with a wet shirt. In football, one can burn as many as 752 - 937 calories per hour. Football is great for supporting healthy bones, physical motor skills, or building healthy self-confidence. Sport requires body work and running, among other things, the result and teammates motivate one to have better results [2]. Sweating during physical activity is completely natural because the body needs to cool down.

When it comes to football jerseys, it's not only appearance and design that matters, but also functionality. Football jerseys are an important piece of equipment for both players and fans. The latest technological innovations that provide players with the best performance, breathability and laser production of specially located meshes keep the body cooler in the places where it heats up the most. A special production system also controls the player's sweating, where high breathability is enabled so that the sweat is transferred from the skin to the outer part of the jersey, where it evaporates faster and does not bother the player. On the parts of the body where the most heat is generated, such as the armpits, there are laser-cut openings and

mesh, which provide additional breathability to these parts [3]. At the beginning of the development of football, the meaning of football jerseys was not great. The players were usually dressed in white short-sleeved T-shirts, and the teams recognized each other by their caps, which were in different colors [4]. This lasted until 1870 and the establishment of the English FA Cup competition. That competition attracted unprecedented media attention, so the spectators demanded that t-shirts be worn to distinguish the teams from each other. The colors were chosen according to the club or school that the team represented. The poorer teams wore simple white shirts, while the richer ones could afford jerseys in different colors. The players would bear the cost of acquiring the jerseys themselves until football became professional when the clubs started to provide the necessary equipment. It was then that a process was started that has been perfected to the extent that jerseys are no longer just a means of recognition and equipment, but real aids to players that facilitate their performance [4].

The jerseys worn by players at the beginning of the twentieth century were made of durable, natural fibers, most often cotton, and were produced in different colors. Wide vertical and horizontal stripes were often seen on the jerseys, which became a very popular design. In the thirties of the 20th century, in Great Britain, numbers began to be placed on the jerseys to indicate the position in which the player plays, which quickly spread to the rest of the world. In the middle of the twentieth century, natural materials began to be replaced by light synthetic materials. During the following decades, different designs of jerseys were alternated, which especially came to the fore in the 1980s, when large sports companies began to produce jerseys emphasizing their brands on them. With the entry of large sports companies into the jersey production business, the era began when the jersey was no longer just an article of clothing, but also an advertising space. In those years, jerseys were made of durable low-mass polyester [4].

Although the field of sportswear materials is very interesting and intriguing, the number of related studies is still limited. Recent studies have focused at investigation of mechanical properties and its retention over time [5-7].

II. MATERIALS AND METHOD

In the Experimental part of this paper, the analysis of materials used for the football sportswear, primarly jerseys was conducted. The materials consisted of different ray materials, i.e. 100% polyester yarn, as well as the combination of polyester and elastane in different ratios. The details of the used materials are shown in Table 1.

Table 1. Overview of materials

Material ID	Yarn composition	Nominal mass per unit area, g/m^2
F10	92% PES, 8% EA	197
F11	84% PES, 16% EA	180
F15	100% PES	126
F16	100% PES	150
F17	100% PES	130

All selected materials were tested for tensile properties, focusing at breaking force and breaking elongation. The Statimat M tensile tester from the German company Textechno was used to test the breaking force and elongation of the knitting, and the test was performed in accordance with the HRN ISO 2062:2009 standard [8]. The tensile tester is fully automated, microprocessor-controlled, which works according to the principle of constant stretching speed. It is equipped with the Testcontrol computer system, which provides static evaluation of measurement data and adjustment of test conditions. The printout of the computer program contains the following data used in the test, for example stretching force (1000 N), distance between clamps (amounts to 100 mm), stretching speed (100 mm/min), preload (0.00 N) and number of measurements (5). The tensile tester contains two clamps, the spacing of which was 100 mm for testing this thesis.

For testing, the specimen is inserted inside the upper clamp and fixed to the lower clamp. Than the tensile tester is started, and the lower clamp starts moving downwards. From the moment the sample is stretched, the computer program records the parameters: breaking elongation (%), breaking force (N), work until breaking (N*cm), strength (cN/mm) and time until breaking (s). When the sample breaks, the computer program reads all the results and prints them graphically. For each material sample, five tests were carried out in the dry state, five in the wet state and for each in the direction of the row and row of meshes. In order to obtain samples in the wet state, they were made identically to those in the dry state, but it was necessary to dip them in a previously prepared artificial sweat solution. The purpose of this test was to compare the quality and relationship of materials, as well as the suitability of such materials for sports purposes, i.e. football jerseys. Fabrics intended for sportswear should possess certain properties when sweating, in such a way that they absorb sweat quickly, while not making the material heavier.

Fig. 1 Phases in material testing using tensile tester [9]

III. Results and Discussion

The figures 2 and 3 show the breaking forces of different knitted fabric compositions measured in two directions: courses (i.e. horizontal) and wales (i.e. vertical), measured in dry and wet conditions [9].

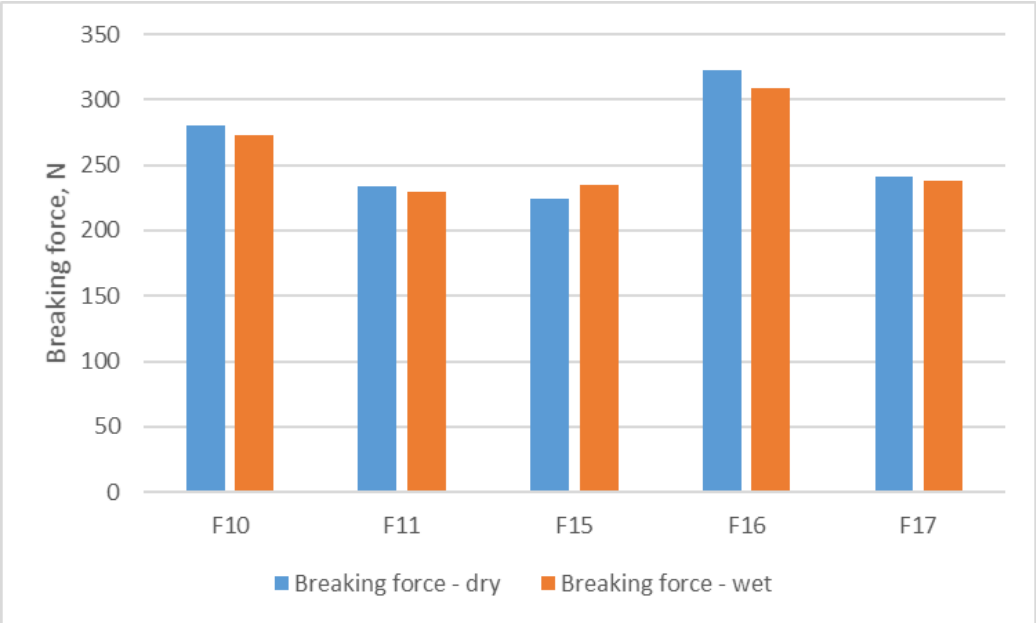

Fig. 2 Breaking force of fabrics measured in the direction of courses

As can be seen from the results, breaking force in dry condition and direction of courses is highest for 100% PES (323 N) and lowest for 100% PES (224 N). The fabrics with elastane have intermediate breaking forces, with the 92% PES and 8% elastane combination being stronger than the 84% PES, 16% elastane combination. Breaking force in wet condition for the same measurement direction is again highest for 100% PES (309 N) and lowest for 84% PES, 16% elastane (230 N). The trend is similar to the dry condition results, with the fabric containing less elastane (92% PES, 8% elastane) showing higher strength compared to the one with more elastane (84% PES, 16% elastane).

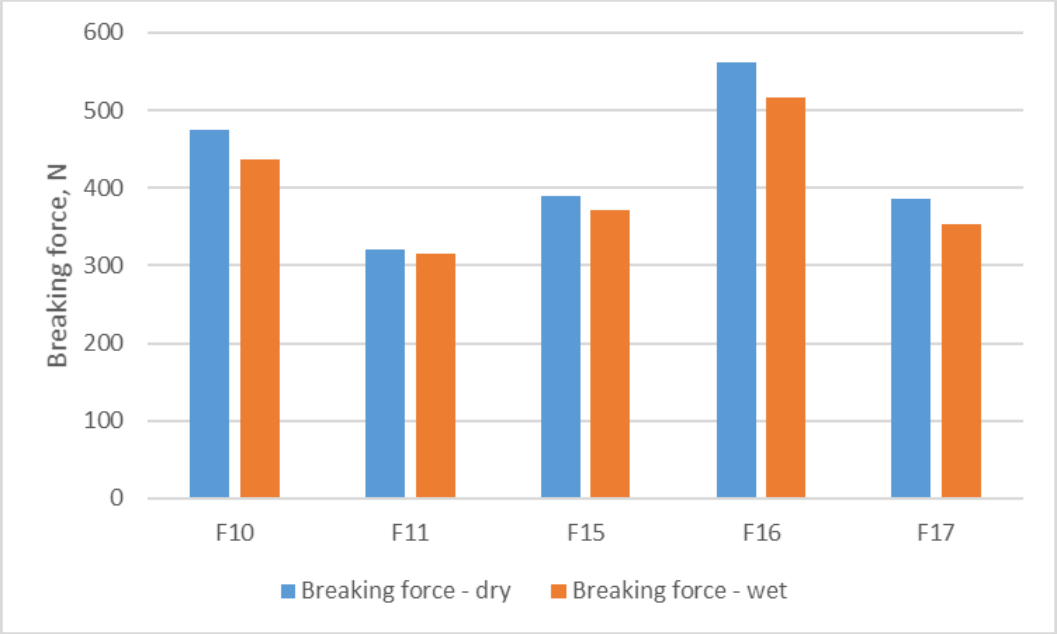

Fig. 3 Breaking force of fabrics measured in the direction of wales

Breaking force in dry condition for the direction of wales is highest for 100% PES (561 N) and lowest for 84% PES, 16% elastane (321 N). The fabric with 92% PES and 8% elastane shows a higher breaking force compared to the one with more elastane. In wet condition, for the same direction of measurement, the breaking force is highest for 100% PES (517 N) and lowest for 84% PES, 16% elastane (316 N). Similar to the dry conditions, the fabric with less elastane (92% PES, 8% elastane) is stronger than the one with more elastane.

Within these measurements, the influencing effects can be observed at four different levels, i.e.:

- effect of elastane plating,
- effect of knitted fabric mass per unit area,
- effect of measuring direction (wales vs. courses)
- effect of condition (dry vs. wet).

As far as the effect of elastane content is concerned, fabrics with lower elastane content (92% PES, 8% elastane) generally have higher breaking forces compared to fabrics with higher elastane content (84% PES, 16% elastane), both in dry and wet conditions. This indicates that increasing elastane content reduces the breaking strength of the fabric.

Among the 100% PES samples, there is variability in the breaking force. One sample consistently shows the highest breaking forces (323 N in courses dry, 309 N in courses wet, 561 N in wales dry, and 517 N in wales wet), suggesting that the mass per unit area of this fabric results in superior strength.

Regarding the influence of measuring direction, it was seen that breaking forces are generally higher in the wales direction compared to the courses direction for all fabric compositions. This suggests that the fabric is stronger along the vertical structure compared to the horizontal.

Finally, regarding the measurements in wet vs. dry conditions, it is seen that the breaking forces are slightly lower in wet conditions compared to dry conditions for most compositions, indicating that the fabric's strength is somewhat compromised when wet. However, the reduction is not drastic.

Overall, the data suggests that while the addition of elastane adds flexibility and stretch to the fabric, it reduces its breaking strength. The pure polyester fabric demonstrates the highest strength, particularly in the wales direction.

The results of measured breaking elongation are shown in figures 4 and 5.

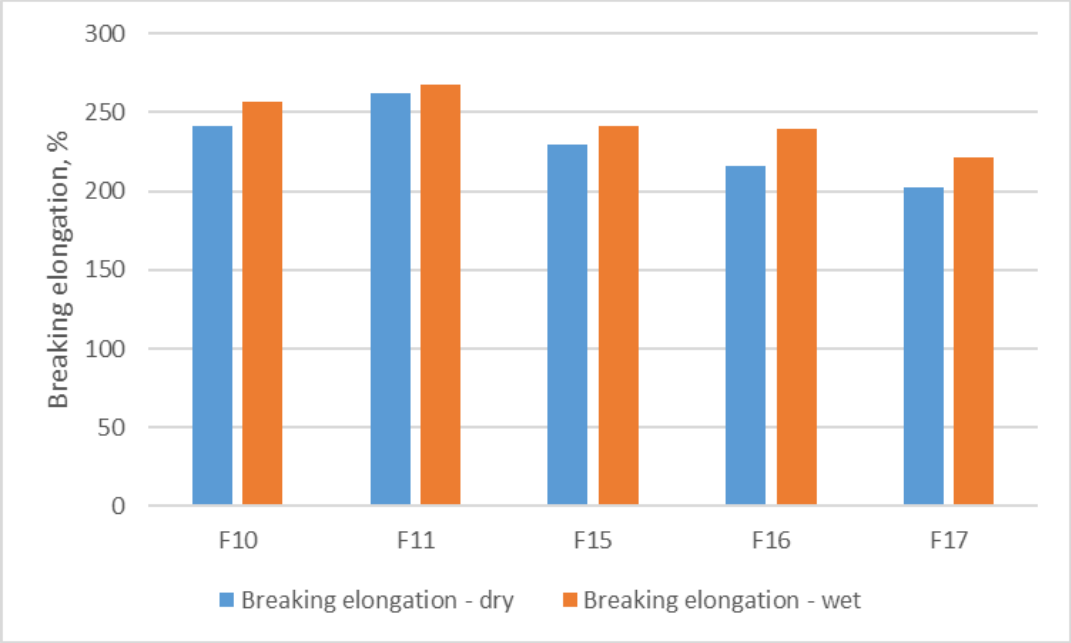

Fig. 4 Breaking elongation of fabrics measured in the direction of courses

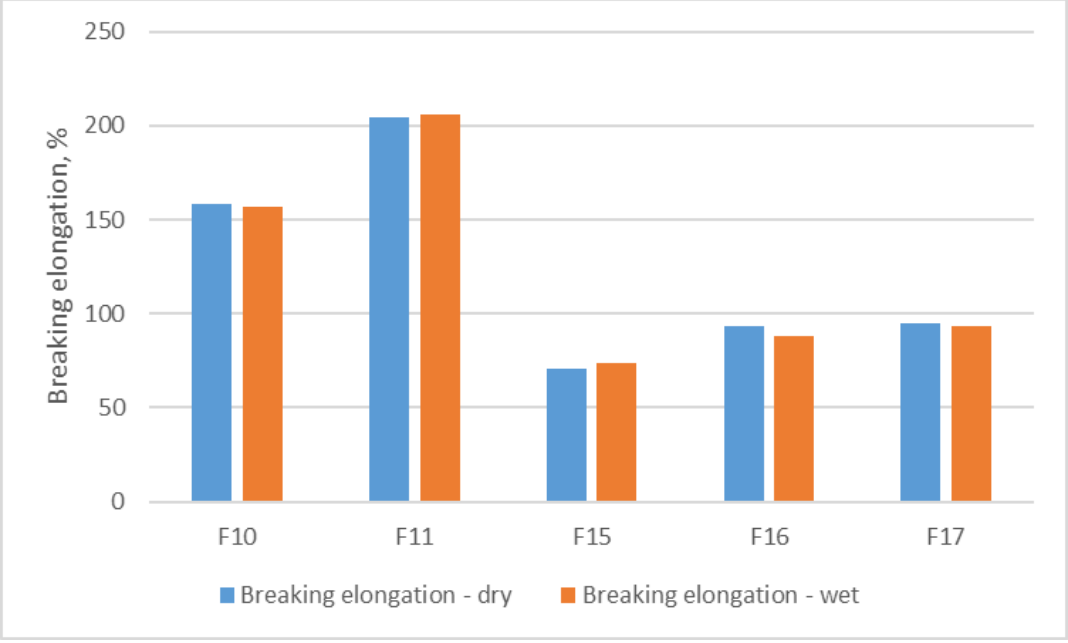

Fig. 5 Breaking elongation of fabrics measured in the direction of wales

Fabrics with elastane (either 8% or 16%) show higher breaking elongation values in both the dry and wet conditions compared to those with 100% PES. The fabric with 84% PES, 16% elastane consistently shows the highest breaking elongation across all conditions and measuring directions. Breaking elongation values in the courses direction are generally higher than those in the wales direction. Wet conditions result

in slightly higher breaking elongation compared to dry conditions across all fabric compositions and directions.

This analysis indicates that adding elastane to polyester fabrics significantly enhances their elongation properties, making them more stretchable and durable under stress.

IV. CONCLUSION

The results of the study have brought to the following concluding remarks:

- the inclusion of elastane increases the fabric's flexibility and stretch but results in a reduction in breaking strength.
- pure polyester fabric exhibits the highest breaking strength, particularly in the wales (vertical) direction.
- adding elastane to polyester fabrics significantly enhances their elongation properties, making them more stretchable and durable under stress.

The outcomes of the study are further to be used when designing highly functional materials for optimal performance of athletes.

ACKNOWLEDGMENT

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Hydrothermal Synthesis and Photocatalytic Evaluation of Ternary MgO/ZnO/Co3O4 Nanocomposites

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Abstract – A simple method for synthesising efficient ternary nanocomposites samples based on Mg, Zn and Co has been divesting using hydrothermal method, Mg molar fractions were varied to observe their effect on the nanostructured materials. The nanocomposites were characterized using structural. XRD diffraction confirmed the formation of different complex crystalline nanocomposite phases MgO, ZnO, Co_3O_4, while FTIR, identified the vibration modes and provided information on functional groups and chemical bands present in samples. An investigation into the photocatalytic degradation of methylene blue (MB) in an aqueous environment using nanocomposites containing magnesium (Mg), zinc (Zn), and cobalt (Co) revealed a composition-dependent photocatalytic efficiency. Notably, the nanocomposite with the highest Mg content exhibited superior photocatalytic activity compared to the initial sample with a lower Mg concentration. This enhanced performance can be attributed to the advantageous electronic properties and increased surface area associated with Mg. These factors promote the generation of reactive oxygen species (ROS) under light irradiation, leading to more efficient MB degradation. Furthermore, a synergistic effect between Mg and the other constituent elements may contribute to improved charge carrier separation and reduced recombination rates of photogenerated electron-hole pairs. This ultimately translates to a faster degradation of the MB pollutant. As a result, Mg-rich nanocomposites hold significant promise as efficient photocatalysts for water treatment applications.

Keywords – Hydrothermal synthesis, X-Ray Diffraction, Nanostructure, mixed-phase, photocatalysis

I. INTRODUCTION

Nanocomposites have garnered significant attention in recent years due to their unique properties and potential applications across various fields, including environmental remediation, energy conversion, and catalysis [1-2]. Photocatalysis has emerged as a promising and eco-friendly technique for the degradation of many organic pollutants[3]. However, current photocatalytic systems face challenges that limit their industrial applications, such as limited visible light utilization, rapid charge recombination, and the low migration ability of photo-generated electrons and holes [4]. To address these issues, various elements, including noble metals, transition metals, non-metals, and metalloids (e.g., graphene, carbon nanotubes, and carbon quantum dots), are doped into photocatalysts as co-catalysts to enhance photodegradation performance [4].

Photocatalysis activity operates through two primary mechanisms: oxidation and reduction reactions in the presence of a photocatalyst. Efficient photocatalytic reactions require photogenerated holes in the valence band (VB) with high oxidation power and photogenerated electrons in the conduction band (CB)

with sufficient reduction power. These fundamental processes can be illustrated using the photocatalytic degradation of organic dyes such as Methylene Blue (MB) [5].

Magnesium oxide (MgO), zinc oxide (ZnO), and cobalt oxide (Co_3O_4) are three vital transition metal oxides (TMOs) widely reported for various applications, including CO oxidation, photocatalysis, biosensors, supercapacitors, fuel cells, batteries, and solar cells [6]. These TMOs are favored due to their physiochemical and electrocatalytic properties, such as their high surface-to-volume ratio, chemical stability, structural variety, non-toxicity, and intrinsic catalytic activity. Mixed metal oxides (MMOs), which consist of two or three transition-metal cations in various nanostructures, have attracted significant attention in electroanalytical techniques due to their improved electrocatalytic activity compared to their individual component oxides [6] [7].

The synthesis of MMOs has been reported using various methods, including the sol-gel technique, the molten salt method, co-precipitation, electrospinning, and the hydrothermal method. In this work, we demonstrate a one-pot hydrothermal synthesis of MgO/ZnO/Co_3O_4 ternary mixed metal oxides. The aim of this study is to synthesize samples of MgO/ZnO/Co_3O_4 nanocomposites using the hydrothermal method and evaluate their photocatalytic activity for the degradation of Methylene Blue dye. This research seeks to enhance our understanding of photocatalytic mechanisms and improve the performance of nanocomposite photocatalysts for environmental applications.

II. Materials and Method

1. Sample preparation

A single-step hydrothermal synthesis method was utilized to fabricate a magnesium-zinc-cobalt (Mg-Zn-Co) ternary nanocomposite oxide. Stoichiometric amounts of magnesium acetate tetrahydrate ($Mg(CH_3COO)_2 \cdot 4H_2O$), zinc acetate dihydrate ($Zn(CH_3COO)_2 \cdot 2H_2O$), cobalt acetate tetrahydrate ($Co(CH_3COO)_2 \cdot 4H_2O$), and urea ($CH_4N_2O$) in a 1:1:1:1 molar ratio were employed as precursors. These precursors were dissolved in deionized (DI) water under continuous stirring to achieve a homogeneous solution. The resulting mixture was maintained at ambient temperature for 30 minutes to ensure complete dissolution and mixing of the precursors.

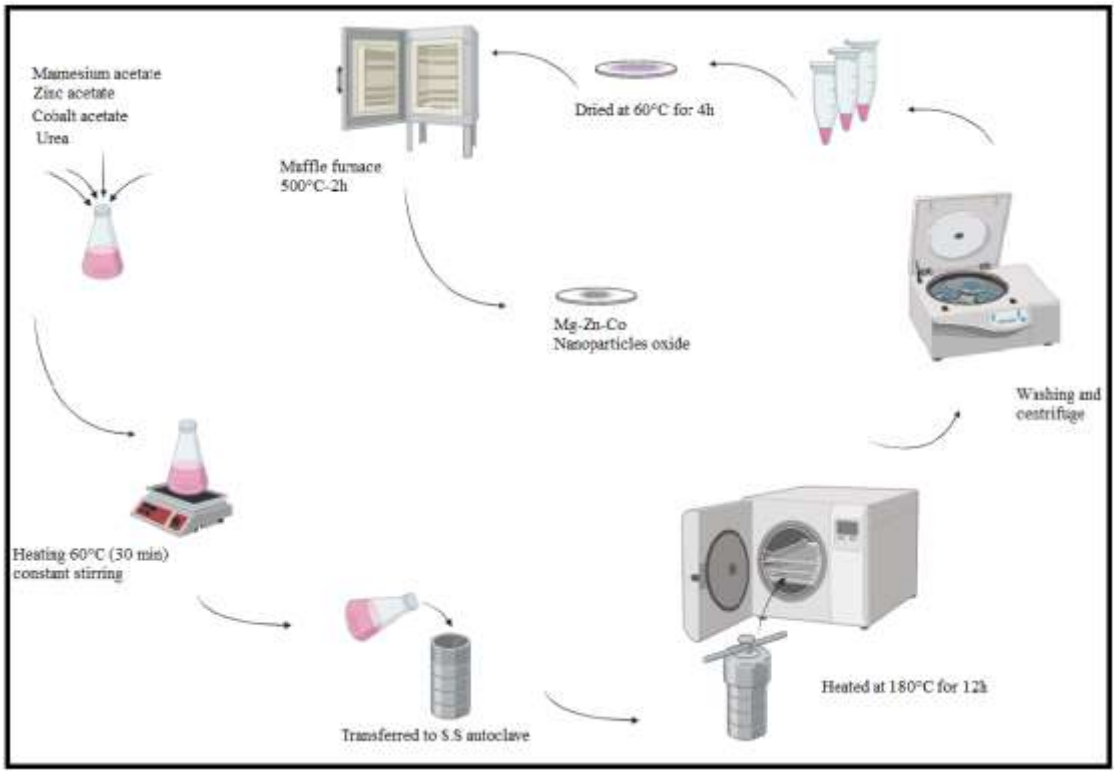


Figure 1. Synthesis of Mg-Zn-Co nanocomposite oxide by Hydrothermal method

Subsequently (Figure 1), the homogeneous solution was transferred to a Teflon-lined stainless steel autoclave and subjected to hydrothermal treatment at 180 °C for 12 hours. Upon completion of the reaction, the autoclave was allowed to cool naturally to room temperature. The resultant solid product was isolated by centrifugation, followed by thorough washing with DI water and ethanol to remove any residual byproducts or unreacted precursors. The washed product was then dried in an oven at 60 °C for 4 hours to eliminate residual solvent. Finally, the result powder was subjected to calcination at 500 °C for 2 hours in air to yield the Mg-Zn-Co nanocomposite oxide. Following the same experimental protocol, three samples with different Mg compositions are prepared, as given by Table 1.

Table 1. Molar fraction ternary samples composition

Samples	**ECH 1**	**ECH 2**	**ECH 3**
Mg:Zn:Co	1 :1 :1	2 :1 :1	3:1 :3

2.a. Characterization methods

The crystallographic phases present in the synthesized nanocomposites were meticulously analyzed using X-Ray Diffraction (XRD) and Fourier Transform Infrared (FT-IR) spectroscopy. XRD measurements were performed on an XPERT-PRO diffractometer to investigate the crystal structure and identify the presence of specific crystalline phases. The diffractometer was operated under controlled conditions with a Cu Kα radiation source (λ = 1.5405 Å) at an accelerating voltage of 45 kV and a current of 40 mA. The diffraction patterns were collected over a 2θ range of 10° to 80° with a step size and scan rate optimized for peak resolution and data quality. The measurements were conducted at a constant temperature of 25 °C to ensure reproducibility. In addition to XRD analysis, FT-IR spectroscopy was employed using a Jasco FT/IR-6300 instrument to characterize the functional groups present in the nanocomposite samples. FT-IR spectra were acquired in the mid-infrared region (400-4000 cm^{-1}) with a high resolution of 4 cm^{-1} for accurate identification of vibrational modes. The scanning speed was set at 2 mm/s to optimize the signal-to-noise ratio, particularly for analyzing surface functional groups.

2.b. Photocatalytic activity measurements

For the investigation of the photocatalytic properties of Mg-Zn-Co nanocomposites, methylene blue (MB) was selected as a model water pollutant. The degradation of MB by Mg-Zn-Co nanocomposites was conducted in a photocatalytic reactor equipped with a 265 nm visible lamp and a quartz tube with a capacity of 100 mL. An aqueous solution of MB (100 ppm) and the fabricated catalyst (10 mg) were subjected to photocatalysis in the quartz reactor at ambient temperature under UV light irradiation.

Prior to irradiation, the prepared suspension was sonicated in the dark to ensure proper dispersion and to establish adsorption–desorption equilibrium between MB and the catalyst. Following this, 2 mL of the centrifuged solution was extracted from the reactor, and its absorbance was measured using a UV-Vis spectrophotometer. The absorbance was recorded at a wavelength of 649 nm within the spectral range of 300–800 nm over a period of 170 minutes.

III. RESULTS AND DISCUSSION

1. XRD Results

The X-ray diffraction (XRD) patterns presented in Figure 2 confirm the formation of crystalline phases corresponding to magnesium oxide (MgO), zinc oxide (ZnO), and cobalt oxide (Co_3O_4) in the synthesized nanocomposites. The MgO phase is identified by its characteristic diffraction peaks at 2θ values of 37.0°, 42.9°, 61.9°, and 64.3°, corresponding to the (111), (200), (220), and (544) reflections of a single-phase

cubic system (JCPDS database card numbers: 087-0653, 030-0794). The Co_3O_4 phase exhibits cubic crystal structure, as evidenced by peaks at 30.8°, 37.9°, 47.5°, 51.0°, 55.4°, 56.3°, 65.2°, and 73.9°, which can be indexed to the (220), (311), (400), (422), (511), (440), (531), and (642) planes, respectively (JCPDS database card numbers: 74-1656, 80-1443, 30-1533). Additionally, the XRD pattern reveals the presence of ZnO nanoparticles with a hexagonal crystal structure, evident from peaks at 31.7°, 34.4°, 68.3°, 72.7°, and 76.0°, corresponding to the (100), (002), (101), (004), and (200) reflections (JCPDS database card numbers: 75-1565, 79-0205).

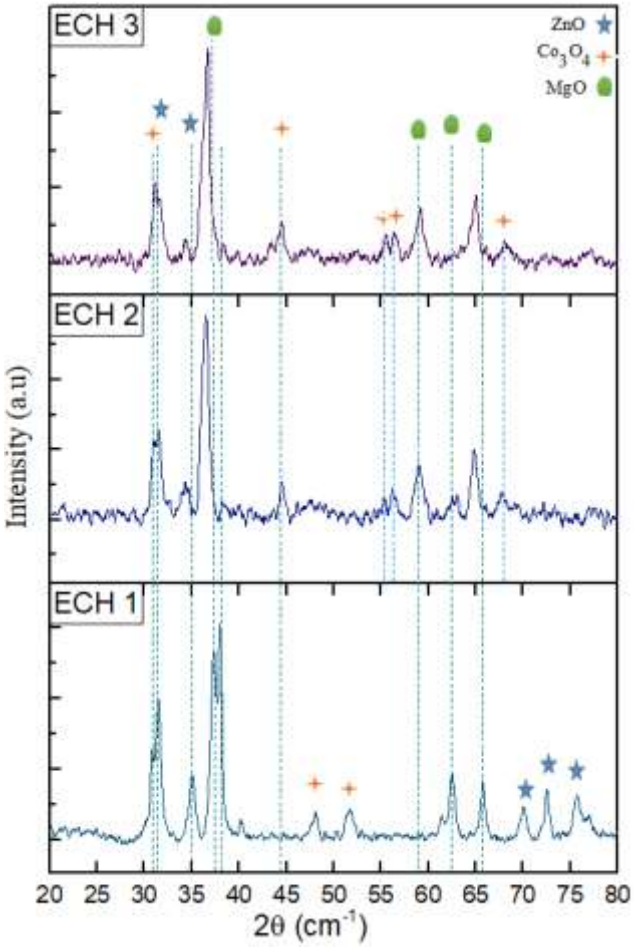


Figure 2. XRD pattern for the samples synthesis

It is worth noting that the observed variations in peak intensities within the XRD patterns can be attributed to two key factors. Firstly, differences in the magnesium concentration between the samples can influence the relative abundance of each crystalline phase. Secondly, the interaction and mutual influence between the three metal oxide phases: MgO, ZnO, and Co_3O_4 may also contribute to these intensity variations. These interactions, along with changes in concentration, can affect the crystal structure and preferential orientation of the crystallites within the samples, ultimately leading to the observed variations in the diffraction patterns.

The Scherrer equation (1) was employed to calculate the crystallite size of the samples [8]:

$$D = \frac{K\lambda}{\beta COS\theta} \qquad (1)$$

Where D id the crystallite size, K is a dimensionless ship factor (0.9), λ is the X-ray wavelength (1.5406), θ is the Bragg angle, and β is the full width at half maximum intensity (FWHM).

Table 2. Average crystallite size of the synthesized samples

Crystallite size	Samples		
	ECH1	ECH2	ECH3
D(nm)	13.91	15.13	15.16

This analysis revealed an initial crystallite size of 13.91 nm. Interestingly, an increase in magnesium concentration (Figure 3) resulted in a larger crystallite size of 15.13 nm and 15.16. The introduction of magnesium may have promoted the growth of larger crystallites through two possible mechanisms. Firstly, the presence of additional magnesium ions could provide more nucleation sites, facilitating the formation of a greater number of crystallites [9]. Secondly, magnesium might enhance the diffusion processes during crystal formation, allowing existing crystallites to grow larger [10]. Furthermore, the interaction between magnesium ions and the other metal oxides (ZnO and Co_3O_4) could also influence the crystallization dynamics. This interaction might facilitate the aggregation and subsequent growth of existing crystallites.

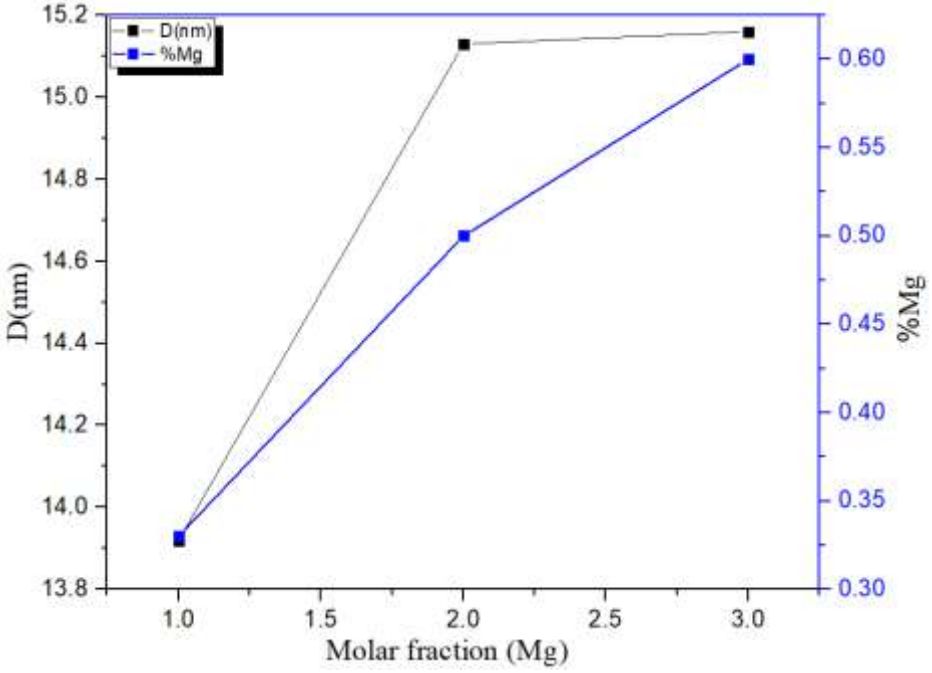


Figure 3. Comparison between the percentage of Mg in the samples and the size of the crystallites in them

2. Ftir spectroscopy

Figure 4 presents the Fourier Transform Infrared (FTIR) spectra of the ternary nanocomposites synthesized using the hydrothermal method. These spectra reveal the characteristic vibrational modes of the chemical bonds present within the materials. Several absorption peaks are observed, including a prominent band at 2330 cm^{-1}. This band can be deconvoluted into two contributing peaks at 2337.3 cm^{-1} and 2360.4 cm^{-1}, which are present in all spectra. The combined band is attributed to the C-O bond stretching vibration, suggesting the presence of adsorbed carbon dioxide (CO_2) from the surrounding atmosphere [11]. Additionally, a peak at 495 cm^{-1} is observed in all spectra, corresponding to the Mg-O bond in the MgO phase [12]. Notably, the intensity of this peak varies with the composition of the samples, being particularly pronounced in samples 2 and 3, which contain the highest magnesium content. Another peak associated with the MgO phase is observed at 548 cm^{-1} in the spectrum of sample 1[13]. Additionally, the peaks located at 560 cm^{-1}, 575 cm^{-1} and 662 cm^{-1} in the spectra of MgZnCo ternary nanocomposites are associated respectively with OB3 (B represents Co^{3+} in an octahedral hole) and ABO (A represents Co^{2+} in a tetrahedral hole) in the in the Co_3O_4 phase [14] [15]. Finally, peaks at 500, 510, and 557 cm^{-1} appear in most spectra, corresponding to vibrations of the Zn-O bond in the ZnO phase [16] [17] [18].

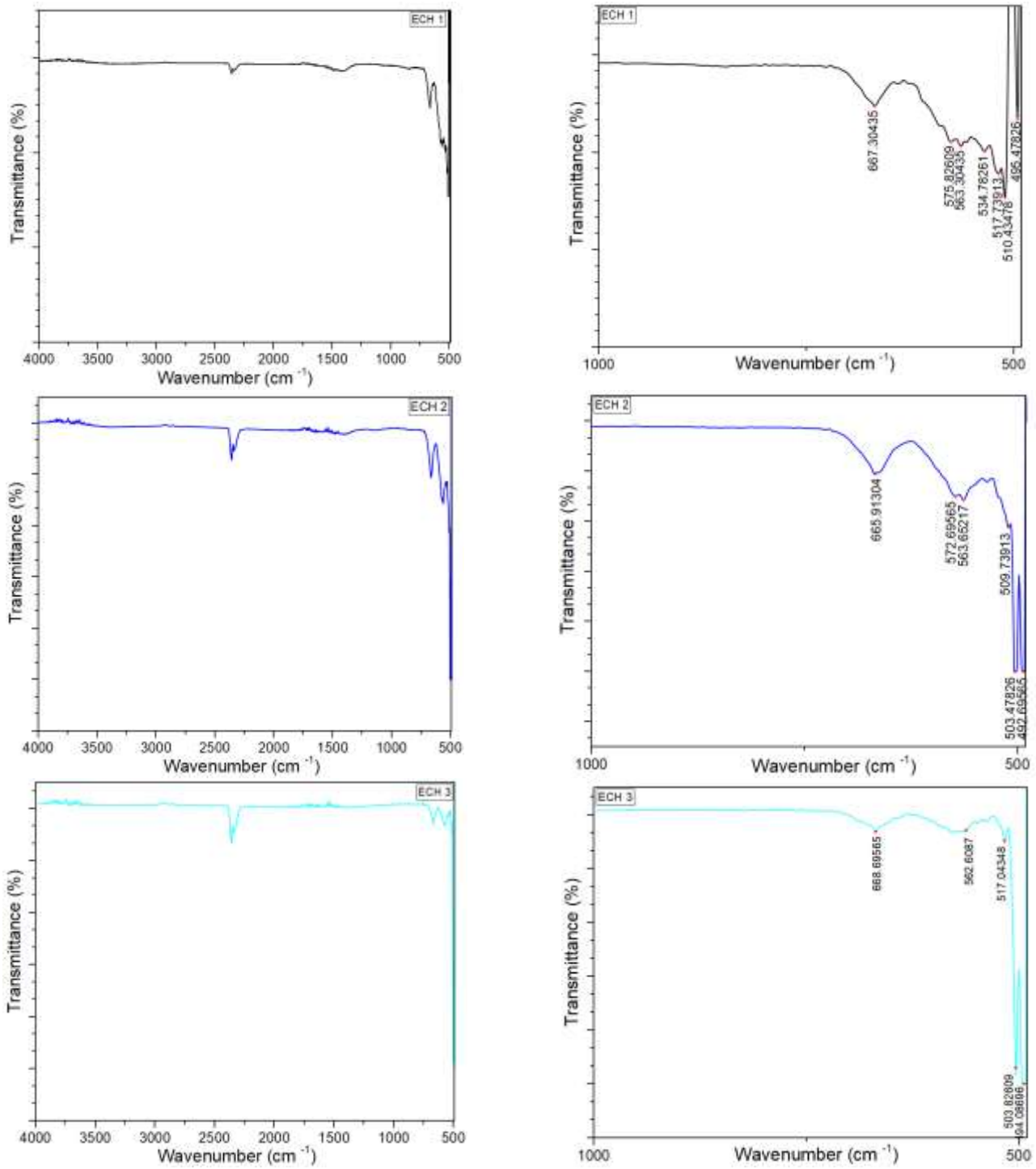


Figure 4. FTIR spectra of the studied samples

3. Photocatalytic degradation of MB

The photocatalytic properties of Mg-Zn-Co nanocomposites with varying cobalt concentrations were investigated through the decomposition of methylene blue (MB). The photodegradation of MB was studied by monitoring changes in absorbance at a wavelength of 649 nm at different time intervals. Figure 5 illustrates the time-dependent absorption spectra of MB aqueous solutions under visible light irradiation with Mg-Zn-Co nanocomposites.

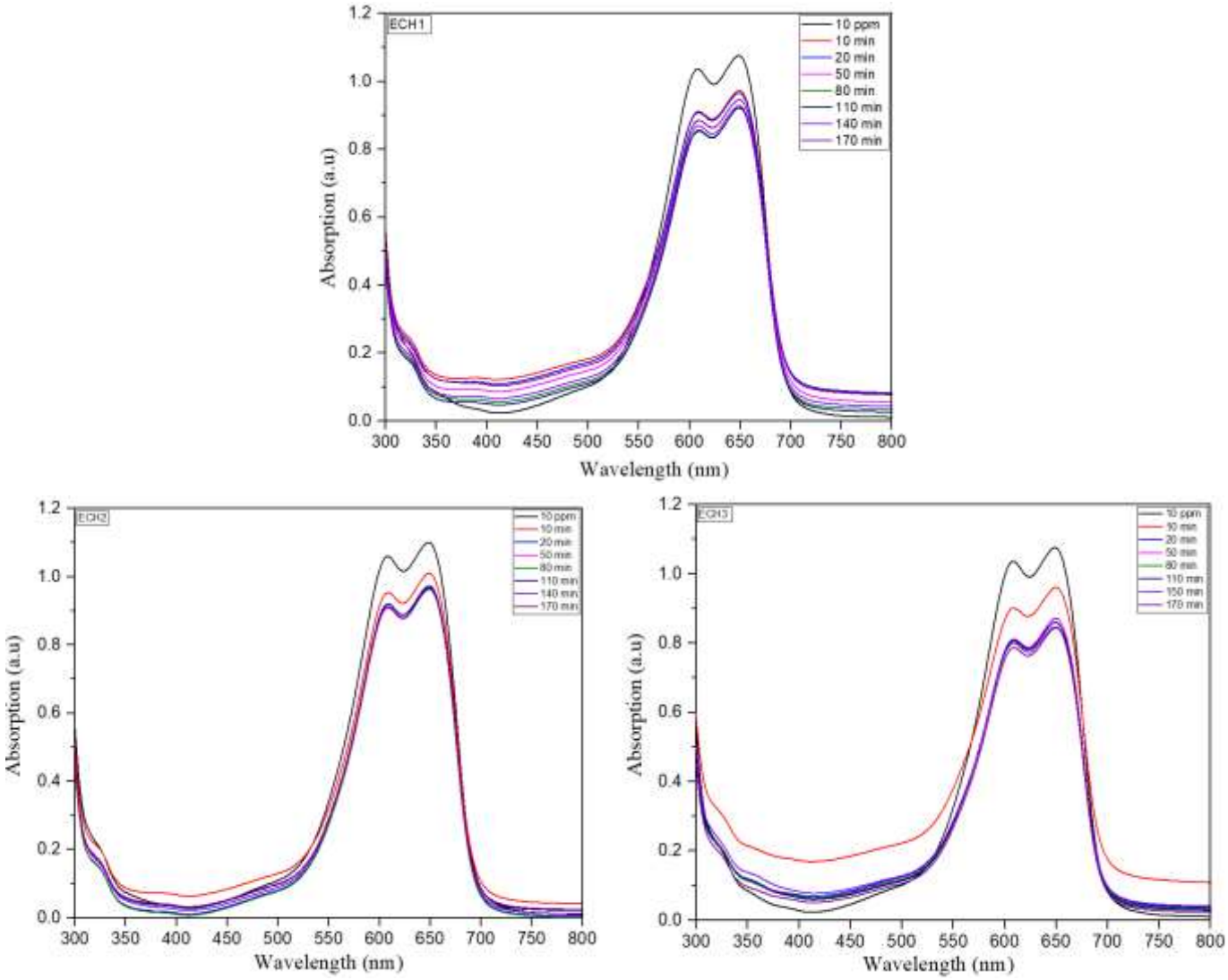
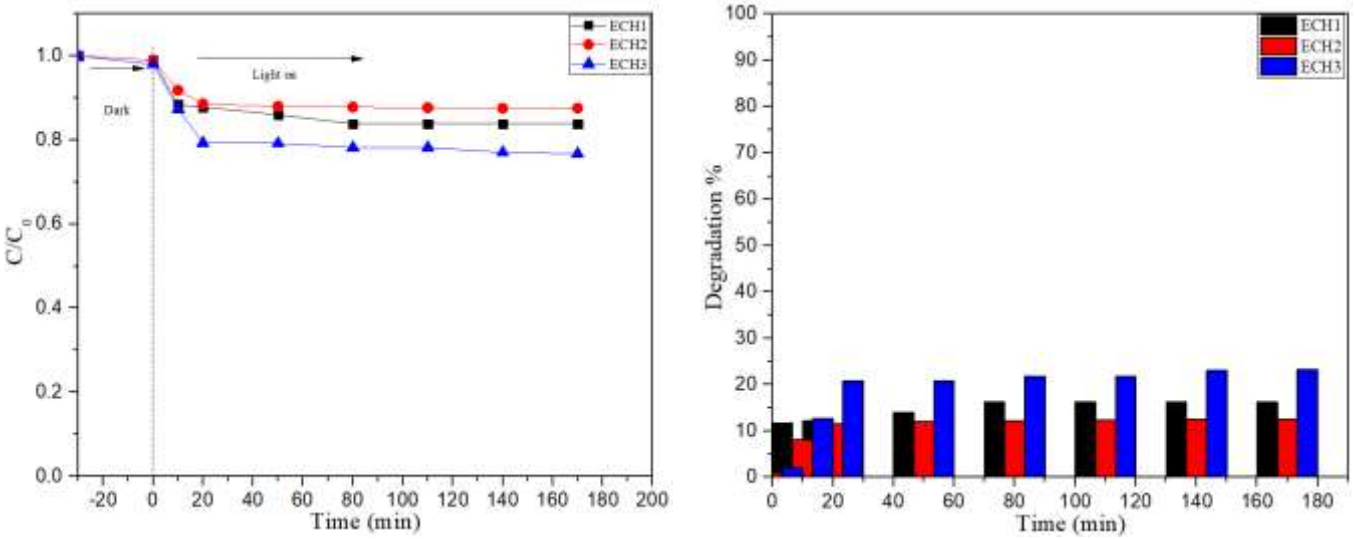


Figure 5. UV–visible absorption spectra of photodegradation of MB for the nanocomposites samples

Analysis of the curves in Figure 5 reveals a slight decrease in the purification percentage, with the absorbance (DO) of MB reducing from 1.1 to 0.83 (ECH1), 0.87 (ECH2), and 0.76 (ECH3). It is evident from Figures 6.a that higher magnesium concentrations in the nanocomposites (ECH3) yield improved photocatalytic performance compared to the initial sample (ECH1). Specifically, the maximum absorbance of the MB solution decreased with increased illumination time, and the maximum degradation (~24 %) was achieved after 170 minutes of irradiation for ECH3.

To further elucidate the relationship between photocatalysis and cobalt concentration in Mg-Zn-Co nanocomposites, studies on the relative concentration (C/C_0) of MB were conducted. Figure 6.b depicts the relative concentration (C/C_0) of MB as a function of irradiation time, where C represents the concentration of MB at a given irradiation time (min), and C_0 denotes the initial dye concentration before irradiation. During the magnetic stirring of the suspensions in the dark for 30 minutes to establish adsorption/desorption equilibrium of MB on the sample surfaces, only a slight decrease in MB concentration was observed. This indicates that the adsorption of MB on the nanocomposite surfaces is limited after equilibrium is reached [19].



(a) (b)

Figure 6. (a) C/C_0 vs time (min) plot for the photodegradation of MB, and (b) Percentage degradation of MB dye as a function of time (min)

With the light on and in the sample containing the highest concentration of magnesium, magnesium can influence the band gap of the photocatalyst material, potentially optimizing it for better light absorption, particularly in the visible range. This improved light absorption can lead to a higher generation of electron-hole pairs, which are essential for photocatalytic reactions [19] [20]. Additionally, Mg may enhance charge separation by introducing favorable defects or altering the electronic structure of the photocatalyst. Improved charge separation reduces the recombination rate of electrons and holes, allowing more charge carriers to participate in the degradation of MB [21]. Furthermore, Mg can affect the morphology and surface area of the photocatalyst, with a higher surface area providing more active sites for the photocatalytic reaction, resulting in more efficient MB degradation [22]. Finally, the interaction between Mg, Zn, and Co could produce synergistic effects that enhance overall photocatalytic performance. Mg might modify the electronic structure or surface properties of Zn and Co, leading to improved photocatalytic activity.

IV. CONCLUSION

This study aimed to synthesize mixed metal oxide (MMO) ternary nanocomposites based on Mg, Zn, and Co using the hydrothermal method and to investigate their photocatalytic activity. By varying the Mg molar fractions, the effects on the nanostructured materials were observed. The resulting nanocomposites were thoroughly characterized using various techniques. X-ray diffraction (XRD) confirmed that the samples had a complex crystalline structure consisting of various crystalline phases, including MgO, Co_3O_4, and ZnO, and indicated variations in the average sizes of the nanoparticles. Fourier transform infrared spectroscopy (FTIR) identified the vibration modes and provided information on the functional groups and chemical bonds present in the samples. The photocatalytic activity of the nanocomposites was tested using Methylene Blue (MB) as a model pollutant. The results showed a reduction in the absorbance (DO) of MB from 1.1 to 0.83 (ECH1), 0.87 (ECH2), and 0.76 (ECH3), indicating that higher magnesium concentrations in the nanocomposites (ECH3) yielded improved photocatalytic performance compared to the initial sample (ECH1). Specifically, the maximum absorbance of the MB solution decreased with increased illumination time, and the maximum degradation (~24%) was achieved after 170 minutes of irradiation for ECH3. These findings suggest that the synthesized MgO/ZnO/Co_3O_4 nanocomposites are future effective photocatalysts with potential applications in environmental remediation and pollutant degradation.

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Diyabet Tedavisinde Kullanılan Beksagliflozin'in Moleküler Yapısının Kuantum Kimyasal Yöntemle İncelenmesi

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Özet **–**Diyabet, vücudun kan şekeri seviyelerini düzenleme yeteneğini etkileyen kronik bir hastalıktır ve tedavi edilmediğinde veya yetersiz yönetildiğinde çeşitli ciddi komplikasyonlara yol açabilmektedir. Beksagliflozin, diyabet tedavisinde kullanılan ve yeni piyasaya sürülen bir etken maddedir. Bu çalışmada Beksagliflozin'in moleküler yapısını, elektronik özelliğini ve kimyasal reaktivitesini daha detaylı incelemek amacıyla kuantum kimyasal hesaplamaları gerçekleştirilmiştir. Beksagliflozin'in optimize moleküler geometrisi, B3LYP fonksiyoneli ve 6-311G(d,p) temel seti ile DFT yöntemi uygulanarak hesaplanmıştır. Molekülün moleküler elektrostatik potansiyel (MEP) diyagramı ve sınır moleküler orbitalleri (HOMO/LUMO) de aynı metot ve temel set kullanılarak elde edilmiştir. Moleküler elektrostatik potansiyel diyagramından Beksagliflozin'in yapısındaki elektrostatik potansiyelin yüksek ve düşük olduğu bölgeler belirlenmiştir. Gerçekleştirilen hesaplamalar molekülün HOMO-LUMO bant boşluk enerjisi değerinin 5,280 eV olduğunu göstermiştir. Beksagliflozin'in molekül içi kovalent olmayan etkileşimleri (NCI) de hesaplanmış ve yapıda bulunan hidrojen bağı, Van der Waals etkileşimi ve sterik etki içeren bölgeleri belirlenmiştir. Moleküldeki kovalent olmayan etkileşimlerin yerlerini, türlerini belirlemek ve görselleştirmek için indirgenmiş yoğunluk gradyanı (RDG) analizi de gerçekleştirilmiştir.

Anahtar Kelimeler – Diyabet, DFT, sınır moleküler orbital, kuantum mekanik, MEP

I. GİRİŞ

Diyabet, dünya genelinde milyonlarca insanı etkileyen kronik bir metabolik hastalıktır ve tip 1 ve tip 2 olmak üzere iki ana formda görülür. Tip 1 diyabet, genellikle çocukluk veya gençlik yıllarında ortaya çıkar ve bağışıklık sisteminin pankreastaki insülin üreten beta hücrelerine saldırması sonucu gelişir. Bu durumda vücut yeterince insülin üretemez ve kan şekeri seviyeleri yükselir. Tip 2 diyabet ise daha çok yetişkinlerde görülür ve genellikle obezite, hareketsiz yaşam tarzı ve genetik faktörlerin birleşimiyle ortaya çıkmaktadır. Bu formda, vücut insüline karşı direnç geliştirir ve pankreas yeterince insülin üretemez. Diyabetin kontrol altına alınmaması durumunda kalp hastalıkları, böbrek yetmezliği, görme kaybı ve sinir hasarı gibi ciddi komplikasyonlara yol açabilir [1].

Beksagliflozin, SGLT2 inhibitörleri olarak bilinen bir grup ilaçtan biridir ve diyabet tedavisinde kullanılmaktadır. Bu tür ilaçlar, idrarda glukoz atılımını artırarak kan şekeri düzeylerini düşürmeye yardımcı olur. Beksagliflozin, özellikle tip 2 diyabet tedavisinde kullanılmaktadır ve hastaların kan şekeri kontrolünü sağlamalarına yardımcı olmaktadır. SGLT2 inhibitörleri, böbreklerdeki SGLT2 proteinini hedef almaktadır. Bu protein glukozun böbreklerde geri emilmesini sağlar, böylece glukoz idrarda atılmamakta ve tekrar kan dolaşımına geri dönmektedir. Beksagliflozin ise, SGLT2 proteinini inhibe ederek bu geri emilimi engeller. Bu durumda daha fazla glukoz idrarla atılmakta ve kan şekeri düzeyleri düşmektedir [2]. Bu çalışmada Beksagliflozin'in bazı kuantum kimyasal hesaplamaları gerçekleştirilmiştir.

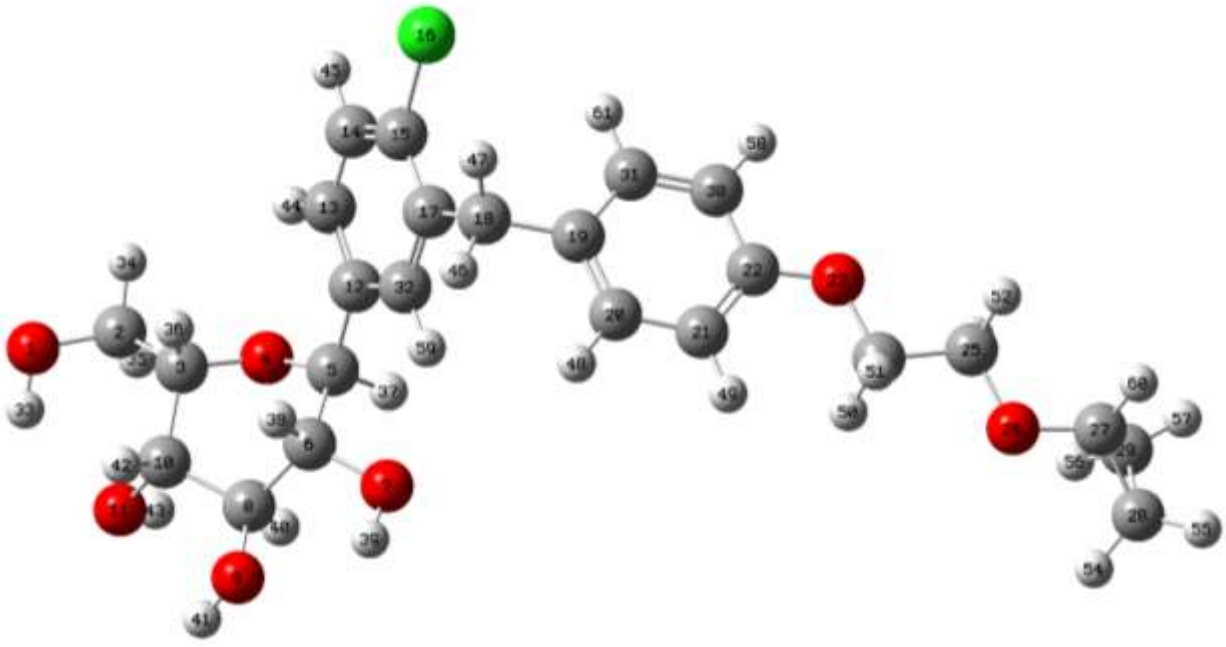
II. MATERYAL VE YÖNTEM

Beksagliflozin'in tüm kuantum kimyasal hesaplamaları Gaussian 09 paket programı kullanılarak yapılmıştır [3]. Moleküle ait görüntüleme işlemleri ise GaussView 5.0.9 programı yardımıyla gerçekleştirilmiştir [4]. Molekülün optimize moleküler geometrisi DFT/B3LYP/6-311G(d,p) seviyesinde hesaplanmıştır [5], [6]. Beksagliflozin'in moleküler elektrostatik potansiyel diyagram ve sınır moleküler orbital hesaplamaları da yine DFT/B3LYP/6-311G(d,p) seviyesinde gerçekleştirilmiştir. Molekülün molekül içi kovalent olmayan etkileşimleri (NCI) ve indirgenmiş yoğunluk gradyanı çalışmaları Multiwfn 3.8 yazılımı ile incelenmiş ve elde edilen sonuçlar VMD 1.9.4a53 programı kullanarak görüntülenmiştir [7], [8].

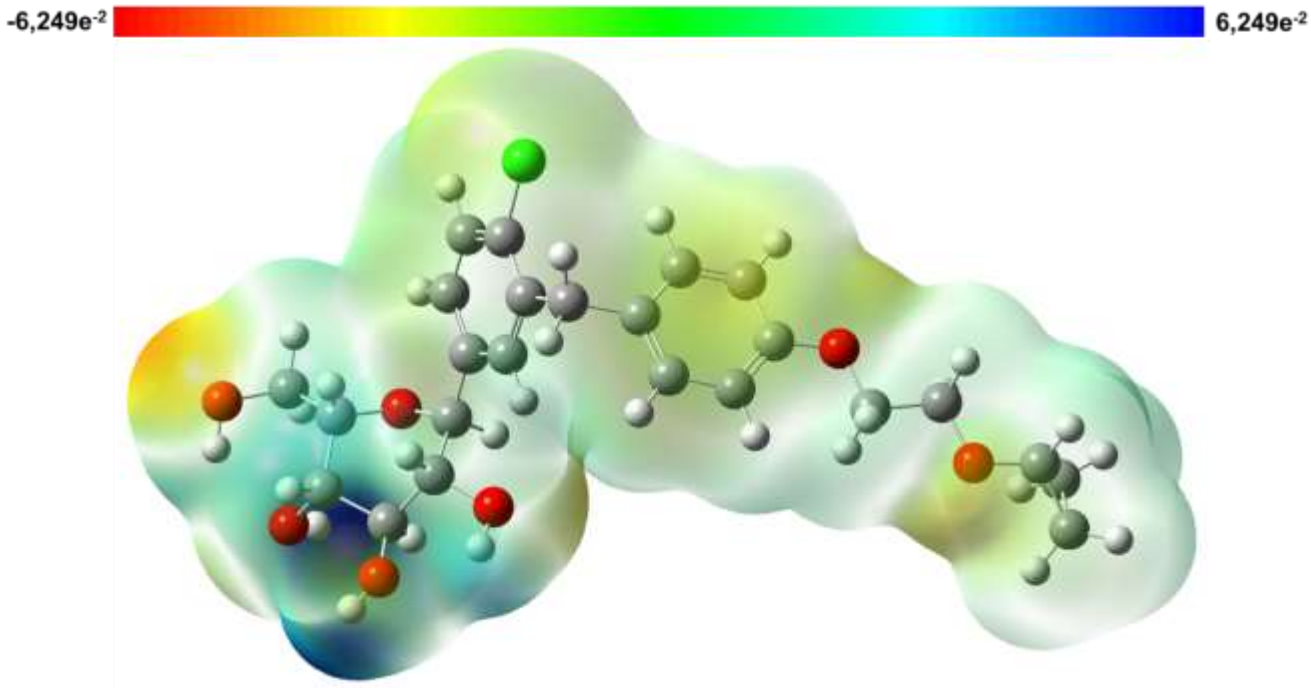
III. BULGULAR

Tablo 1. Beksagliflozin'in DFT/B3LYP/6-311G(d,p) seviyesinde hesaplanmış optimize moleküler geometrisine ait seçilmiş bazı geometrik parametreler

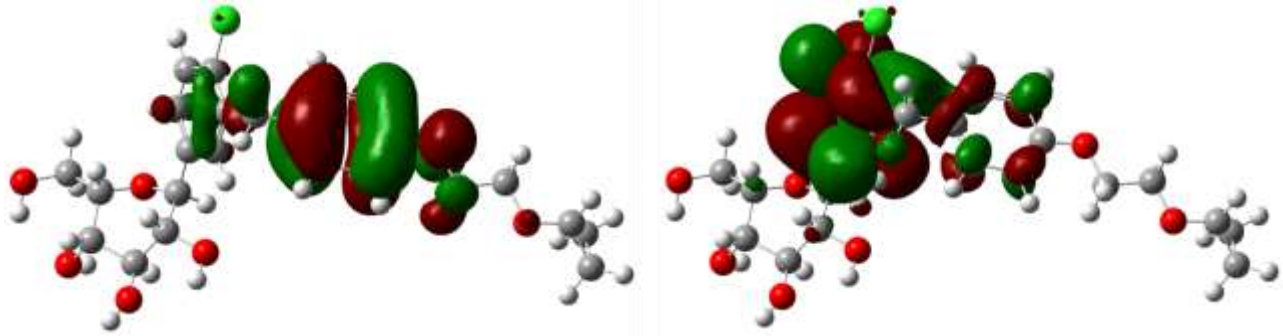
Bağ Uzunluğu (Å)	
O4-C5	1,435
C3-C2	1,531
C5-C12	1,524
C15-Cl16	1,770
C22-O23	1,366
C27-C28	1,492
Bağ Açısı (º)	
C3-O4-C5	113.7
C3-C2-O1	111,9
C17-C18-C19	113,6
C24-C25-O26	106,9
Dihedral Açısı (º)	
O4-C5-C12-C13	-15,3
C15-C17-C18-C19	-102.5
C21-C22-O23-C24	0,6
O23-C24-O25-C26	-179,6



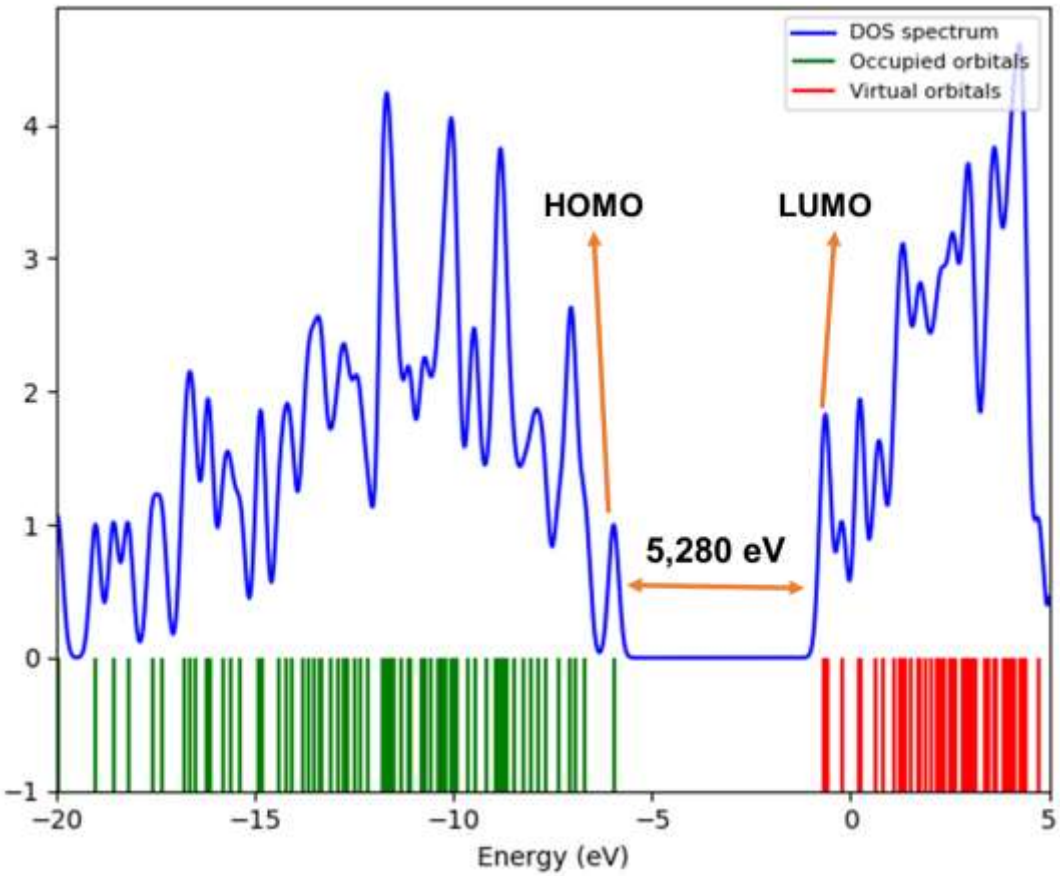
Şekil 1. Beksagliflozin'in DFT/B3LYP/6-311G(d,p) seviyesinde hesaplanmış optimize moleküler geometrisi



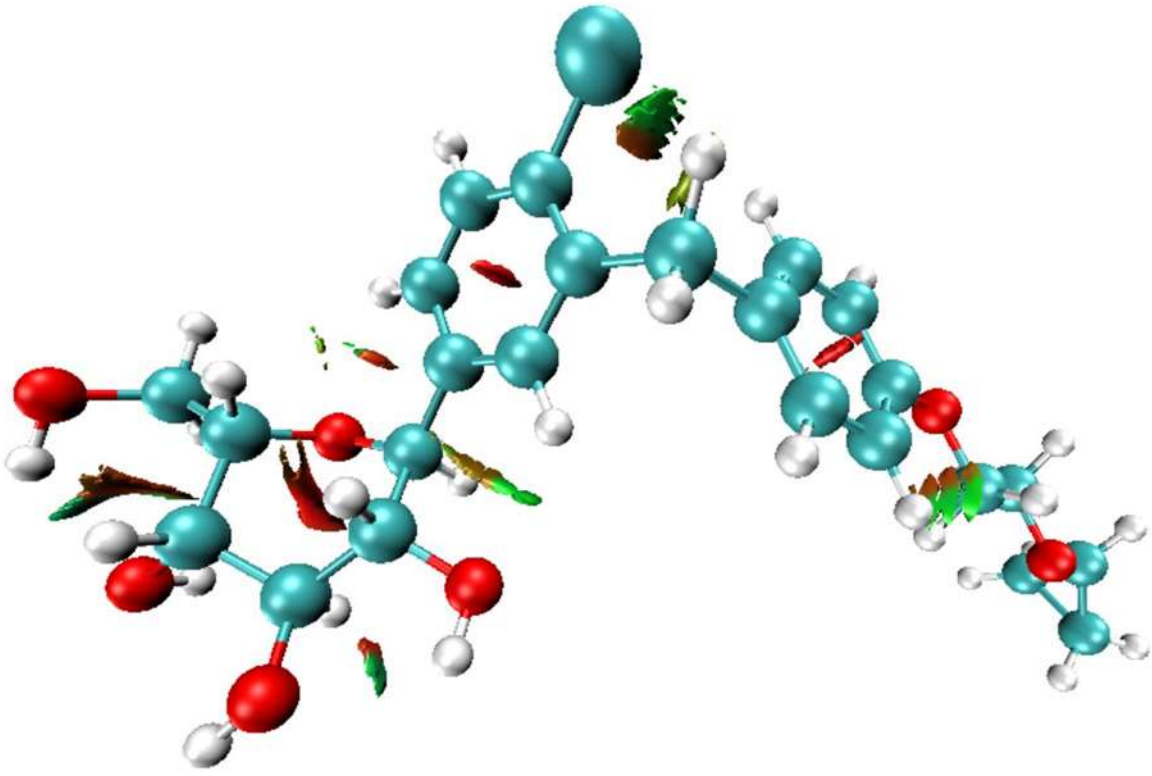
Şekil 2. Beksagliflozin'in DFT/B3LYP/6-311G(d,p) seviyesinde hesaplanmış MEP diyagramı



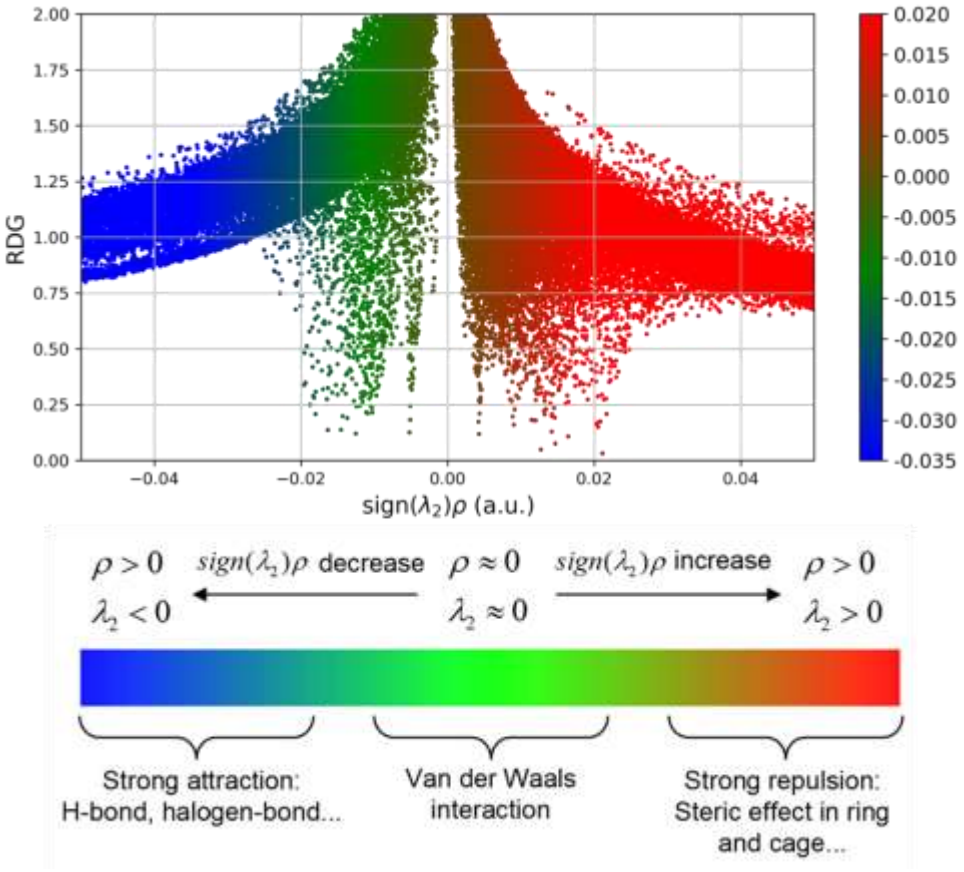
Şekil 3. Beksagliflozin'in DFT/B3LYP/6-311G(d,p) seviyesinde hesaplanmış HOMO (solda) ve LUMO (sağda) orbitalleri



Şekil 4. Beksagliflozin'in DFT/B3LYP/6-311G(d,p) seviyesinde hesaplanmış TDOS grafiği



Şekil 5. Beksagliflozin'in molekül içi kovalent olmayan etkileşimleri (NCI)



Şekil 6. Beksagliflozin'in indirgenmiş yoğunluk gradyanı (RDG) grafiği

IV. TARTIŞMA

Beksagliflozin'in moleküler geometrisinin optimizasyonu DFT/B3LYP/6-311G(d,p) seviyesinde gerçekleştirilmiş ve elde edilen geometri Şekil 1'de gösterilmiştir. Bu moleküler geometriden elde edilen seçilmiş bağ uzunluğu, bağ açısı ve dihedral açısı değerleri ise Tablo 1'de verilmiştir. Molekülün tetrahidropiran (oksan) halkası içinde yer alan O4-C5 bağ uzunluğu 1,435 Å olarak hesaplanmıştır. Tetrahidropiranın kendisine bağlı alkol ve klorofenil birimleri ile yapmış olduğu C3-C2 ve C5-C12 bağ uzunlukları sırasıyla 1,531 ve 1,524 Å olarak elde edilmiştir. Klorofenil ve bu yapıya bağlı oksijen atomunun oluşturduğu C22-O23 bağının uzunluğunun ise 1,366 Å olduğu belirlenmiştir. Beksagliflozin'in bağ açıları incelendiğinde tetrahidropiran halkası içindeki C3-O4-C5 ve bu halkanın alkol birimi ile yapmış olduğu C3-C2-O1 bağ açıları sırasıyla 113.7° ve 111,9° olarak bulunmuştur. Yapıdaki iki fenil grubu arasındaki C17-C18-C19 bağ açısı 113,6°, eterik yapıda bulunan C24-C25-O26 bağ açısı ise 106,9° olarak hesaplanmıştır. Yapıdaki tetrahidropiran ve klorofenil birimleri arasında bulunan O4-C5-C12-C13 ve klorofenil ve fenil birimleri arasında yer alan C15-C17-C18-C19 dihedral açısının sırasıyla -15,3° ve -102.5° olması, bu grupların aynı düzlemde bulunmadığını göstermiştir. Diğer taraftan moleküldeki eter biriminde bulunan O23-C24-O25-C26 ve eter ile fenil grubu arasındaki C21-C22-O23-C24 dihedral açısının sırasıyla -179,6° ve 0,6° olarak hesaplanması, bu birimlerin aynı düzlemde bulunduğunu ortaya koymuştur.

Moleküler elektrostatik potansiyel diyagramı (MEP), bir molekülün elektron yoğunluğunun ve elektrostatik potansiyelinin üç boyutlu bir temsilidir. MEP, molekülün farklı bölgelerindeki elektron yoğunluğunun dağılımını görselleştirmek için kullanılmaktadır. Bu diyagramdan elde edilen bilgiler, molekülün kimyasal reaktivitesini, moleküller arası etkileşimlerini ve molekülün biyolojik aktivitesini anlamak için oldukça önemlidir. Beksagliflozin'in hesaplanan MEP diyagramı Şekil 2'de gösterilmiştir. Molekülün MEP diyagramında negatif elektrostatik potansiyelin çok fazla olduğu herhangi bir bölgeye

rastlanmamıştır. Ancak alkol gruplarında yer alan oksijen atomu üzerinde bir miktar kırmızı renkli alanın bulunması, bu bölgelerde orta düzeyde negatif elektrostatik potansiyelin varlığına işaret etmiştir. Diğer taraftan alkol gruplarındaki hidrojen atomu üzerinde gözlenen mavi bölgeler, bu noktalarda pozitif elektrostatik potansiyelin yüksek olduğunu yani bu bölgelerin elektronca fakir bir özelliğe sahip olduğunu göstermiştir. Alkol gruplarındaki oksijen atomunun yüksek elektronegatifliğinin hidrojenle yapmış olduğu kovalent bağı zayıflatmasının böyle bir sonucu ortaya çıkardığı söylenebilir.

HOMO (Highest Occupied Molecular Orbital), bir moleküldeki en yüksek enerjili dolu moleküler orbitaldir. HOMO, bir molekülün elektron verme (oksidasyon) kapasitesini belirlemektedir. HOMO enerjisi ne kadar yüksekse, molekül elektronlarını o kadar kolay verebilir ve bu da molekülün elektron vericilik (nükleofilik) özelliklerini gösterir. Diğer taraftan LUMO (Lowest Unoccupied Molecular Orbital) da bir moleküldeki en düşük enerjili boş moleküler orbitaldir. LUMO, molekülün elektron alma (indirgeme) kapasitesini belirlemektedir. LUMO enerjisi ne kadar düşükse, molekül elektronları o kadar kolay kabul edebilir ve bu da molekülün elektron çekicilik (elektrofilik) özelliklerini göstermektedir. Beksagliflozin'in HOMO'larının daha çok fenil grubu, eter grubu oksijen atomu ve bir miktar da klorfenil birimi üzerinde bulunduğu belirlenmiştir. Bu bölgeler Beksagliflozin'in nükleofilik olarak davranacağı alanlar olduğu düşünülmektedir. Molekülün LUMO'ları ise en çok klorofenil bir miktar da fenil grubu üzerinde yer aldığı görülmüştür. Beksagliflozin'in başka moleküllerle vereceği reaksiyonlarda bu bölgelerin elektrofilik olarak davranabileceği öngörülmüştür (Şekil 3). Beksagliflozin için elde edilen TDOS grafiği Şekil 4'de verilmiş olup bu grafikten hareketle molekülün dolu orbitallerinin çoğunlukla yaklaşık olarak -15 ile -8 eV arasında yer aldığı görülmüştür.

HOMO-LUMO enerji farkı, bir molekülün bazı kimyasal ve fiziksel özelliklerini etkilemektedir. Özellikle HOMO-LUMO enerji farkı, bir molekülün kimyasal reaktivitesini belirlemektedir. Küçük bir enerji farkı, molekülün kolayca uyarılabileceğini ve reaksiyona girebileceğini gösterirken büyük bir enerji farkı ise molekülün daha kararlı ve inert olduğunu ifade etmektedir. Beksagliflozin'in HOMO ve LUMO enerji değerleri sırasıyla 5,969 ve -0,689 eV olarak hesaplanmıştır. Şekil 4'den de görüldüğü üzere molekülün HOMO-LUMO enerji farkı 5,280 eV olarak elde edilmiştir. Molekülün HOMO-LUMO enerji farkının yüksek olduğu gözlenmiştir. Dolayısıyla Beksagliflozin'in sert bir karaktere sahip ve kimyasal reaksiyonlara daha az eğilimli olabileceği sonucuna ulaşılmıştır.

Moleküllerin kovalent olmayan etkileşimlerini (NCI) incelemek için indirgenmiş yoğunluk gradyanı (RDG) grafikleri kullanılmaktadır ve bu grafiklerde mavi, yeşil ve kırmızı bölgeler, farklı etkileşim türlerini ve yoğunluklarını göstermektedir. Beksagliflozin'in NCI ve RDG grafikleri sırasıyla Şekil 5 ve 6'da gösterilmiştir. Moleküldeki tetrahidropiran ve fenil halkalarında kırmızı bölgelerin bulunması bu kısımlarda sterik etkinin varlığına işaret etmiştir. Tetrahidropiran halkası ve bu halkaya bağlı hidroksil gruplarının iç kısımlarında sterik etki, dış kısımlarda ise Van der Waals etkileşimlerinin bulunduğu belirlenmiştir. Beksagliflozin'in yapısında bulunan kovalent olmayan etkileşimlerden hidrojen bağının -0,05 ile -0,02 au, Van der Waals etkileşiminin -0,02 ile 0 au, sterik etkinin ise 0 ile 0.05 au arasında noktasal saçılmaya sahip olduğu belirlenmiştir.

V. SONUÇLAR

Sonuç olarak, bu çalışmada, Beksagliflozin'in moleküler yapısı, elektronik özellikleri ve kimyasal reaktivitesi incelenmiştir. Kuantum kimyasal hesaplamalar kullanılarak yapılan analizler yardımıyla, Beksagliflozin'in optimize moleküler geometrisi, moleküler elektrostatik potansiyel diyagramı ve HOMO-LUMO bant boşluğu belirlenmiştir. Beksagliflozin'in optimize moleküler geometrisi, B3LYP fonksiyoneli ve 6-311G(d,p) temel seti kullanılarak DFT yöntemi ile hesaplanmış ve molekülün HOMO-LUMO bant boşluk enerjisi 5,280 eV olarak bulunmuştur. Moleküler elektrostatik potansiyel diyagramı ile, molekülün yüksek ve düşük elektrostatik potansiyele sahip bölgeleri ortaya konmuştur. Ayrıca, indirgenmiş yoğunluk gradyanı (RDG) analizi ile, moleküldeki kovalent olmayan etkileşimlerin türleri ve

yerleri belirlenmiş, hidrojen bağlarının, Van der Waals etkileşimlerinin ve sterik etkilerin yer aldığı bölgeler görselleştirilmiştir. Elde edilen sonuçlar, Beksagliflozin'in moleküler yapısının ve etkileşimlerinin nasıl olabileceği konusunda bazı bilgiler sunmaktadır. Ayrıca elde edilen bulguların, Beksagliflozin'in diyabet tedavisindeki rolünün daha iyi anlaşılmasına ve konu ile ilgili gelecekteki araştırmalara yön verilmesine yardımcı olabilecek potansiyele sahip olduğunu düşünmekteyiz.

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Protein Metabolizması Bozukluklarının Sağlık Üzerindeki Etkileri: Fenilketonüri (PKU) ve Çölyak Hastalığı

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Özet **–** Proteinler, canlı hücrelerin temel yapı taşlarını oluşturan ve yaşamın devamı için elzem olan organik bileşiklerdir. Metabolik tepkimeleri katalize eden enzimlerin yapısında yer alırlar ve vücudun birçok bölümünde önemli fonksiyonları üstlenirler. Ancak bazı genetik ve metabolik bozukluklar, proteinlerin ve amino asitlerin vücutta doğru bir şekilde işlenmesini engelleyebilir. Bu bozuklukların en dikkat çekici örneklerinden biri fenilketonüri (PKU) olup, fenilalanin hidroksilaz enzimi eksikliği nedeniyle fenilalaninin tirozine dönüştürülememesi sonucu ortaya çıkar. Bu durum, fenilalaninin kanda ve beyinde birikmesine neden olur, bu da ciddi nörolojik hasarlara ve zihinsel geriliğe yol açabilir. Diğer yandan çölyak hastalığı, gluten proteininin sindirilememesi sonucu bağırsaklarda alerjik reaksiyonlar oluşturur ve besin emilimini bozar. Her iki hastalıkta da erken teşhis ve uygun diyet tedavisi hayati öneme sahiptir. PKU'da fenilalanin içeriği düşük diyetler ve çölyak hastalığında glutensiz beslenme, hastaların yaşam kalitesini artırmada kritik rol oynar. Bu nedenle, doğru beslenme ve tedavi yöntemleriyle bu protein temelli hastalıkların etkileri yönetilebilir ve hastaların sağlıklı bir yaşam sürmesine yardımcı olunabilir.

Anahtar Kelimeler – Fenilketonüri (PKU), Çölyak Hastalığı, Protein Metabolizması, Fenilalanin, Gliadin

I. GİRİŞ

Protein kelimesi, eski Yunanca'da "ilk önce gelen" anlamındaki " Proteom" kelimesinden türemiştir. Canlılar için elzem olan bu bileşikler, %50-55 karbon, %6-7 hidrojen, %20-23 oksijen, %12-19 azot ve %0.2-3.0 kükürt içermektedir ve yalnızca ribozomlarda sentezlenirler. Hücrenin temel yapısını oluşturur, yıpranan dokuların onarımını sağlar, enerji kaynağı olarak kullanılır ve vücudu mikroplara karşı savunan antikorların yapısında bulunurlar. Ayrıca hücre içi ve dışı sıvıların ozmotik dengesini sağlar, hemoglobindeki globin kısmını oluşturur ve pH değişikliklerini tamponlarlar. Canlı bir hücrenin kuru ağırlığının %50'sini oluştururlar [1]. Örneğin; karaciğer, yağsız çizgili kas ve böbrek dokularının kuru ağırlığının %70-80'i proteindir. Memelilerin çizgili ve çizgisiz kaslarının %18-20'si, kan plazmasının %6,5-7,5'i, beynin yaklaşık %8'i ve yumurta sarısının %15'i proteinlerden oluşur. Bitkilerde ise yaprak, sap, kök ve yumrularındaki protein miktarı tohumlarına oranla daha azdır. Marulda %1,2, kuşkonmazda %1,8, lahanada %1,6, patateste %2 protein bulunurken bazı hububat ve baklagillerde protein oranı daha yüksektir. Kuru fasulyede %18-22, soya fasulyesinde %37-39 civarında protein bulunur [2,3]. Proteinler, vücut dokularının yapımında ve onarımında görev alırlar. Enzimlerin tümü, hormonların birçoğu ve virüsler protein yapısında yer alır. Vücudun elzem amino asit ihtiyacını giderirler ve gıdaların duyusal özelliklerini ve besleyici değerini belirleyen önemli bir etkendir [3]. Organizmada taşıma ve depolama görevlerinde yer alırlar ve bağışıklık sisteminde görev alarak vücudun kendine ait olan ile olmayanının ayrımında önemli bir rol oynarlar. Canlıda büyüme ve değişimden sorumludurlar.

Amino asitler, değişik kimyasal yapıda bir köke (R) bağlı bir karboksil (COOH) ve bir amin (NH_2) grubundan oluşan organik yapılardır. Birbirleriyle karboksil ve alfa amino gruplarından bir molekül su

çıkararak birleşmeleri ile peptitler oluşur. Bu bağa "peptit bağı" denir ve peptit bağında amino asitlerin diziliş sırası o proteinin özelliğini belirler. Peptit bağlarının sayısı, amino asitlerin türü ve polipeptit içinde bulunma sırası gibi faktörler vücuttaki her organın ve bireyin kendine özgü bir protein yapısını oluşturur. DNA'da meydana gelen herhangi bir bozulma sonucu protein zincirine farklı bir amino asidin gelmesi o proteinin işlevini bozar ve görevini yerine getiremez [5].

Proteinler ve amino asitler canlı hücreler için çok önemliyken bazı hastalıkların temel nedeni olabilmektedir [6]. Örneğin, çölyak hastalığında gluten proteini ve fenilketonüri hastalığında fenilalanin bu duruma örnektir.

A. Amino Asit Metabolizması Bozuklukları

Amino asitler, canlılar için kritik öneme sahip olmasına rağmen bazı metabolik bozukluklara da neden olabilirler. Öne çıkan amino asit metabolizması bozuklukları şunlardır:

- Akçaağaç şurubu hastalığı (MSUD): Lösin, izolösin ve valin amino asitlerinin metabolizmasında yer alan enzimlerin eksikliği veya yokluğundan kaynaklanır. Bu durum ciddi nörolojik fonksiyon bozukluklarına, nöbetlere, komaya, solunum yetmezliğine ve birçok hastada ölüme neden olur. Hayatta kalan hastalar genellikle zihinsel gerilik yaşar. İdrar ve kan örneklerinde yüksek seviyelerde lösin, izolösin ve valin amino asitleri bulunur. İdrarda ise akçaağaç şurubu veya yanmış şeker kokusu hissedilir [7].
- Histidin Metabolizması Bozuklukları: Enzim eksikliği çocukta konuşma kusuru gibi belirtiler gösterir [8].
- Glisin Metabolizması Bozuklukları: Enzim sorunları, çocukluk ya da yetişkinlikte böbrek yetmezliği veya hipertansiyondan ölüme yol açabilir [9].
- Triptofan Metabolizması Bozukluğu: Hartnup hastalığı, triptofanaz enzim eksikliği sonucu idrarda bol triptofan bulunur [10].
- Fenilalanin ve Tirozin Metabolizması Bozuklukları (PKU): Fenilalanin hidroksilaz kusuru zekâ geriliğine neden olur [11].

B. Fenilalanin ve Tirozin Metabolizması Bozuklukları (PKU)

Fenilalanin, temel bir amino asit olup, insan sağlığı için hayati öneme sahiptir ve diyetle alınması zorunludur. Proteinlerin yaklaşık %4-5'ini oluşturur ve özellikle jelatin (%2) ve yumurtada (%6) yüksek oranda bulunur [11]. Fenilalanin, vücutta tirozine dönüşerek dopamin, norepinefrin, melanin, adrenalin ve tiroksin gibi önemli bileşiklerin yapımında kullanılır [12].

Fenilalanin vücutta protein sentezi için kullanılmayan fazla kısmı (%75), fenilalanin hidroksilaz (FAH) enzimi tarafından tirozine dönüştürülür [11]. Bu dönüşüm sırasında, norepinefrin gibi önemli nörotransmitterlerin sentezi gerçekleşir. Fenilalanin eksikliği, zihinsel düzensizlikler, anksiyete, depresyon ve kronik yorgunluğa yol açabilir [11, 12].

PKU, fenilalanin hidroksilaz enzimini kodlayan gendeki mutasyon sonucu ortaya çıkan kalıtsal bir metabolizma bozukluğudur. Bu mutasyon, enzimin yetersizliğine veya eksikliğine neden olarak fenilalaninin tirozine dönüşümünü engeller ve fenilalanin plazma düzeylerinin normalin 20-30 katı artmasına yol açar. Beyinde biriken fenilalanin, mental gerilik ve diğer nörolojik bozukluklara neden olur [13]

PKU'nun tedavisinde erken teşhis ve fenilalanin kısıtlı diyet uygulanır. Bu diyet, protein ve fenilalanin içeriği düşük, yaşa ve kiloya uygun vitamin-mineral eklenmiş aminoasit karışımlarından oluşur. PKU hastaları için yasak olan gıdalar arasında etler, süt ürünleri, baklagiller ve aspartam içeren gıdalar yer alırken, sınırlı tüketilebilecek gıdalar sebzeler, meyveler ve bazı yağlardır [14, 15].

PKU teşhisi, yenidoğan tarama programları ile topuk kanı alınarak yapılır. Hastalığın sıklığı etnik gruplara ve coğrafi bölgelere göre değişiklik gösterir. Avrupa'da 10.000 canlı doğumda 1, ABD'de 1/13.000, Asya'da ise 1/15.000 sıklığında görülür. Verilen bilgilere göre, fenilketonüri (PKU) hastalığının Türkiye'de diğer ülkelere kıyasla daha sık görüldüğü görülmektedir. 2007, 2008 ve 2010 yıllarında Türkiye'de doğan yenidoğanlarda PKU tanısı konmuş vakaların sayıları sırasıyla 246, 217 ve 182 olarak

verilmiştir. Ülke genelinde PKU sıklığı 1/6228 olarak belirtilmiştir, bu da Türkiye'de her 6228 doğumdan birinin PKU hastası olduğunu göstermektedir. PKU hastalığının bu kadar sık görülmesinde etkili olan faktörlerden biri, Türkiye'de taşıyıcı oranının %4 olmasıdır. Taşıyıcı olma durumu, genetik geçişin anne-baba arasında veya akraba evliliklerinde daha sık olmasıyla ilişkilendirilmektedir. Bu durum, akraba evliliklerinin PKU hastalığının sıklığını artırıcı bir faktör olarak gösterilmesine yol açmaktadır. Türkiye'nin PKU hastalığının sıklığı açısından diğer ülkelere göre önemli bir durumda olduğu ve bu konuda genetik danışmanlık ve erken teşhisin önemli olduğu vurgulanmaktadır. Bu bilgiler, ülkemizdeki sağlık politikalarının bu tür kalıtsal hastalıkların yönetimi ve tedavisi için nasıl şekillendirilmesi gerektiğine dair önemli ipuçları sunmaktadır [16, 17].

Sonuç olarak, PKU'nun tedavisinde diyetin önemli rolü vardır. PKU hastaları için fenilalanin içeriği düşük özel gıdaların geliştirilmesi ve kullanılması, bu hastaların yaşam kalitesini artırmada kritik öneme sahiptir Türkiye'de bu hastalığın taşıyıcılık oranı %4'tür ve bu durum her yıl 250-300 çocuğun bu hastalıkla doğmasına neden olmaktadır [18].

C. Çölyak Hastalığı

Çölyak hastalığının başlıca nedeni, gluten proteininin bir alt fraksiyonu olan gliadindir. Gluten, yulaf, buğday, çavdar, pirinç, darı, kuş yemi gibi tahıllarda bulunan proteinlerdir ve insanoğlu için vazgeçilmez bir besin kaynağı olmuştur. Özellikle buğday, un, irmik, nişasta, bulgur, ekmek, makarna, kek, bisküvi gibi yarı mamül veya mamüllerin üretiminde önemli bir yer tutar. Gluten proteini, buğday tanesinin büyük bir kısmını oluşturmaktadır ve kimyasal yapısı protein (%7-18), su (%8-14), mineral madde (%1-2), karbonhidrat (%65-75), lipit (%1-3), eser miktarda vitamin ve enzimden oluşur [19,20,21].

Unda bulunan proteinler hamur oluşturmayan (%15 albumin, globulin, peptidler ve aminoasitler) ve hamur oluşturanlar (%85 Gliadin ve Glutenin) olarak ikiye ayrılır. Gliadin, alkol ile çözünür ve hamurun uzayabilirliğinden sorumludur. Glutenin ise asidik ortamlarda çözünür, hamurun elastikiyetinden sorumludur ve toplam protein miktarının %40-50'sini oluşturur [21, 22]. Glutenin hamurun reolojik ve pişme özelliklerinin gelişmesinde önemli bir rol oynar. Ayrıca et, sosis, çorba gibi hazır gıdalarda tekstür geliştirici, inceltici, su veya yağı tutucu olarak da kullanılır [23].

Çölyak hastalığı, gluten veya bazı tahıl proteinlerine karşı bağırsaklarda görülen bir alerjik reaksiyondur ve genetik bir hastalıktır. Çölyak hastaları gluten içeren gıdalar tükettiklerinde ince bağırsağındaki villus yapısı zarar görerek tahriş olur ve gerekli vitamin ve minerallerin emiliminde güçlük yaşarlar. Bu durum, vücuttaki tüm sistemleri olumsuz yönde etkiler ve besin yetersizliğine yol açarak birçok hastalığa sebep olabilir [21, 22].

Çölyak hastalığının klasik belirtileri arasında ishal, kusma, iştahsızlık, karın şişliği, kilo kaybı, kabızlık ve büyüme geriliği yer alır. Büyük çocuklar ve yetişkinlerde ise tedavi edilemeyen veya nedeni bulunamayan kansızlık, kemik zayıflığı gibi belirtiler gözlemlenir. Erken teşhis edilmezse, depresyon, osteoporoz ve tümör gibi ciddi sağlık problemlerine yol açabilir. Kesin tedavi yöntemi glutensiz bir yaşam şeklidir, buğday, arpa ve çavdar unu içeren her türlü besin maddesi glutensiz beslenmede sakıncalıdır [24].

Dünya genelinde çölyak hastalığının yaygınlığı, bazı ülkelerde yapılan araştırmalara göre değişiklik göstermektedir. Çölyak hastalığı, tüm dünyada oldukça yaygın olan ve nüfusun yaklaşık 100 de 1'i ile 300'de 1'ini etkileyen önemli bir hastalıktır. Hastalığın geniş bir klinik yelpazeye sahip olması, atipik seyir gösterebilmesi veya hiç belirti vermemesi nedeniyle gerçek prevalansı belirlemek zordur. Bu nedenle, çölyak hastalığı olan bireylerin yalnızca %10'una tanı konulabildiği tahmin edilmektedir [25]. Ülkemizde çölyak hastalığının görülme sıklığının 100 de 1'i ile 300'de 1'ini arasında olduğu düşünüldüğünde, en az 280 bin ve en çok 850 bin hastanın olması beklenmektedir. Sağlık Bakanlığı Sağlık Bilgi Sistemlerinden elde edilen verilere göre, 2022 yılı sonu itibariyle Türkiye'de tanı konmuş çölyak hastası sayısı 154.027 olarak belirtilmiştir. Ayrıca, Türkiye'de çölyak hastalığı oranının yüksek olmasının bir nedeni de akraba evliliklerinin yaygın olmasıdır. Glutensiz beslenme, çölyak hastaları için zorunlu hale gelmiştir ve gıda sektöründe bu tür ürünlerin üretimi önem kazanmıştır[26].

Glutensiz ürünler ile ilgili yasal düzenlemeler, 2012 yılında Türk Gıda Kodeksi Yönetmeliği Glutensiz Ürünler Tebliği ile belirlenmiştir [27]. FAO ve WHO tarafından kabul edilen ve gluten içermeyen gıdalar

için geliştirilen Kodeks Standardı'na göre, glutensiz gıdalar, buğday prolamini ile çavdar, arpa, yulaf veya bunların melez varyetelerini içermeyen ya da bu bileşenlerin gluten miktarı 200 ppm'i geçmeyen şekilde hazırlanan gıdalar olarak tanımlanır [28, 29].

II. SONUÇ

PKU, fenilalanin hidroksilaz enziminin yetersizliği veya eksikliği nedeniyle fenilalaninin tirozine dönüşümünü engeller ve fenilalanin plazma düzeylerinin normalin 20-30 katına çıkmasına yol açar. Bu durum, beyinde birikerek mental gerilik ve diğer nörolojik bozukluklara neden olur. PKU'nun tedavisinde erken teşhis ve fenilalanin kısıtlı diyet uygulanması büyük önem taşır. Bu diyet, protein ve fenilalanin içeriği düşük, yaşa ve kiloya uygun vitamin-mineral eklenmiş aminoasit karışımlarından oluşur. PKU hastaları için özel olarak geliştirilen fenilalanin içeriği düşük ürünler, hastaların yaşam kalitesini artırmada önemli bir rol oynar.

Çölyak hastalığı ise gluten proteinlerine karşı bağırsaklarda görülen alerjik reaksiyonlar sonucu ortaya çıkar. Bu hastalık, genetik bir yatkınlığa bağlı olarak gelişir ve gluten içeren gıdaların tüketimi sonucu ince bağırsakta hasara yol açar. İnce bağırsağın villus yapısının zarar görmesi, vitamin ve mineral emiliminde güçlük yaratır ve besin yetersizliklerine yol açar. Çölyak hastalığının kesin tedavisi, ömür boyu glutensiz bir diyet uygulamaktır. Bu diyet, buğday, arpa ve çavdar unu içeren her türlü besin maddesini dışlar ve glutensiz alternatifleri tercih eder. Glutensiz beslenme, çölyak hastalarının yaşam kalitesini önemli ölçüde iyileştirir ve hastalığın belirtilerini kontrol altına alır.

Her iki hastalıkta da erken teşhis ve bilinçli beslenme büyük önem taşır. Yenidoğan tarama programları, PKU'nun erken teşhisi ve tedavisinde kritik rol oynar. Aynı şekilde çölyak hastalığının teşhisinde de doğru ve zamanında yapılan tanı testleri hayati öneme sahiptir. Bu hastalıkların yönetiminde, hastaların ve ailelerinin bilinçlendirilmesi, uygun diyetlerin uygulanması ve düzenli tıbbi takip, yaşam kalitesini artırmada ve uzun vadeli komplikasyonları önlemede önemli katkılar sağlar.

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Şarap ve Fransız Paradoksu

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Özet – Fransız Paradoksu, Fransızların doymuş yağ oranı yüksek bir diyet tüketmesine rağmen koroner kalp hastalığı (KKH) oranlarının nispeten düşük olmasını ifade eder. 1980'lerde fark edilen bu durum, dengeli ve ölçülü şarap tüketiminin sağlıklı bir yaşam tarzının parçası olabileceği öne sürülmüştür. Bu paradoksun önemli bir nedeni, antioksidanlar ve polifenoller, özellikle resveratrol açısından zengin kırmızı şarap tüketimidir. Bu bileşiklerin inflamasyonu azaltarak, LDL kolesterolün oksidasyonunu engelleyerek ve genel damar sağlığını destekleyerek kardiyovasküler sağlıkta önemli bir rol oynadığı düşünülmektedir. Modern şarap üretim teknikleri, faydalı bileşiklerin konsantrasyonunu maksimize etmeye odaklanarak üzüm çeşitlerinin dikkatli seçimi, fermantasyon süreçleri ve yaşlandırma yöntemleri üzerinde yoğunlaşmaktadır. Bu süreç, şarabın antioksidan kapasitesini artırarak sağlık üzerindeki olumlu etkilerini maksimize eder. Ayrıca, yaşlandırma yöntemleri de şarabın kimyasal bileşimini ve dolayısıyla sağlık faydalarını etkileyebilir. Şarap teknolojisindeki yenilikler, sadece sağlık açısından değil, aynı zamanda tat ve kalite açısından da şarabın geliştirilmesine katkı sağlar. Modern ekipman ve tekniklerle, üreticiler üzümün en iyi özelliklerini koruyarak yüksek kaliteli şaraplar üretebilmektedir. Bu teknolojik yenilikler, şarabın hem lezzet profilini hem de sağlık yararlarını artırmaktadır. Sonuç olarak, Fransız Paradoksu ve modern şarap teknolojisi arasındaki ilişki, şarabın doğru tüketildiğinde sağlık üzerinde olumlu etkiler sağladığını göstermektedir. Dengeli ve ölçülü şarap tüketimi, modern üretim teknikleriyle birleştiğinde hem sağlık hem de tat açısından üstün özelliklere sahip şarapların üretilmesine olanak tanır. Bu çalışmada, mevcut araştırmaları ve teknolojik yenilikleri sentezleyerek Fransız Paradoksu 'nu ve şarap teknolojisini anlamayı amaçlamaktadır.

Anahtar Kelimeler – Fransız Paradoksu, Antioksidanlar, Polifenoller, Şarap, Kardiyovasküler

I. GİRİŞ

Fransız paradoksu" terimi, bazı Fransız popülasyonlarının, doymuş yağ asitlerinin nispeten yüksek olduğu bir diyet tüketmelerine rağmen, koroner kalp hastalığı (KKH) insidansının nispeten düşük olması gözlemine dayanmaktadır. İlk olarak 1819'da İrlandalı doktor Samuel Black tarafından tanımlanan bu olgu, 1992'de Bordeaux Üniversitesi'nden bilim adamı Dr. Serge Renaud tarafından "Fransız paradoksu" olarak adlandırılmıştır [1]. Renaud, bu paradoksu ılımlı kırmızı şarap tüketimine bağlamış ve orta derecede alkol alımının, yüksek yoğunluklu lipoprotein-kolesterol (HDL-C) seviyeleri üzerindeki olumlu etkileriyle aterosklerozu azaltarak KKH'yi önleyebileceğini öne sürmüştür. Ancak, Renaud, Fransız toplumundaki plazma HDL-C seviyelerinin diğer Batılı ülkelerle kıyaslandığında anlamlı derecede yüksek olmadığını, dolayısıyla başka mekanizmaların da rol oynadığını savunmuştur. Daha önce yayımlanmış çalışmaları yeniden değerlendirdikten sonra, KKH'deki azalmanın HDL-C seviyelerindeki artıştan ziyade, hemostatik dengedeki iyileşme, yani azalmış trombosit agregasyonu kaynaklı olduğunu sonucuna varmıştır [1].

Birleşmiş Milletler Gıda ve Tarım Örgütü'ne (FAO) göre, 2003 yılında Fransa'daki toplam diyetsel yağ tüketimi yaklaşık 168 g/kişi/gün iken, Amerika Birleşik Devletleri'nde 155 g/kişi/gün, Birleşik Krallık'ta

134 g/kişi/gün ve İsveç'te 126 g/kişi/gün idi. Fransa'da hayvansal yağ tüketimi 47 g/kişi/gün iken, Amerika Birleşik Devletleri'nde 16 g/kişi/gün, Birleşik Krallık'ta 19 g/kişi/gün ve İsveç'te 52 g/kişi/gün idi. Alkollü içeceklerin genel tüketimi Fransa'da ~255 g/kişi/gün, Amerika Birleşik Devletleri'nde 269 g/kişi/gün, Birleşik Krallık'ta 340 g/kişi/gün ve İsveç'te 211 g/kişi/gün olmasına rağmen, şarap tüketimi Fransa'da 145 g/kişi/gün, Amerika Birleşik Devletleri'nde 19 g/kişi/gün, Birleşik Krallık'ta 49 g/kişi/gün ve İsveç'te 47 g/kişi/gün idi. Böylece, Fransa'da toplam alkollü içecek tüketiminin yaklaşık %57'sini şarap oluştururken, Amerika Birleşik Devletleri'nde %7'sini, Birleşik Krallık'ta %15'ini ve İsveç'te %22'sini oluşturmaktaydı [2,3,4].

Dünya Sağlık Örgütü'nün yayımladığı küresel kalp hastalığı ve felç salgını atlasına göre, 2002 yılında Fransa'da KKH'den ölüm oranı (%0,8), Amerika Birleşik Devletleri (%1,8), Birleşik Krallık (%2,1) ve İsveç'ten (%2,3) iki ila üç kat daha düşüktü. Bu, hayvansal (doymuş) yağlar açısından zengin bir diyete ve dünya çapında en yüksek şarap tüketimine rağmen, Fransa'nın 1994 yılında en düşük ikinci KKH ölüm oranına sahip olduğunu bildiren Criqui ve Ringel'in bulgularıyla tutarlıdır [4].

A. Şarap

Fransa, kırmızı, rose, beyaz, köpüklü ve zenginleştirilmiş şaraplar gibi tüm şarap türlerini üretmektedir. Ayrıca, Cabernet Sauvignon, Chardonnay, Pinot Noir, Sauvignon Blanc, Syrah veya Shiraz gibi birçok üzüm çeşide yetişmektedir. Fransız şarapları, farklı bölgelerdeki üzüm çeşitleri, üretim yöntemleri ve sınıflandırma sistemleri nedeniyle ulusal olmaktan çok bölgesel bir kimliğe sahiptir [5].

Her ne kadar herhangi bir alkollü içecek türünün orta düzeyde alımının kardiyovasküler sistem için faydalı olduğu düşünülse de kırmızı şarabın ek kardiyovasküler faydalar sağlayabileceğine dair kanıtlar mevcuttur [6]. Kopenhag Şehir Kalp Araştırması'nda, 30 ila 70 yaşları arasındaki 13.285 erkek ve kadının yaklaşık 12 yıl boyunca takip edilmesi sonucu, kırmızı şarap alımının artmasıyla kardiyovasküler hastalık riskinin azaldığı gözlemlenmiştir. Hiç şarap içmeyenler için bağıl risk 1,00 iken, günde üç ila beş bardak içenler için bu oran 0,51 olarak bulunmuştur. Ancak yüksek alkollü içki alımında ölüm oranı, hiç içmeyenler için 1,00'den, günde üç ila beş içki içenler için 1,34'e yükselmiştir [7].

Şarabın ana bileşenleri su ve alkol olmasına rağmen, şarapta 500'den fazla bileşik tanımlanmıştır. Su, üzüm suyundan elde edilir ve biyolojik olarak saftır. Alkol içeriği, şaraplar arasında %10'dan %17'ye kadar değişir ve esas olarak mayalar tarafından parçalanan şekerlerden elde edilir. En yaygın alkol etanoldür; ancak şarapta bulunan diğer alkoller arasında 1-propanol, 2-metil-1-propanol, 2-metil-1-butanol ve 3-metil-1-butanol yer alır. Gliserol de mevcut olup genellikle bir miktar tatlılık katar. Asitler, şaraba ekşi veya keskin bir tat kazandırır ve üzüm kaynaklı tartarik asit, malik ve sitrik asitler şaraptaki toplam asitliğin temel bileşenleridir. Fermantasyonla üretilen süksinik, laktik ve asetik asitler de şarapta bulunur [8,9].

Üzümlerden elde edilen fenolik bileşikler, şaraba rengini ve tat farklılıklarını verir. Flavonoidler ve flavonoid olmayan bileşikler şarapta önemli yer tutar ve özellikle kırmızı şaraplarda bu bileşiklerin miktarı daha yüksektir. Resveratrol, özellikle kırmızı şarapta bulunan ve kardiyovasküler faydaları olduğu düşünülen bir fitoaleksindir. Beyaz şarap, kırmızı şaraba göre daha düşük miktarda resveratrol içerir çünkü üretiminde daha kısa maserasyon süresi kullanılır. Fransa'nın Beaujolais, Midi, Rhone, Bordeaux ve Burgundy bölgelerinden gelen kırmızı şaraplar, resveratrol açısından zengin olup, konsantrasyonları 3,7 ila 7,1 mg/L arasında değişir [10].

B. Şarap ve Resveratrol

Şarap, çok çeşitli polifenoller içeren karmaşık bir içecektir. Polifenoller, doğal antioksidanlardır ve insan sağlığı üzerinde çeşitli olumlu etkileri olduğu bilinmektedir [9].

Modern şarap üretim teknikleri, faydalı bileşiklerin konsantrasyonunu maksimize etmeye odaklanmaktadır.

Bu süreçte dikkat edilen başlıca unsurlar şunlardır:

Üzüm Çeşitlerinin Seçimi: Üzüm çeşitlerinin dikkatle seçilmesi, şarabın polifenol ve resveratrol içeriğini önemli ölçüde etkileyebilir. Kırmızı üzüm çeşitleri genellikle daha yüksek polifenol ve resveratrol içeriğine sahiptir. Bu nedenle, şarap üreticileri, yüksek polifenol ve resveratrol içeriği ile

bilinen üzüm çeşitlerini tercih ederler. Özellikle, Cabernet Sauvignon, Merlot ve Pinot Noir gibi kırmızı üzüm çeşitleri, yüksek polifenol içeriği ile öne çıkar [11].

Fermantasyon Süreçleri: Fermantasyon süreçleri, şarabın antioksidan kapasitesini artırmak için optimize edilebilir. Kırmızı şarap üretiminde, üzüm kabukları fermantasyon sırasında şarap ile daha uzun süre temas halinde tutulur. Bu süreç, polifenol ve resveratrol gibi biyoaktif bileşiklerin şaraba geçişini artırır. Fermentasyon süresinin uzatılması, şarabın antioksidan kapasitesini ve dolayısıyla sağlık faydalarını artırabilir. Fermantasyon sürecinin optimize edilmesi, sıcaklık kontrolü ve fermantasyon süresinin dikkatli bir şekilde yönetilmesi ile sağlanabilir. Kontrollü sıcaklık altında yapılan fermantasyon, polifenol ve resveratrol miktarını artırırken istenmeyen yan ürünlerin oluşumunu engelleyebilir. Ayrıca, üzüm kabuklarının fermantasyon sırasında karıştırılması, polifenol ekstraksiyonunu artırabilir [5,12].

Yaşlandırma Yöntemleri: Yaşlandırma yöntemleri, şarabın kimyasal bileşimini ve sağlık faydalarını önemli ölçüde etkiler. Meşe fıçılarda yaşlandırma, şarabın lezzet profilini ve polifenol içeriğini zenginleştirir. Meşe fıçılarda yaşlandırma, şaraba odunsu ve baharatlı tatlar katarken, polifenol miktarını da artırabilir. Bu süreç, meşe odununun şaraba tanen ve diğer biyoaktif bileşenler salması ile gerçekleşir. Fıçılarda yaşlandırma dışında, alternatif yaşlandırma teknikleri de kullanılabilir. Örneğin, çelik tanklarda yaşlandırma, şarabın daha taze ve meyvemsi bir profil kazanmasını sağlayabilir. Bununla birlikte, polifenol içeriği açısından fıçılarda yaşlandırmanın yerini tutmayabilir. Alternatif yöntemler, şarap üreticileri tarafından belirli bir lezzet profili ve kimyasal bileşim elde etmek için kullanılabilir [5,12]. Polifenoller ve sağlık üzerindeki etkileri;

Ateroskleroz ve Koroner Kalp Hastalığı: Polifenoller, kan damarlarını genişleterek ve kolesterol oksidasyonunu önleyerek kalp hastalıklarına karşı koruma sağlar. Antioksidan özellikleri sayesinde, damar sertliğini ve kalp krizi riskini azaltabilirler [13].

Kanser Kemoterapi Önleyici Özellikler: Polifenoller, hücre çoğalmasını kontrol eden ve kanser hücrelerinin büyümesini engelleyen mekanizmaları destekler. Bu nedenle, kanser riskini azaltmada potansiyel kemoterapi önleyici ajanlar olarak görülmektedirler [14].

C. Polifenollerin İçeriği ve Profili

Polifenollerin içeriği ve profili, şarap yapımında kullanılan üzüm çeşidine, coğrafi kökene, yetiştirme yöntemlerine ve şarap yapım süreçlerine bağlı olarak değişir [5,11,12].

Örneğin:

Üzüm Çeşidi: Farklı üzüm çeşitleri, farklı polifenol profilleri sunar. Kırmızı üzüm çeşitleri, genellikle beyaz üzüm çeşitlerine göre daha yüksek polifenol içerir. Bunun sebebi, kırmızı üzümün kabuklarının ve tohumlarının yüksek miktarda polifenol barındırmasıdır. Kırmızı şaraplar, üzüm kabukları ve tohumları ile birlikte fermente edildiği için polifenol içeriği daha yüksektir [5,12].

Coğrafi Köken: Üzüm bağlarının bulunduğu bölgenin iklim ve toprak özellikleri, üzümlerin polifenol içeriğini etkiler. Sıcak ve kuru iklimlerde yetişen üzümler, daha yüksek polifenol seviyelerine sahip olabilir. Toprak yapısı da üzümlerin besin alımını ve dolayısıyla polifenol sentezini etkileyebil [15].

Yetiştirme Yöntemleri: Organik tarım yöntemleri, genellikle daha yüksek polifenol konsantrasyonlarına katkıda bulunabilir. Kimyasal pestisitler ve gübreler kullanılmadan yapılan organik tarım, bitkilerin doğal savunma mekanizmalarını güçlendirir, bu da daha yüksek polifenol üretimine yol açar . [15].

Şarap Yapım Süreçleri: Fermentasyon ve diğer şarap yapım süreçleri sırasında polifenol miktarı ve türü değişebilir. Kırmızı şaraplar, üzüm kabuklarıyla birlikte fermente edildiği için beyaz şaraplardan daha fazla polifenol içerir. Bu süreçte, polifenoller üzüm kabuklarından şaraba geçer ve şarabın antioksidan kapasitesini artırır [15].

D. Resveratrolün Özellikleri

Resveratrol, trans-3,4',5-trihidroksistilben adı verilen bir stilbenoid olup, iki aromatik halkadan oluşan doğal bir fenol ve fitoaleksindir. Bu bileşik, bitkiler tarafından stres durumlarına karşı bir savunma mekanizması olarak üretilir [16,17].

Üretim Mekanizması: Resveratrol, özellikle hayvan veya patojenlerin bitkilere saldırması, bitkilerin yaralanması veya ultraviyole (UV) ışığa maruz kalmaları sonucunda üretilir. Bu durumlar, bitkilerin dayanıklılık mekanizmalarını güçlendirmek için resveratrol sentezlemesini tetikler [17].

Strese Bağlı Sentez: Resveratrol miktarı, bitkilerin maruz kaldığı stres koşullarına bağlı olarak değişir. Daha fazla stres altında, bitkiler daha yüksek miktarda resveratrol üretebilir. Örneğin, bağcılıkta kullanılan bazı tarım teknikleri, bitkilerin strese maruz kalmasını artırarak resveratrol seviyelerini yükseltebilir [18].

E. Sağlık Üzerinde Faydaları

Kalp Sağlığı: Resveratrol, kalp sağlığını iyileştiren önemli bir biyoaktif bileşiktir. Bu polifenol, kan damarlarını genişleterek ve LDL kolesterolün oksidasyonunu önleyerek kardiyovasküler hastalık riskini azaltabilir. LDL kolesterol, okside olduğunda arter duvarlarına zarar verebilir ve ateroskleroz gelişimine yol açabilir. Resveratrol, bu süreci engelleyerek kalp krizi ve felç riskini düşürebilir [19,20].

Kanser: Resveratrolün kanser hücrelerinin büyümesini engelleyebileceği bazı laboratuvar ve hayvan çalışmaları tarafından gösterilmiştir. Bu bileşik, kanser hücrelerinde apoptoz (programlanmış hücre ölümü) indükleyerek ve hücre döngüsünü durdurarak tümör büyümesini baskılayabilir. Özellikle kolon kanseri hücreleri üzerinde yapılan çalışmalar, resveratrolün ribonükleotid redüktaz aktivitesini inhibe ederek kanser hücrelerinin çoğalmasını engelleyebileceğini göstermiştir [20,21].

Beyin Sağlığı: Resveratrol, nöroprotektif özellikleri sayesinde beyin sağlığı üzerinde de olumlu etkiler yapabilir. Bu bileşik, serbest radikallerin neden olduğu oksidatif stresi azaltarak ve beyin hücrelerini koruyarak Alzheimer hastalığı gibi nörodejeneratif hastalıkların riskini azaltabilir. Klinik çalışmalar, resveratrolün beyin hücrelerinin sağlığını koruyarak bilişsel işlevleri iyileştirebileceğini ve yaşa bağlı bilişsel gerilemeyi yavaşlatabileceğini göstermiştir [22].

Şeker Hastalığı: Resveratrol, insülin duyarlılığını artırarak ve kan şekerini düzenleyerek diyabet yönetimine yardımcı olabilir. Bu biyoaktif bileşik, pankreas beta hücrelerinin fonksiyonunu iyileştirerek insülin salınımını artırabilir ve hücrelerin insüline olan duyarlılığını artırarak kan şekerini kontrol altında tutabilir. Ayrıca, resveratrol, diyabetin neden olduğu oksidatif ve nitrozatif stresi azaltarak organ hasarını önleyebilir [23,24].

Sonuç olarak, şarapta bulunan polifenoller ve resveratrol gibi biyoaktif bileşikler, sağlık üzerinde çeşitli olumlu etkiler sağlayabilir. Ancak, bu faydaların sağlanabilmesi için şarap tüketiminde ölçülü olunması önemlidir. Araştırmalar, hafif ila orta derecede kırmızı şarap tüketiminin daha düşük kardiyovasküler hastalık görülme sıklığı ile ilişkili olduğunu göstermektedir. Bu çalışmalar, orta düzeyde tüketimle karşılaştırıldığında, hiç şarap tüketmemenin veya kronik olarak aşırı şarap tüketmenin (günde üç veya daha fazla içecek) ve diğer alkollü içeceklerin artan kardiyovasküler hastalık riskiyle ilişkili olduğunu bildirmiştir.

II. SONUÇLAR

Şarap, 3000 yılı aşkın bir süredir beslenme ve sosyo-dinsel işlevlere hizmet ederek insan kültürünün bir parçası olmuştur. Üretimi her kıtada gerçekleşmekte ve kimyasal bileşimi, şarap üretim teknikleri, üzüm çeşidi ve iklim faktörlerinden etkilenmektedir.

Küresel olarak, şarabın kardiyovasküler faydaları, muhtemelen alkol ve diğer şarap bileşenlerinin (özellikle resveratrol ve diğer polifenolik bileşikler) aterogenez, pıhtılaşma ve fibrinoliz üzerindeki etkilerinden kaynaklanmaktadır. Orta düzeyde kırmızı şarap tüketiminin kardiyovasküler hastalıkları önlemek ve tedavi etmek için umut verici bir "terapötik" seçenek olabileceğini öne süren kanıtlar artmaktadır. Ancak, kırmızı şarap tüketiminin yararlı etkilerinin herhangi bir üzüm türüne atfedilip atfedilemeyeceği belirsizdir ve herhangi bir şarap kaynağının diğerlerinden daha iyi olduğu söylenemez. Ayrıca, alkollü içeceklerin ve özellikle kırmızı şarabın rapor edilen faydalarının sosyoekonomik karıştırıcı faktörler tarafından etkilenip etkilenmediğinin belirlenmesi gerekmektedir. Kırmızı şarap tüketiminin insan sağlığı üzerindeki etkileri daha iyi tanımlanmalı ve alkolden uzak duranlara hafif ila orta düzeyde kırmızı şarap tüketimine başlamaları konusunda kesin tavsiyede bulunulmadan önce ek

araştırmalar yapılmalıdır. Özellikle, resveratrolin sağlık yararlarını en üst düzeye çıkarabilecek optimum dozaj henüz belirlenmemiştir ve bu, kapsamlı bir araştırma alanıdır.

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Modular Construction and Bioclimatic Strategies: A Sustainable Approach to Building Design

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Abstract – Usually, modular construction involves the off-site manufacturing of standard building components in a factory before the components are assembled on the construction site. It is common to use terms like "prefabrication," "off-site construction," and "modular construction" interchangeably. The construction of modular constructions nowadays is flourishing all over the globe. The roots of the Albanian prefabricated constructions are extended for the first time around the 1970s. This paper will indeed analyze some recently built modular construction in Albania, considering and comparing it with international case studies.

The demand for new construction in Albania is rising rapidly. Currently, the most common structures are cast-in-place beam-column designs, driven by both traditional mindsets and industrial capabilities. However, with Albania's economic growth, there is an increasing need for affordable, quickly built, and technologically advanced buildings. Modular construction, which assembles prefabricated modules on-site, offers a solution. This method aligns with bioclimatic design principles, reducing environmental impact and optimizing resources, marking a shift toward sustainability in the construction industry.

The purpose of this article is to explore the potential integration of "modular construction techniques" with "bioclimatic design concepts" to create buildings that are environmentally friendly, energy-efficient, and multipurpose by function.

This study explores the use of modular construction techniques in conjunction with bioclimatic techniques to increase "building sustainability". Combining these tactics encourages energy efficiency and a reduced environmental effect, making people far more resilient and weather-adaptable. The synergy between the two of them is necessary.

Keywords – modular buildings and techniques, prefabricated buildings, cast-in-place structures, prefabrication roots in Albania, bioclimatic principles of buildings

I. INTRODUCTION

For many years, modular building has been an affordable construction choice. Today, it's not just seen as a product type but as a comprehensive method of construction. Modular construction involves building structures—whether apartments, business buildings, or homes from shipping containers—off-site under controlled conditions. These structures use the same materials and adhere to the same codes and standards as traditional buildings but are completed in nearly half the time.

In traditional construction, raw materials are brought to the site, where workers cut and assemble them. However, with modular construction, significant portions of the project are fabricated off-site, sometimes in a different town or even a different country. These prefabricated modules are then shipped and assembled on-site to form a complete building.

Although some consider modular construction a modern method, it has been utilized in various industries for decades. Nowadays, it is mainly used for multi-family apartments, hotels, and commercial buildings. What makes these projects modular is that the factory-produced units are three-dimensional structures with floors, walls, and ceilings. These units come with most of the interior finishes and fixtures already installed.

In recent times, some modular companies have started incorporating traditional stick-building methods and highly automated robotic assembly lines into their processes. This evolution signifies a further advancement in modular construction techniques. Since affordable housing and faster building are essential, the flourishing of such kind of industry over the years was necessary. During the post-war era, it became more and more popular, particularly in the US and the UK. Furthermore, its popularity in the Western World began to vanish somehow, in 1968 when in the UK an apartment tower collapsed and cast doubts and concerns about the safeness of the prefabricated buildings. Meanwhile, they flourished between the 60s and 80s, in Eastern Europe (former communist countries) as an instrument to cope with the boiling housing crisis. However, they lost significance since the collapse of the Berlin Wall, because of the fragmentation of the construction industry. Nowadays, these kinds of structures are becoming again more and more widely recognized, as they are receiving new attention and financial support. Digital tools that operate in the field, have fundamentally altered the idea of modular building. There exists a stronger trend in the private sector toward building more things away from the construction site. “Modular construction” is one approach. In some other cases nowadays, there are also “multiple modular construction techniques” such as in the United States. In such cases, architects, engineers, and contractors planned to fabricate modules very far away from the site, truck them into the site, and then mount them on top of each other to complete apartment buildings. These techniques streamline the logistics of distribution and make module design easier. Also, the customer's perception of such kind of building is rapidly changing, due to more variety in material selections which enhances the aesthetic attractiveness of prefabricated buildings [1].

Housing and administrative building “mass production” has a long tradition in Europe, especially in the northern countries and in the United States. This type of architecture came into life for political and economic reasons, which encouraged the construction of “prefabricated structures” also in the Eastern bloc countries during the 1960s and 1970s. Meantime, Germany, Austria, and Scandinavia which had very ecological mindsets and standards, were converted into the champions of the “eco-architecture”.

Biases on prefabricated structures, which ended up somehow as the symbols of “cheap and unattractive structures”, are changing meantime. The latest technologies such as CAD/CAM/ CAE systems are archiving a wider audience and the supplies are increasing and diversified. These systems get a reduction in execution time, establish a more uniform and perfect finish, and reduce the environmental impact and occupational hazard at the site. The three more common prefabrication systems (wood, steel, and concrete) include a lower cost for the manufacturer and the customers [2].

Modular constructions are considered a preferred typology in comparison with traditional buildings because of several benefits. The decrease in the “competition time” is one of them. There are other components involved in the issue such as better “environmental performance”, better quality of life, structural flexibility, and increases in the safety of workers at the construction site. But nowadays there are still lower rates of acceptance of modular building in emerging nations.

The construction industry is indeed vital to a country's economic growth. The primary goal is to meet the housing and infrastructure demands of societies. Currently, the most common building method worldwide is “on-site construction”. Based on that the project competition time lasts longer, the quality is decreased, the construction waste is increased, the cost overruns are enhanced, and the environmental sustainability becomes inefficient [3], [4], [5].

The shift of focus toward “innovative construction techniques” in many developed countries aims to address the previously pointed problems with traditional building techniques. The procedure includes constructing the buildings and elements separately, which are produced off-site, and then transporting them to the construction site for installation and final assembly [6], [7].

Four forms of off-site construction may be distinguished: modular construction, non-volumetric preassembly, volumetric preassembly, and modular construction [8], [9]. Since 80–85% of the work involved in the building phase is completed in a factory, modular structures are the most comprehensive

type of off-site construction. Meanwhile, extra ground work such as excavations, foundations, and module installation, are completed at the building site [10]. Furthermore, modular constructions benefit from the continuity of workflow [11]; reduction of construction waste [12]; reduction of project competition time [13]; reduction of CO2 [14]; and a drop in the number of contractors on-site; and improvement of the safety of workers [15].

Modular construction has many advantages in comparison to conventional buildings. So, they are being implemented in many countries and regions, including also Australia. "Modular building" has been recognized by construction companies as a critical concept for improving the state of the industry as it is now [16]. About 30% of residences constructed in wealthy nations like the UK are made by using modular prefabricated technologies. In contrast with the national average, up to 70% of residences in Scotland and Ireland are anticipated to be constructed using this technology [17]. Japan is now the world leader in off-site modular building, by constructing over 70,000 prefabricated dwellings annually. As "conventional building techniques" generate a significant quantity of refuse and carbon emissions in China, the implementation of modular construction can achieve a reduction of construction waste up to 74%, as well as a reduction of carbon emissions up to 34% [18].

The unique characteristics of modular constructions are associated with multiple complexities such as collaboration between the developers and other project participants; - like clients, main contractors, sub-contractors, designers, architects, transporters as well as manufacturers [19].

The application of modular construction has a significant initial financial expense, and the payback period could be at risk in achieving the return on the initial investment [20]. As a result of such experiences in the building sector, consisting both of failure and success, the industrialized nations seem to have acquired the ability to manage these kinds of risks.

It must be underlined that "modular constructions" are innovative constructions that have completely transformed the building sector. They have changed the manners of planning, designing, project implementation, and managing performance [21]. Reliability, durability, safety, constructability, and transportability are essential qualities for modular construction [22].

On the other hand, the goal of "bioclimatic design" is to maximize building performance by making use of the regional climate and environmental factors; as it seeks to reduce the need for mechanical systems while maximizing natural light, ventilation, and thermal comfort. Green roofs, thermal mass use, natural ventilation, and passive solar design are important bioclimatic techniques. These tactics minimize energy use and improve occupant comfort while coordinating with the local climate characteristics.

When compared to conventional construction methods, modular construction has fewer environmental drawbacks such as less waste from materials, less energy use, and a smaller carbon footprint. Furthermore, the regulated manufacturing environment enables more economical resource usage.

II. REFLECTIONS ON MODULAR CONSTRUCTIONS

Below are some reflections on (dis-)advantages based on local and international experiences of the modular way of construction.

1. The advantages of modular construction:

- Saves time - It permits certain work to be completed in a factory while foundations and site construction are being done at the location at the same time. The advantage of saving time is that it accelerates construction while maintaining project schedule efficiency. The modular method can reduce the entire timetable by thirty to sixty percent.
- No weather delay - The modules are manufactured in a controlled environment, thus building modular structures is not affected by severe weather. It offers more pleasant and safe working environments for employees. They become more proficient and more productive. The majority of the appliances are included with the modules once they come on-site including flooring, cabinets, countertops, plumbing, and electrical fixtures.
- No need to archive components: Staging and moving materials on a small urban site, like in Tirana, can be challenging. This often leads to clutter, slower production, and concerns about theft. When modules

are constructed in a factory instead, building sites can stay safer and cleaner. This also provides more space for workers to move around freely.

- Lower Labor Costs - One major but sometimes debated advantage of modular construction is its impact on labor costs. Today, skilled construction workers are in short supply in many countries, and in some cities, their services are very expensive. This makes it difficult to complete building projects within budget and on schedule. With modular construction, however, skilled workers can operate in fixed, controlled, and safer environments. Modular plants can draw in top talent and take advantage of easy access to raw materials and transportation links like highways and railways. This method can potentially lower construction costs by up to 25%.
- Reduced waste volume: Recent building experiences in Tirana's downtown area demonstrate that modular building and restricting the quantity of trash on each project may achieve up to a 90% reduction in materials. Even in the factories that assemble the construction components, recycling is being maximized.

2. The challenges of modular construction:

- Mass production vs. Limited Variety: On a large scale, the modular mass manufacturing technique promotes increasingly homogeneous and repetitious areas and goods. For this reason, investors choose a modular strategy when developing hotels and residential buildings, provided that each unit can be standardized and stacked. Unique or non-repetitive construction shapes significantly reduce time and cost benefits for suppliers and buyers.
- Higher number of complex decisions -vs- Front loaded design – The majority of choices and design/engineering work must be finished initially according to the modular method. It necessitates that contractors and architects/engineers understand the nuances of the modular manufacture and construction phases. Additionally, this pushes owners and purchasers to make final decisions considerably in advance of the building's completion, yet last-minute alterations can be quite problematic.
- Independent of how they are built, the approval procedure can be challenging since requirements for compliance with local and federal building standards and laws must be met. However, some countries have more favorable laws for modular production than others. Meantime building inspection systems could also vary a lot and might complicate both the approval and execution phases.
- Few suppliers continue to carry the majority of the risk. While firms that produce commercial and multi-family goods are expanding, their ability to grow depends on other factors such as liquidity. Manufacturers of modular houses are primarily focused on building single-family homes. Before signing a contract that transfers all risks to them, buyers and contractors must exercise adequate caution. Halfway through the project, changing manufacturers might also be disastrous.
- Transportation costs and risk - There is also the risk associated with transporting the modules, as they are prefabricated in a factory far from the construction site. These modules need to be either transported directly to the site or staged at a nearby location for later relocation to the site. However, mistakes during the transportation of the module could lead to serious damages, repair needs, or replacements. This needs previous extra work for planning and tracking the transportation itinerary and its best timing, to avoid situations like bridges, tight turns, traffic problems, crane setup, and temporary road closure permits. This imposes extra costs and expertise on insurance issues.
- Difficult financing process - Since modular construction involves purchasing materials on a faster timeline, the bills tend to be much larger earlier in the construction process than what investors and bankers are typically accustomed to. Therefore, is needed more patience to understand the amounts and timing of the foreseen funding, making sure that the work is not disrupted. This means making sure to explain well investors' building plans via the site and factory visits [23].

III. METHODOLOGY

The methodology is based on the historical, descriptive, and comparative manner of implementing the principles of bioclimatic architecture into modular constructions in some European cases, considering also the Albanian case study as a developing country. In Tirana, prefabricated buildings have a brief historical heritage. Tirana needs to gain experience from international case studies to further advance.

IV. INTERNATIONAL CASE STUDIES

The objectives of bioclimatic techniques and modular building are similar. They emphasize efficiency, sustainability, and less environmental effect. By combining these strategies, structures may be designed that are not only quickly constructed but also naturally energy-efficient and ecologically conscious.

Here are some international examples of modular constructions using some of the bioclimatic principles:

1. School in Leknes, Norway

The school is located in the Norwegian archipelago of Lofoten, a part of the Arctic Circle. Its topography includes dramatic landscapes and mountains, open sea views sheltered bays, untouched land, and beaches.

The prefabricated modules that are used represent the latest advanced technology in the Scandinavian market. The modules are from Cramo's new C90 series. As a result of 30 years of extensive experience in the field, the outcome is categorized by a modern design with a focus on functionality, work environment, and energy consumption. Also, the transportation by ships from the Estonian Factory is completely environmentally friendly and integrated within the green philosophy. The building was completed in a record time. 74 prefabricated modules were positioned within one week. The building has three floors. On the ground floor and first floor are positioned the classrooms; meanwhile on the third floor are positioned the rooms for school administrators and teachers. The building meets all the requirements of a modern school [24].

Fig.1 School in Leknes, Norway [24].

2. Sustainable prototype. Studio 804 (University of Kansas, School of Architecture and Urban Planning), Greensburg, KS, USA.

The project was conducted one year after a devastating tornado in the Greensburg area. The sustainable prototype uses active and passive systems as the main core for the environmental strategy, based on bioclimatic principles and passive sustainable strategies. The building uses recycled materials in full interaction with nature [2].

The Sustainable Prototype became Kansas's first LEED Platinum building. The main goal was to construct a structure that would be open to the town and the southern sun while shielding the artwork from the sun's UV rays. This would prevent the artwork from deteriorating and also create a pleasant viewing area. Studio 804 got in touch with a supplier of airplane hangar doors to find an adaptable simple-to-use and manually controllable method of opening and closing the south wall. The door was designed so that, when closed, it creates louvers to block the sun and, when open, it allows gatherings to spill onto the large buffalo grass lawn to the south [25].

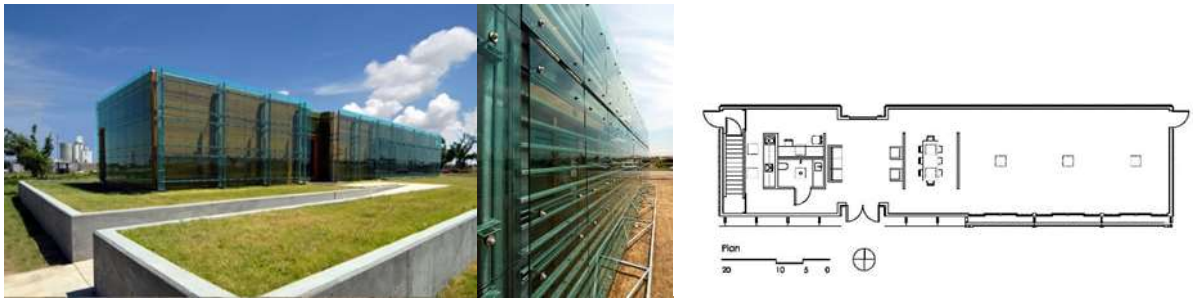

Fig. 2 Sustainable prototype [25].

3. Hedge Building. Atelier Kempe Thill Architects and Planners, Rostock, Germany.

The building is composed of a rectangular floor plan, with dimensions of 6.5x20x10 m. It has a monolithic structure. Within the structure are included two 4m high doors and high ceilings topped with polycarbonate sheets. The volume has a close nature and the green walls fuse it with the exterior [2].

The architects' goal in designing the pavilion was to explore the poetic possibilities inherent in the logic of Dutch agriculture, which is characterized by absolute rationality and industrialization. They attempt to provide a romantic touch to the pavilion solely via objective and logical ways.

The ivy hedge on the smart screen is cultivated in Dutch glasshouses. It is manufactured in garden pieces that are 1.2 by 1.8 meters in dimensions. These plants are essentially industrial products that may be used to construct "green walls." Ivy often takes years to develop to the point where a green building is created. The growing phase of the construction process is shortened by smart displays. A typical wall of ivy has an organic design; which a wall of "smart screens" does not. Rather, it is made up of several almost similar parts, which highlights its industrial nature. The pavilion is like a pergola. Its small size of 4-meter-high doors, and its roof, give it the appearance of an enclosed "house" [26].

Interesting lighting conditions dominate the room. It has the feel of a traditional museum room thanks to light coming in through the ceiling, and more light comes in through the surrounding hedges. An intriguing interplay between the inside and exterior is the end product [26]. The smart building uses bioclimatic principles by creating a heat trap during the winter season and shading with green walls during the summer season, self-efficient in terms of internal thermal comfort.

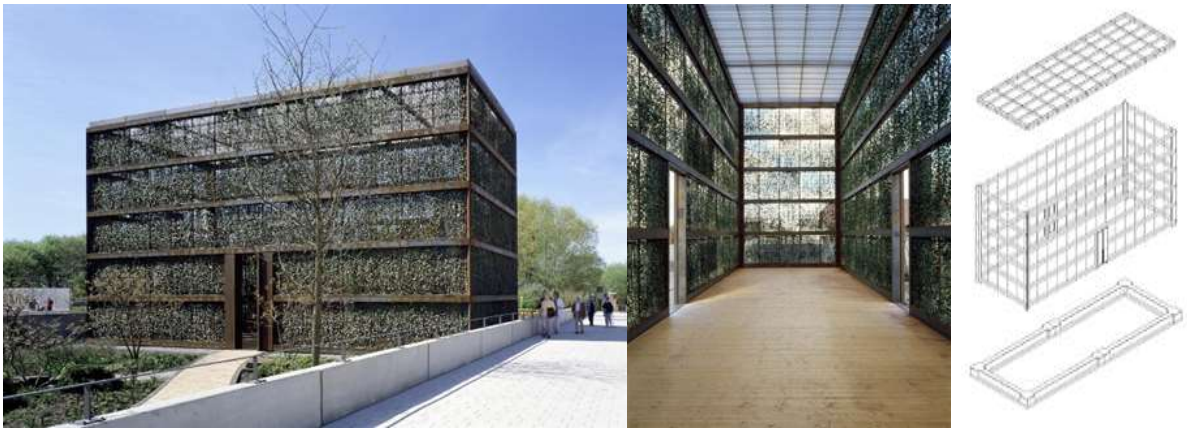

Fig. 3 Hedge Building [26].

V. The Case Study of Tirana, Albania

Due to the war's devastation of cities, the housing crisis following World War II became a pressing national emergency in the first 2 decades of the post-war period. To meet urgent demands, the first homes were constructed by building brick-made blocks, or by using temporary supplies donated voluntarily by other countries. The overtly neoclassical Russian school dominated the architecture of the time for both: the new individual buildings ore the construction of massive and sturdy structures. The motifs of such

architecture were ostentation, domination, and pomposity. The majority of the new buildings constructed between 1950 and 1970 used silicate or red-coated bricks for the retaining walls. The growth of the building materials industry also contributed to the standardization of architectural elements. By bringing the design aspects together, this method significantly aided in the typification of homes and the unification of housing morphology. Many of these systems received criticism in the late 1960s and early 1970s for their compositional remedies for the social repercussions of forced expropriations, for encouraging antisocial conduct, and for rejecting the city's building customs. The kitchen space that was connected to the living room was reduced to adhere to the primary building cost-cutting philosophy. Often, plastering and other elements of the facade were also eliminated to further reduce costs. During this period, the National Architecture and Design Institute created a variety of dispersed and repeatable models to feed local housing initiatives, that had no relation at all with national or local customs, culture, or climatic circumstances, all over the country [27], [28], [29].

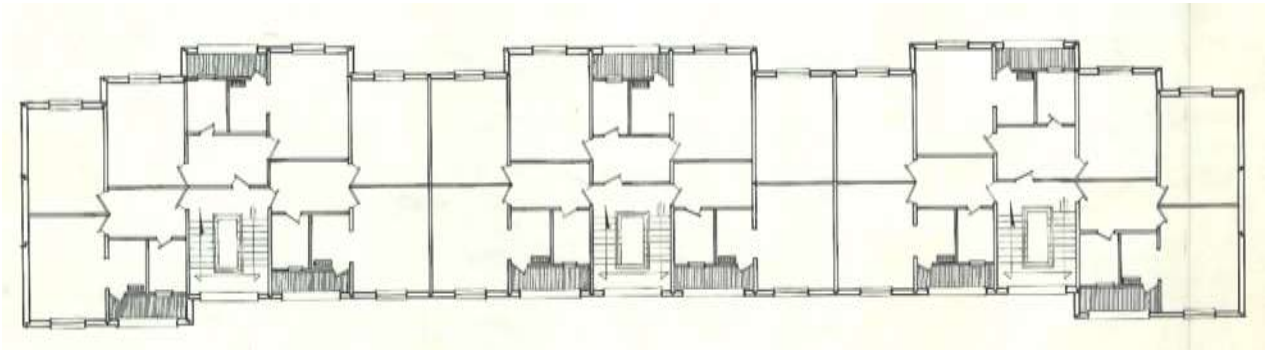

Fig. 4 Prefabricated building in Albania during the 1970s. Typical plan [30].

Albanian authorities of the time invested in the building materials production industry. Therefore, a building materials factory "Josif Pashko" began operations in Tirana for the first time in the country by the beginning of the 70s. However, this factory featured a consistent structure with load-bearing panels, based on Russian and Chinese building technologies. Precast reinforced concrete panels allow rapid construction of residential buildings. The leading institution was the architectural bureau of the “Institute of Design No.1” in Tirana. The Institute developed four different typologies/techniques of intervention, considering precast panels (four different types of modules). These modules could be combined into linear schemes. Furthermore, buildings starting from 2 up to a maximum of 6 floors could be created. The central staircase of the four modules consists of two ramps and two platforms. The intermediate platform is open and shaped like a lodge, and one staircase provides access to two or three apartments per story [31].

Generally, to combine linear plans and to construct urban complexes, the prefabricated structures were mainly made up of four distinct planimetric modules featuring two blind-side walls and bilateral exposure [32].

During the period of socialism, there were constructed a lot of prefabricated buildings at country scale. These buildings often had prefabricated reinforced concrete panels covering them and a concrete core (staircase). They were joined together via the welding of iron/metal parts. The building panels were created by using such materials, while the staircase's reinforced concrete was poured straight onto the building site. They were built quickly and effectively, but hardly provide comfortable temperatures indoors owing to thermal air infiltration and thermal bridges at their sites of interaction [33].

Generally, from the bioclimatic point of view, these buildings were positioned randomly in the area without taking into consideration the solar orientation of the building to maximize the benefit from the sun during the winter. This resulted in a considerable reduction in heating loads [34], [37].

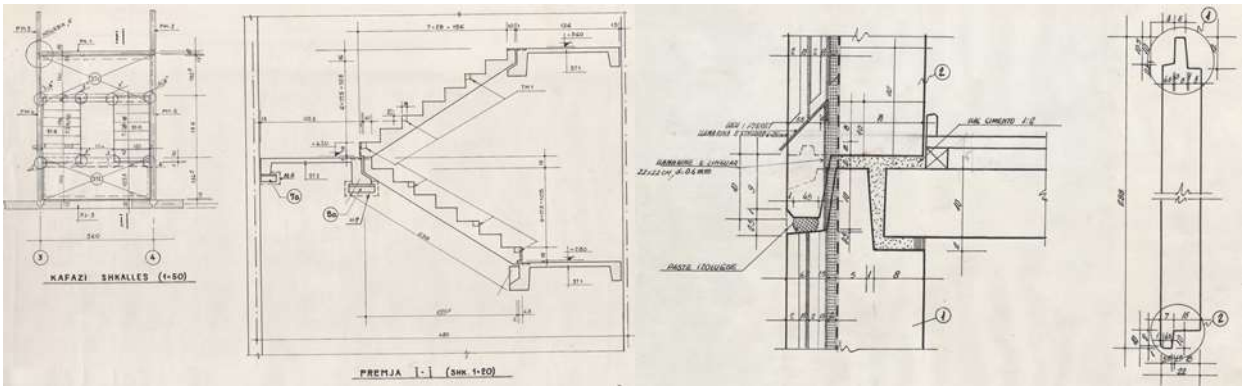

Fig.5 A. Staircase, plan, and section; B. Vertical section of horizontal joint and vertical cut of external panels [30].

Nowadays, the construction of modular buildings in Albania is not so present. Regrettably, despite their limitations in the past, prefabricated initiatives, now are rare in the Albanian construction sector and receive insufficient attention as a result of prejudice, inadequate organizational goals, lack of infrastructure and expertise, and fragmentation of the building industry. Albania has to work more with education and training institutions, industry players, and government regulations, to encourage the adoption of contemporary and new prefabricated and modular building technologies, to meet past and current difficulties [35], [36].

One of the recently built semi-prefabricated buildings in Tirana is a multifunctional one located in the main national infrastructure and economic corridor which connects the capital Tirana with the international airport, and the main port city of Durres. The structure of the NOVA Company building (designed by Arch.4 Studio in Tirana) is a combined one: a cast-in-place beam-column structure, and a prefabricated one (metallic structure). Recently, such kind of structures have gained more popularity in Tirana at least.

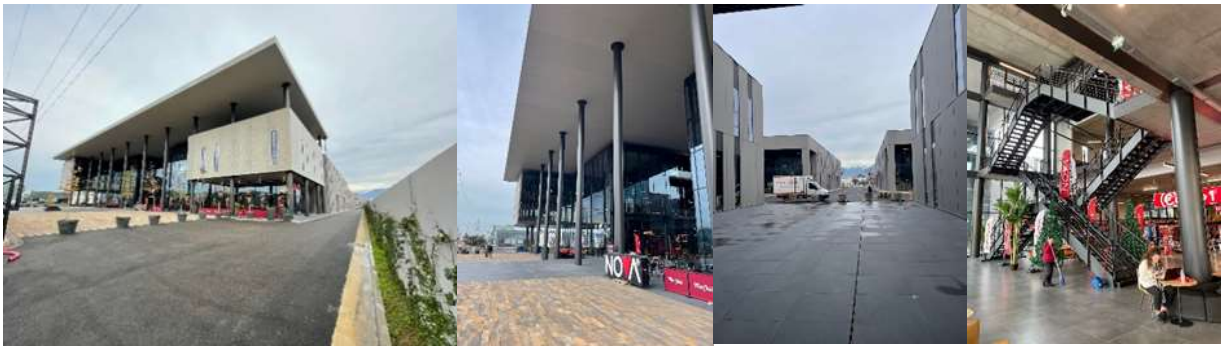

Fig. 6 Semi-prefabricated NOVA building, Tirana, Albania (Source: Authors).

The main building facade faces south, and the overhanging shading platform is designed to provide shade during the summertime. The smart glass facade is withdrawn from the first line of construction to protect against overheating and benefit from solar radiation during the winter season, using bioclimatic principles. The outer coat of the building is realized using prefabricated panels.

Another typical example of a metallic prefabricated structure is at the POLIS University building in Tirana, Albania. The added volume of the existing building was designed by Metro-Polis Architecture Studio of the university and was finished in 2010. The architects involved in the project were Arch. Fagu, E; Arch. Marku, E; Dr. Aliaj, B; and Dr. Dhamo, S. The structural engineer was Eng. Sula, B; and the mechanical engineer was Dr. Alushaj, R. The prefabrication of the metallic structure of the building was carried out by an Italian company "Mangili & Associati" SpA, transported via ship, and then assembled directly on the construction site. The walls and ventilated façade were implemented by FB-ART Shpk Tirana, in cooperation with the German company "Moeding Keramikfassaden".

The orientation of the main facade that was added to the existing warehouse is located at the back of the building toward the south. The principles of bioclimatic design are also applied here to the newly added volume/structure (serving now as the main entry hall of the university). The thermal trap (smart glass facade) faces south and has a direct benefit from solar radiation (as part of the implemented bioclimatic

strategies) and is combined with the thermal mass of the ground floor platform. During summertime, the façade is protected from overheating through aluminum shaders positioned in the structural glass facade. The maximum angle of the sun on the summer solstice in Tirana (21 June) is 75°, hence the shaders were calculated purposely considering such a problem. Meanwhile, on both sides of the glass facade, ventilated facades have been created to increase the thermal performance of the building, and protect it from east and west. A study conducted by Xhexhi, K, and Aliaj, B reveals also that the thermal performance of such type of facades is much higher compared to an external standard wall [38]. The overhanging shader on the top of the building protects further the building, especially in the summertime from solar radiation. The quality of the glass structural facade is essential to be discussed. The glass implanted reflects the sun's rays to avoid overheating during summertime.

Fig. 7 Polis University's semi-prefabricated building, Tirana, Albania (Source: Authors)

VI. DISCUSSIONS

It is imperative to acknowledge the importance of incorporating "bioclimatic concepts" into these initiatives. The case studies that have been examined, including the ones from Tirana, demonstrate a definite tendency to respect nature by employing a variety of construction techniques and materials that both significantly benefit the environment and have no adverse effects on it, starting from the early stages of construction.

The use of bioclimatic concepts is constantly being expanded, particularly in "modular structures" to lower energy consumption, carbon footprint, building time lag, and reducing costs, to create a more sustainable future.

The case of Tirana and the other international case studies is a need and also a demand to change the synergy between bioclimatic architecture and modular buildings, making possible a fusion between them. The symbiosis between the two must be real and necessary.

VII. CONCLUSIONS

The primary goals of bioclimatic techniques and modular building are similar mainly because they emphasize efficiency, sustainability, and less environmental costs or effects. By combining these strategies, structures may be designed that are not only quickly constructed but also naturally energy-efficient and ecologically conscious.

It is important to consider the involvement of economic issues when merging modular construction and bio-climatic design into one entity; this involves complexities of design, constraints on funds and the regulatory environment. Collaboration between bioclimatic technologies and modular buildings necessitates careful consideration of policy proposals, scientific improvements, and industry stakeholders' cooperation. The success of the development process is dependent on resolving these difficulties.

The combination of modular construction economy and the environmental adaptability inherent in bio-climatic design results in a holistic and sustainable approach to building. The recent merger is a big step toward designing more durable, flexible, and environmentally friendly structures that can fulfill the needs

of our modern society. As construction techniques evolve, there is an exciting opportunity to increase sustainability by merging modular building approaches with bioclimatic practices. This fusion has the potential to result in more environmentally friendly constructions and innovative technology.

In countries like Albania, where urban reconstruction is still in its earliest stages, there is much to learn from more prosperous countries' successful initiatives as well as their mistakes. However, it is critical to customize these principles to our specific circumstances. Tirana, Albania's capital city, demonstrates this trend by investigating the incorporation of bioclimatic design principles into modular construction. Furthermore, these structures should fulfill several functions to ensure their maximum utilization in the future.

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Nitrate Residues in Drinking Water of Rural Areas and Daily Intake by Human

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Abstract – Groundwater pollution is an important problem for agricultural areas. Certain pollutants in movable structure are highly likely to leach into the ground and contaminate the groundwater. In rural areas, groundwater is widely used for drinking and utility water purposes. Therefore, contamination of groundwater with pollutants directly affects the health of human living in rural areas. Nitrate can occur in water resources as a result of agricultural activities especially from chemical fertilizer. The aims of this study are: to investigate the nitrate levels in groundwater in three rural areas (Ugurlu, Doruc and Bolatlar villages) where intensive agricultural activities are carried out, in Şanliurfa, Turkiye and, to calculate the daily nitrate intake from the drinking water of the people living in these regions. In the measurements made in 2 periods, it was determined that the groundwater samples of all villages were above 50 mg/L, which is the acceptable limit value for nitrate. Maximum nitrate concentration was found in samples from Ugurlu village as 283 mg/L and 503 mg/L in January and July 2021, respectively. As a result, insufficient drainage and uncontrolled irrigation in the field brought the groundwater closer to the soil surface and accelerated the soluble nitrate leaching to the shallow aquifer. High nitrate levels in groundwater increase the daily nitrate intake of individuals using this water and increase the risk of nitrate-related diseases.

Keywords – Water, Food Contamination, Nitrate Intake, Human Health

I. INTRODUCTION

Irrigation that started in Harran Plain in 1995 has reached a very large area today, but it has brought various problems caused by excessive water consumption in the plain. It was noticed that the long-term and intensive agricultural activities and irrigation in the region negatively affected the groundwater quality. Based on this consideration, groundwater quality monitoring in the region was carried out and many studies were published on these results in different periods (1, 2, 3, 4).

In rural areas that consume groundwater for drinking and utility water purposes, water quality directly affects human health. Due to high nitrate concentrations above the acceptable limits in the groundwater, it is necessary to pay attention to the daily nitrate intake that enters the body.

II. MATERIALS AND METHOD

Groundwater analyzes were made on the water samples from 10 wells (Fig. 1) reflecting the shallow aquifer characteristics in Harran Plain. Sampling was carried out in 2 periods, January 2021 and July 2021. Nitrate analyses were made with the ion chromatography in Harran University Science Technology Application and Research Center (HUBTAM) Laboratories.

It was reported by the Food and Agriculture Organization in 2003 that the permissible daily intake of nitrate in 1995 was 3.6 mg/kg of body weight [5], according to the European Commission's Food Science Committee. Global health for adults with an average weight of 60 kg 3.7 mg/kg [6].

Fig. 1. Sampling points location map

III. RESULTS

A. *Nitrate Contamination in Groundwater*

The high nitrate values (Table 1) above the 50 mg/L, which is the acceptable limit value for nitrate in drinking water [7] in the Uğurlu, Bolatlar, Kısas, Doruç and Uğraklı wells can be explained by the vertical transport of the fertilizer-derived mobile nitrate ions. These wells draw attention as sampling points where the negative effects of excessive agricultural irrigation are encountered as high nitrate values. During the irrigation period (for July), nitrate leaching occurs due to the applied chemical fertilizers with the excessive irrigation on the cotton and corn.

In other words, it was expected that nitrogen fertilizer would infiltrate into the groundwater with the effect of irrigation and the nitrate amount in the wells would increase in July. Contrary to what was expected, nitrate values in the wells (except the Uğurlu well) decreased after the irrigation compared to pre-irrigation period (to January). It is thought to be caused by the increase in groundwater levels after irrigation (in July) and therefore the decrease in nitrate concentrations with the dilution effect.

Table 1. Nitrate concentration in groundwater for two different periods.

Wells	**Nitrate in January 2021**	**Nitrate in July 2021**
	(mg/L)	(mg/L)
Uğurlu	283,330	502,522
Yardımcı	50,354	47,166
Ozanlar	48,632	32,904
Doruç	102,421	73,034
Uğraklı	67,680	57,138
Bolatlar	153,734	141,592
Yaygılı	28,650	28,726
Olgunlar	45,418	23,222
Kısas	109,109	0
Çamlıdere	44,421	0

IV. DISCUSSION

A. *Dietary and Drinking-Water Exposure*

The current acceptable daily intake (ADI) for nitrates is 3.7 milligrams per kilogram of body weight per day (mg/kg bw/day) [5, 6]. People exposed to nitrates include it in their diet as natural ingredients or intentional additives. The primary nitrate and nitrite source in food are vegetables, cured meat and dairy products [8]. Ignoring the amount of nitrate taken from the food, the daily nitrate intake of human from only water in a region using contaminated groundwater as drinking water are calculated and presented in Table 2. The daily water intake of an adult is taken into account as approximately 2500 ml.

As can be seen in the Table 2, results above the ADI values for nitrate were ob-tained in 3 villages. Even if the amount of nitrate intake with food is not taken into account, villagers living in Uğurlu, Bolatlar and Doruç exceeded the acceptable daily nitrate intake amount from the water they consume during the day. For most of the population, about 97% of daily intake comes from food and only 3% from drinking water [9].

Table 2. Daily drinking water nitrate exposure for human supplying water from contaminated groundwater. *

Wells	**Average nitrate concentration (mg/L)**	**Possible daily nitrate intake from only drinking water Milligrams per kilogram of body weight per day (mg/kg/day)**
Uğurlu	392.9	16.4
Yardımcı	48.8	2.0
Ozanlar	40.8	1.7
Doruç	87.7	3.7
Uğraklı	62.4	2.6
Bolatlar	147.7	6.2
Yaygılı	28.7	1.2
Olgunlar	34.3	1.4
Kısas	54.6	2.3
Çamlıdere	22.2	0.9

*The daily water intake of an adult is taken into account as approximately 2500 ml and calculations were made for 60 kg person.

V. CONCLUSION

High nitrate values above the acceptable limit of 50 mg/L were detected in ground-water in certain villages in the Harran Plain, located in an area with intensive agricul-tural activities. Excess amount of nitrate in the soil enters the drinking water through the leaching or transporting from groundwater to surface water. The intake of the excess amount of nitrate into our bodies from food products and drinking water causes dangerous diseases.

As a result of the nitrate contamination of drinking water sources, villagers living in Uğurlu, Bolatlar and Doruç exceeded the acceptable daily intake (ADI) of 3.7 mg/kg/day for nitrates. It is necessary to pay attention to the issue of toxic and harmful parameters above the acceptable limits entering the body with contaminated water and foods.

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Beyin Tümörlerinin Bilgisayar Destekli Tespiti: Derin Öğrenme ve Makine Öğrenmesi Yaklaşımları

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Özet – İnsan ölümlerinin en yaygın nedenlerinden biri beyin tümörleri olup, bu hastalıktan ölenlerin sayısı gün geçtikçe artmaktadır. Beyin tümörleri beyindeki hücrelerin kontrolsüz çoğalmasıyla oluşan kitleler olarak tanımlanmaktadır. Bu tümörler kötü huylu veya iyi huylu olabilirler ve erken aşamada doğru bir şekilde tanımlanmazsa ve uygun tedavi uygulanmazsa ölümcül sonuçlar doğurmaktadır. Manyetik Rezonans Görüntüleme (MRG), tümörlerin tespiti ve türlerinin belirlenmesi için uzmanlar tarafından kullanılan en popüler medikal görüntüleme yöntemlerinden biridir. MR görüntü analizi ve segmentasyonu, beyin tümörlerinin erken teşhisinde büyük oranda etkili olup hastaların iyileşmelerinde önemli rol oynamaktadır. Bu çalışmada, beyin MR (Magnetic Resonance) görüntüleri üzerinde lezyon tespit işleminin gerçekleştirilmesinde kullanılan derin öğrenme ve makine öğrenmesi teknikleri incelenmiştir. Çalışma kapsamında, derin öğrenme ve makine öğrenmesi kullanılarak gerçekleştirilmiş çalışmalar analiz edilmiş ve bu doğrultuda yapılan çalışmaların sağladığı katkılar değerlendirilmiştir. Bu çalışmalar arasında, derin öğrenme yöntemleri kullanan ve Geliştirilmiş AlexNet (EAN) ile NASNet mimarilerini içeren araştırmaların daha öne çıktığı görülmüştür. Geliştirilmiş AlexNet (EAN) %99,32 ile en iyi performansı gösterirken, NASNet %99,6 doğruluk elde etmiştir. Makine öğrenmesi alanında incelenen çalışmalar değerlendirildiğinde, en başarılı sonuçların KSVM-SSD (Kernel Support Vector Machine-Social Sürü Optimization) kullanılarak elde edildiği görülmüştür. BRATS 2018, 2019 ve 2020 verilerinde sırasıyla %99,2, %99,36 ve %99,15 doğruluk oranlarına ulaşılmıştır. Ayrıca, bu yöntemin Naive Bayes ve DNN gibi diğer sınıflandırıcılar arasında oldukça iyi performans gösterdiği tespit edilmiştir.

Anahtar Kelimeler – Beyin Tümörü, Görüntü İşleme, Bilgisayar Destekli Tespit, Derin Öğrenme, Makine Öğrenmesi

I. GİRİŞ

Merkezi sinir sistemini etkileyen beyin tümörleri, potansiyel olarak ölüm noktasına götürecek kadar hayatı tehdit eden kanser türleri arasında yer almaktadır. Bu kanserler beyin etrafındaki sıvı akışını bloke ederlerse sorunlara neden olabilirler, bu da kafatası içindeki basıncın artmasına neden olmaktadır. Kanserin beyin dokusuna ve çevresine bu şekilde zarar verdiği belirlenmiştir [1]. Kanserli olmayan (iyi huylu) veya kanserli (kötü huylu) olmak üzere iki çeşidi olan tümörler yeni bir büyüme oluşturan ya da doğum sırasında (doğuştan) mevcut olan anormal hücre kitlesi olarak adlandırılabilirler. İyi huylu olanlar yavaş veya hızlı büyüyebilir, kötü huyludan farklı olarak vücudun diğer bölgelerine yayılmaz ve cerrahi müdahale ile çıkarılması daha kolaydır. Kötü huylu tümörler, çevredeki dokuları istila etme yeteneğine sahiptir. Bazı kanserli beyin tümörleri, ameliyat ile tamamen çıkarılabilirken ileri derecede tehlikeli olan bazı kötü huylu tümörlerin kenarlarının tanımlanması zor olabilir, bu durum cerrahların tümörün tamamını çıkarmasını

zorlaştırır [2]. Amerika Birleşik Devletleri Merkezi Beyin Tümörü Kaydı (CBTRUS), ABD'deki birincil beyin ve CNS tümörlerine odaklanan en büyük popülasyon tabanlı veri kaynağıdır. CBTRUS verilerine göre, kötü huylu beyin tümörlerinin ortalama yıllık yaşa göre ayarlanmış insidans oranı (AAAIR) 7,06, kötü huylu olmayanların ise 17,18'dir. En yaygın kötü huylu tümör glioblastoma, en yaygın kötü huylu olmayan tümör menenjiyomdur. 2014-2018 verilerine göre, glioblastoma erkeklerde, menenjiyom ise kadınlarda daha yaygındır. Beş yıllık sağkalım oranları kötü huylu tümörlerde %66,9, kötü huylu olmayan tümörlerde %92,1'dir. Beyin tümörlerinin teşhisinde en uygun yöntem MRG'dir. MRG, tümörlerin büyüklüğü, şekli ve yerleşimini detaylı gösterir. MR görüntülerinin analizi için yapay zeka algoritmaları kullanılarak, tümör tespiti daha doğru yapılabilmekte ve doktorların işlerini kolaylaştırmaktadır [3].

II. MATERYAL VE YÖNTEM

Beyin tümörleri üzerinde gerçekleştirilen birçok çalışma, Derin Öğrenme (DL) ve Makine Öğrenimi (ML) kullanılarak yapılan bilgisayar destekli tespit sayesinde tıbbi teşhis süreçlerinde daha hızlı ve hassas sonuçlara ulaşmayı mümkün kılmaktadır. Bu teknolojik gelişmeler, hastalara erken teşhis ve daha etkili tedavi seçenekleri sunarak yaşam kalitesini artırmada önemli bir rol oynamaktadır. Tıbbi görüntüler, hastalığın tanısı için gerekli olan uygun bilgilerin gerçek kaynağı olarak kabul edilir [4]. Hastalığın çeşitli yöntemlerle başlangıç aşamasında tespiti, kanser ve tümörlere bağlı ölüm oranlarının azaltılmasında en önemli faktörlerden biridir. Kullanılan yöntemler sayesinde radyologların ve doktorların hastalığı tespit edebilmesi ve iç yapısını inceleyebilmesini kolaylaştırmaktadır.

A. Makine Öğrenmesi

Makine öğrenimi yöntemleri, beyin tümörlerinin tespiti için veri ön işleme, bölütleme, öznitelik çıkarımı, boyut indirgeme ve sınıflandırma olmak üzere beş kritik adımdan oluşmaktadır. Veri ön işleme adımının gerçekleştirilmesi veri setinin temizlenmesi ve düzenlenmesini sağlar bu sayede modelin kalitesi ve etkinliği büyük ölçüde arttırılır [5]. Bölütleme ile yoğunluğa dayalı yöntemler, beyin segmentasyonunda uzaysal alanda etkili olup, piksel değerlerine dayanırlar. Bu tür yöntemler aynı zamanda eşikleme ve bölge tabanlı bir yaklaşımla sınıflandırılabilirler [6]. Özellik çıkarımı sayesinde görüntüdeki önemli bölgeleri temsil ederek boyut azaltma sağlanır. Tümör tespiti için kritik öneme sahip olan özellik çıkarımı, tümörün konumunu ve büyüklüğünü belirleyen bölge bazlı özellikler, tümörün geometrik özelliklerini çıkaran şekil bazlı özellikler ve tümörün iç yapısını ve dokusunu analiz eden doku özellikleri gibi çeşitli yöntemlerle gerçekleştirilebilir. Elde edilen özelliklerle tümörlerin patolojik olarak doğru sınıflandırılması sağlanır [7]. Boyut indirgenmesi, verilerin boyutunu azaltarak hesaplama yükünü ve gürültüyü minimize etme sürecidir. PCA (Principal Component Analysis), Genelleştirilmiş Diskriminant Analizi (GDA), LDA (Linear Discriminant Analysis) ve otoenkoderler gibi tekniklerle veri boyutu küçültülür, bu sayede aşırı uyumun (overfitting) azaltılması, depolama ihtiyacının azalması ve hesaplama verimliliği gibi avantajlar sağlamaktadır [8]. Makine öğrenmesinin en önemli adımlarından biri olan sınıflandırmada, doğruluk ve genelleme optimizasyonunu sağlayan algoritmalar arasında Yapay Sinir Ağları, Destek Vektör Makineleri, En Küçük Kareler SVM'leri, K-En Yakın Komşu ve Naive Bayes gibi yöntemler yaygın olarak kullanılmaktadır [9].

B. Derin Öğrenme

2006 yılında Geoffrey Hinton ve ekibi, yapay sinir ağı temelli derin öğrenme kavramını tanıtarak çalışmalarına başlamışlardır [10]. Derin öğrenme, yapılandırılmamış ve büyük veri setlerini analiz edebilir, bu da karmaşık sorunları çözmede etkili olmasını sağlar. Derin öğrenme algoritmaları, genellikle daha fazla veriyle eğitildikçe daha iyi performans gösterir. Bu, modelin daha genel ve kapsamlı bir anlayış geliştirmesine yardımcı olur. Makine öğrenmesi, manuel özellik çıkarımı ve segmentasyon gibi daha fazla ön hazırlık gerektirirken, derin öğrenme bu adımları modelin içinde otomatikleştirir. Derin öğrenme modelleri, görüntülerden kendiliğinden özellik çıkarabilir ve doğrudan sınıflandırma yapabilir. Bu, makine öğrenmesinde gerekli olan manuel müdahaleleri azaltır ve daha karmaşık verilerle daha iyi çalışmasını sağlar. Özellikle büyük veri setleriyle çalışırken, derin öğrenme, gerekli veri işleme adımlarını entegre bir şekilde ele alarak üstün performans sağlar. Ama derin öğrenme işleyişinde veri artırma ve özellikler çeşitli CNN mimarileri büyük önem taşımaktadır [11]. Tablo 1'de en sık kullanılan veri arttırma teknikleri yer

almaktadır. Veri Arttırma, orijinal veri setini değiştirerek yeni veri setleri oluşturma işlemidir. Çeşitli tekniklerle işlenmiş sentetik kopyalar oluşturulur. Örneğin, görüntülerde, dönme, yansıtma, kırpma, kaydırma ve renk tonu değişikliği gibi yöntemler kullanılarak veri miktarı artırılır [12].

Tablo 1. Veri artırma teknikleri [13]

Sıra No	**Veri Arttırma Tekniği**	**Parametreler**
1	Çevirme	Üst, Sol, Alt, Sağ
2	Döndürme	90°, 60, 45, -45°, -60°
3	Kayma	X-ekseninde 10°, Y-ekseninde 10
4	Çarpıklık (Eğme)	Sol, Sağ, İleri, Geri

Son 12 yıl içerisinde çeşitli CNN mimarileri geliştirilmiştir. Model mimarileri sayesinde kullanılan uygulamalarda performans artırımında büyük rol oynamaktadır. 1989 yılından itibaren CNN mimarisi birçok değişime ve yeniliğe uğramasıyla beraber (yapısal yeniden formülasyonu, düzenlileştirmeyi, parametre optimizasyonlarını vb. içermektedir) CNN'in performansının önemli artışı göz önündedir. Ayrıca işlem biriminin yeniden düzenlenmesinin yanı sıra yeni blokların geliştirilmesi nedeniyle bu performans artışı söz konusudur. En önemli gelişmeler ise ağ derinliğinin kullanımı konusunda gerçekleşmiştir. 2012'de tanıtılan AlexNet modelinden başlayarak, 2020'ye kadar geliştirilen Yüksek Çözünürlük (HR) modeline kadar birçok farklı model bulunmaktadır [14].

C. Veri Setleri

Beyin tümörlerinin tespitinde kullanılmak üzere birçok veri seti geliştirilmiştir. Brain Web, Internet Brain Segmentation Repository (ISBR) ve Multimodal Brain Tumor Segmentation Benchmark (BraTS) tümör segmentasyonu için, felç durumunun değerlendirilmesi için Isles, MS verileri üzerinde lezyon segmentasyonu ve tespiti için ve çeşitli beyin bölgelerinin segmentasyonu için NeoBrainS12, NeoBrainS13, MRBrainS en yaygın kullanılan halka açık veri setleri yer almaktadır [15].

D. Beyin Tümörü Tespiti Çalışmaları

Makine öğrenmesi ile derin öğrenme arasında bazı farklılıklar vardır ve bu da çalışmaların performansını etkilemektedir. Makine öğrenmesi, genellikle sınırlı miktarda veriyle çalışır ve sınırlı veriyle daha etkili sonuçlar elde ederken, derin öğrenme büyük veri setlerinde daha etkili olur çünkü çok katmanlı bir sinir ağı yapısına sahiptir. Geleneksel makine öğrenmesi yöntemleri, veriler arasındaki ilişkileri öğrenmek için önceden tanımlanmış özellikler veya algoritmalar kullanırken, derin öğrenme, veriden özelliklerin otomatik olarak öğrenildiği derin sinir ağlarını kullanır. Derin öğrenme, katman olarak daha karmaşık olduğundan, makine öğrenmesine oranla daha derin ve daha karmaşık ilişkileri öğrenme yeteneğine sahiptir. Bu çalışma, beyin tümörleri tespiti için makine öğrenmesi ve derin öğrenme uygulamalarına ilişkin sistematik bir literatür taraması sunmayı amaçlamaktadır. 2020-2024 yılları arasında tanınmış dergi ve konferanslardan elde edilen 20 birincil çalışmanın ayrıntılı analizi yapılmıştır. Beyin tümörü tespiti için makine öğrenmesi ve derin öğrenmeye dayalı farklı yaklaşımlara genel bir bakış sağlamak amacıyla çeşitli yöntemleri içeren çalışmalar seçilmiştir.

E. Makine Öğrenmesi ile Beyin Tümörü Tespiti Çalışmaları (2020-2024)

Rao ve Karunakara'ın BRATS veri setleri üzerinde gerçekleştirdikleri çalışmada KSVM kullanarak etkili beyin tümörü tespiti için çeşitli aşamaları içeren bir metodoloji önermişlerdir. Bu aşamalarda; ön işleme

olarak görüntü yumuşatma ve kalite iyileştirme için NMF (Normalleştirilmiş Medyan Filtresi), binom eşikleme yöntemiyle segmentasyon, GLCM (Gri Seviye Birlikte Oluşum Matrisi) ve SGLDM (Uzamsal Gri Seviye Bağımlılık Matrisi) tekniklerinin birleşimiyle özellik çıkarımı, Harris Hawks optimizasyon (HHO) algoritmasıyla özellik seçimi gerçekleştirilmiştir. Sınıflandırma olarak KSVM-SSD modeli önerilmiştir ve performansı BRATS 2018, 2019 ve 2020 veri setlerinde sırasıyla %99,2, %99,36 ve %99,15 doğruluk oranları ile analiz edilmiştir [16]. Ansari ve diğerlerinin gerçekleştirdikleri çalışmada, GLCM kullanarak özellik çıkarımı ve DWT tabanlı BT segmentasyonu kullanılarak performans artırılmıştır. Segmentasyon sonrası gürültü morfolojik işlemlerle giderilmiştir. SVM tabanlı sınıflandırıcı ile %98,91 doğruluk elde edilmiştir [17]. Hamid ve Khan'ın çalışmasında, T2-FLAIR MRI görüntülerinde uzaysal filtreler, Laplace filtresi ve medyan filtresi kullanılarak gürültü azaltılmış ve görüntü kalitesi artırılmıştır. Optimal eşikleme ile tümörler ayrılmıştır. DICOM görüntüleri DWT ile küçültülmüş, PCA ile boyutlar daha da azaltılmış ve GLCM'ye uygulanmıştır. SVM tabanlı sınıflandırıcı ile %95 doğruluk oranı elde edilmiştir [18]. Sarkar ve diğerleri, Bangladeş'in Satkhira ve Khulna bölgelerindeki hastanelerden ve web sitelerinden toplanan toplam 60 MRG görüntüsü kullanarak beyin tümörlerini tespit ve sınıflandırmak için bir yöntem önermiştir. Çalışmanın adımları ön işleme, bölütleme, özellik çıkarma, seçme ve tümörün tespiti ve sınıflandırılmasıdır. SVM sınıflandırıcısı kullanılarak tümörlerin benign veya malign olduğu belirlenmiştir. Elde edilen doğruluk, duyarlılık ve özgüllük oranları sırasıyla %98.30, %98 ve %100'dür [19]. Anitha ve diğerlerinin gerçekleştirdikleri çalışmada, GLCM ve Naive Bayes sınıflandırma kullanarak glioma beyin tümörlerini segmentlemeyi amaçlamıştır. Ön işleme aşamasında gürültüler filtrelenmiş, GLCM ve olasılıksal özellikler çıkarılmış, ardından Naive Bayes sınıflandırıcı ile eğitilmiştir. Watershed segmentasyon kullanılarak tümörler izole edilmiştir. BRATS 2015 veri seti kullanılarak normal beyin dokusu MR görüntülerinde %99,2, anormal glioma beyin dokusu MR görüntülerinde %97,3 doğruluk elde edilmiştir [20]. Khan ve diğerleri, T1 ağırlıklı MR görüntülerinden çıkarılan Çok Ölçekli Morfolojik Doku Özellikleri (MMTF) ve En Küçük Kareler Destek Vektör Makineleri (LS-SVM) yöntemini birleştirerek yenilikçi bir metodoloji sunmuştur. 259 beyin MRI taramasından oluşan veri setinde 50 normal ve 209 anormal görüntü bulunmaktadır. Eğitim için 30 normal ve 90 anormal görüntü, test için ise 20 normal ve 119 anormal görüntü kullanılmıştır. Görüntüler Kaggle veri arşivinden ve SIEMENS 1.5 Tesla MR cihazı ile elde edilmiştir. Çeşitli sınıflandırıcıların karşılaştırılması yapılmış olup, RBF, ANN, SVM ve LS-SVM için doğruluk oranları sırasıyla %90.0, %87.0, %95.0 ve %98.97 olarak rapor edilmiştir. LS-SVM tabanlı yaklaşım, %98.97 doğruluk oranıyla diğer sınıflandırıcılardan üstün performans göstermiştir [21]. Türkoğlu, 3024 MRI görüntüsünden oluşan bir beyin tümörü veri seti kullanarak, Bayesian optimizasyon tabanlı SVM sınıflayıcı, dört önceden eğitilmiş CNN modeli ve MrMr özellik seçme yöntemine dayalı bir hibrit model geliştirmiştir. İlk aşamada, önceden eğitilmiş derin mimarilerle temsilci özellikler elde edilmiş, ardından MrMr yöntemiyle bu özellikler arasından en etkili olanları seçilmiştir. Son olarak, Bayesian optimizasyon yöntemiyle SVM sınıflayıcısının hiperparametreleri belirlenmiştir. Bu yöntemle %98.04 doğruluk oranı elde edilmiştir [22]. Tjahyaningtijas ve diğerleri, BraTS 2018 veri setinden elde edilen MRI taramalarını kullanarak beyin tümörü sınıflandırması için Derin Sinir Ağı (DNN) yaklaşımını benimsemiştir. Çalışmada, değiştirilmiş U-Net (mU-Net) segmentasyonu ile beyin tümörleri tanımlanmış ve özellikler çıkarılmıştır. Segmentasyon sonuçlarından elde edilen özellikler, Gri Seviye Birlikte Oluşum Matrisi (GLCM), Gri Seviye Çalışma Uzunluğu Matrisi (GRLLM) ve Gri Seviye Boyut Bölge Matrisi (GLSZM) gibi yöntemlerle çıkarılmış ve Max-Min normalizasyonu ile işlenmiştir. Özellikler, bilgi kazanım oranı yöntemi ile seçilmiş ve DNN modeli kullanılarak beyin tümörleri sınıflandırılmıştır. Elde edilen sonuçlar, DNN sınıflandırma yönteminin %91,3 doğruluk oranına sahip olduğunu ve bu değerin SVM yöntemine göre %2,75 daha yüksek olduğunu göstermektedir [23]. Rezaei ve diğerleri gerçekleştirdikleri çalışmada, 233 hastadan toplanan 3064 MRI görüntüsüyle menenjiyom, glioma ve hipofiz tümörleri için bir sınıflandırma yöntemi geliştirilmiştir. Görüntülerdeki gürültüyü azaltmak için Wiener ve medyan filtreleri kullanılmış, özellik çıkarma için GLCM, DRLM ve BoW yöntemleri kullanılmıştır. KNN, WSVM ve HIK-SVM gibi üç farklı sınıflandırıcı ensemble learning ile birleştirilerek %92,46 doğruluk sağlanmıştır [24]. Chen ve diğerleri tarafından yapılan çalışmada, Tiantan Hastanesi'nden desteklenen 120 hastadan elde edilen beyin MRI görüntülerini kullanarak beyin tümörlerinin otomatik tespiti ve sınıflandırılması için bir çalışma yürütmüştür. Görüntü işleme aşamalarında gürültü azaltma ve

kontrast iyileştirme yöntemleri kullanılmış, eşik segmentasyonu ve bölge büyüme teknikleriyle kafa tası etkisi azaltılmıştır. GLCM ile doku özellikleri çıkarılmış ve SVM-EKF kombinasyonuyla sınıflandırma yapılmıştır. K-ortalamalar kümeleme algoritması ise tümörlerin otomatik segmentasyonunda kullanılmıştır. Çalışma %96,05 doğruluğa ulaşarak başarılı sonuçlar elde etmiştir [25].

F. Derin Öğrenme ile Beyin Tümörü Tespiti Çalışmaları (2020-2024)

Almadhoun ve Abu-Naser, Kaggle'dan alınan 10.000 beyin MRI görüntüsünü kullanarak beyin tümörlerinin sınıflandırılması için çeşitli derin öğrenme modelleri ve kendi modellerini karşılaştırmışlardır. Veri setini döndürme, genişlik kaydırma, yükseklik kaydırma ve yatay-dikey çevirme gibi veri artırma teknikleriyle genişletmişlerdir. Kendi modellerinde %100 eğitim doğruluğu ve %98,28 doğrulama doğruluğu elde etmişlerdir. Diğer modellerde ise VGG16 %99,86, ResNet50 %98,14, MobileNet %88,98 ve InceptionV3 %99,88 doğruluğa ulaşmıştır. En iyi sonuçları InceptionV3 ve VGG16 modelleri elde etmiştir [26]. Sadad ve diğerleri tarafından yapılan çalışmada, Figshare'den elde edilen beyin MRI görüntülerini sınıflandırmak için MobileNet V2, Inception V3, ResNet50, DenseNet201 ve NASNet gibi derin öğrenme modelleri kullanılmıştır. Ayrıca, ResNet50-UNet segmentasyonu ile de bir model oluşturulmuştur. Çalışmada glioma, hipofiz ve meningioma gibi üç farklı beyin tümör türü ele alınmış ve her bir tümör için sagittal, aksiyal ve koronal görüşler kullanılmıştır. Elde edilen sonuçlara göre, MobileNet V2 için %91.8, Inception V3 için %92.8, ResNet50 için %92.9, DenseNet201 için %93.1 ve NASNet için %99.6 doğruluk oranları gözlemlenmiştir. Ayrıca, ResNet50-UNet segmentasyon modeli %95.04 doğruluk sağlamıştır. Modeller karşılaştırıldığında, NASNet en yüksek doğruluğa sahip model olarak öne çıkmıştır [27]. Badža ve Barjaktarović tarafından yapılan çalışmada, beyin MRI görüntülerini sınıflandırmak için veri kümesini genişletmek amacıyla her görüntüyü iki şekilde dönüştürmüşlerdir. İlk dönüşümde, görüntüler 90 derece döndürülmüş, ikinci dönüşümde ise dikey olarak çevrilmiştir. Bu yöntemle veri seti üç kat büyütülerek toplamda 9192 görüntü elde edilmiştir. Geliştirilen yeni bir CNN mimarisi, T1 ağırlıklı kontrastlı manyetik rezonans görüntülerinde Glioma, Hipofiz ve Meningioma olmak üzere üç beyin tümörü sınıfını sınıflandırmak için kullanılmıştır. MRI görüntüleri farklı boyutlarda ve int16 formatında sağlanmış, normalleştirilmiş ve 256 × 256 piksel boyutuna yeniden boyutlandırılmıştır. Çalışmada k-katlı çapraz doğrulama kullanılarak ağın eğitim performansı değerlendirilmiş ve en iyi sonuçlar artırılmış veri seti kullanılarak elde edilmiştir. Bu şekilde yapılan konu bazında çapraz doğrulama ile elde edilen doğruluk %96,56 olarak kaydedilmiştir [28]. Grampurohit ve diğerleri tarafından yapılan çalışmada, yazarlar CNN modeli ve VGG-16 mimarisini kullanılmıştır. Büyütme işleminden önce, 155 tümörlü ve 98 tümörsüz görüntü bulunmaktaydı ve büyütme işleminden sonra 1085 tümörlü ve 980 tümörsüz görüntüye veriseti çıkartılmıştır. Çalışma sonucunda sırasıyla CNN, VGG-16 modelleri için %93,36, %97,16 doğruluk oranları elde edilmiştir. Modeller karşılaştırıldığında VGG-16 en yüksek doğruluğu göstermiştir [29]. Gurunathan ve Krishnan, değiştirilmiş LeNet CNN mimarisini kullanarak beyin MRG görüntülerini sınıflandırmıştır. Kullanılan CNN mimarisi, iki evrişim katmanı ve iki havuzlama katmanı ile bir tamamen bağlı sinir ağından oluşmaktadır. Veri seti olarak 256 beyin MRG görüntüsü BRATS 2015 veri setinden elde edilmiş olup, yetersiz veri sayısını artırmak için görüntü çevirme, sol ve sağ kaydırma gibi veri artırma yöntemleri uygulanmıştır. Local Binary Pattern (LBP) ve Gray Level Co-occurrence Matrix (GLCM) kullanılarak tümör bölgesi segmente edilmiş ve bu bölgelerden özellikler çıkarılmıştır. Elde edilen özellikler sayesinde tümör şiddet seviyeleri hafif veya ciddi olarak sınıflandırılmıştır. Önerilen sistem, normal olarak sınıflandırılan 150 beyin MR görüntüsünde %98,6'lık bir sınıflandırma oranı sağlamıştır. Ayrıca, ciddiyet sınıflandırması için %96,8'lik bir doğruluk elde edilmiş ve önerilen yöntemle elde edilen ortalama teşhis oranı yaklaşık %97,7 olarak belirlenmiştir [30]. Saeedi ve diğerleri tarafından yapılan çalışmada, 3264 adet T1-ağırlıklı kontrastlı manyetik rezonans görüntüsünü (MRI) içeriyordu. Bu görüntüler, glioma, meningioma ve hipofiz bezi tümörleri ile tümörsüz sağlıklı beyinlerden oluşan dört farklı sınıfa ayrılmıştı. Veri setinin kamuoyuna açık bir kaynaktan, GitHub'dan temin edildiği belirtilmiş. Elde edilen doğruluk oranları NN için %86, RF için %82, SVM için %80, LR için %62, SGD için %52 ve MLP için %28 idi. Ancak önerdikleri 2D CNN ve otomatik kodlayıcı ağı(Auto-encoder Network) sırasıyla %96,47 ve %95,63 doğruluk elde edilmiştir [31]. Methil tarafından gerçekleştirilen çalışmada, beyin

tümörü sınıflandırması için Evrişimli Sinir Ağı (CNN) kullanılmıştır. Veri seti, 3762 tümör görüntüsünden ve 253 ek görüntüden oluşmaktadır. Önişleme adımlarında histogram eşitleme ve morfolojik açılma kullanılarak görüntü kontrastı artırılmış ve gürültü temizlenmiştir. Eğitim ve doğrulama için veri seti %70-%30 oranında bölünmüş, upsampling ile veri seti 4222 görüntüye çıkarılmıştır. Test veri seti olarak internetten rastgele seçilen 20 görüntü kullanılmıştır. CNN, eğitim setinde %98,55, doğrulama setinde %99,73 geri çağırma oranı elde etmiştir. Bu, çalışmanın oldukça başarılı sonuçlar elde ettiğini göstermektedir [32]. Pedada ve diğerleri tarafından gerçekleştirilen çalışmada, beyin tümörlerini 3D MRI görüntülerinden doğru bir şekilde segmente etmek için modifiye bir U-Net yapısı önerilmiştir. Önerilen U-Net modeli, giriş katmanı olan kodlayıcı kısmı, önceden eğitilmiş bir ResNet34 modeliyle değiştirilerek, U-Net'in daha iyi özellikler çıkarabilmesi sağlanmıştır. Bu yöntem, BraTS 2017 ve 2018 veri kümelerinde değerlendirilmiş olup, segmentasyon doğrulukları sırasıyla %93,40 ve %92,20 olarak elde edilmiştir, bu da yaklaşımın etkinliğini göstermektedir [33]. Khan ve diğerleri tarafından gerçekleştirilen çalışmada, beyin anormalliklerini tanımlamak ve meningiom, gliom ve hipofiz tümörlerini sınıflandırmak için iki derin öğrenme modeli tanıtılmıştır. 23 katmanlı CNN mimarisi, büyük hacimli verilerle çalışmak için tasarlanmışken, transfer öğrenimi tabanlı VGG16 eklentisi sınırlı veri setleri için optimize edilmiştir. Ayrıca, performansı artırmak için kapsamlı bir veri artırma tekniği uygulanmıştır. Figshare veri seti için %97,8 ve Harvard Medical Veri Seti için %100 tahmin doğruluğu elde edilmiştir [34]. Azhagiri ve Rajesh tarafından yapılan çalışmada, Brats2015 veri seti kullanılmıştır. İlk olarak, görüntüler sabit 224×224 piksel çözünürlüğünde gri tonlamalı hale dönüştürülmüş ve Gauss filtresi ile yumuşatılarak gürültü azaltılmıştır. Veri artırımı için kırpma, döndürme, rastgele döndürme, sabit boyutlu döndürme, renkli kırpma ve gürültü ekleme gibi işlemler uygulanmıştır. Image Data Generator fonksiyonu, tıbbi görüntülerin kalitesini koruyarak veri kümesini genişletmiştir. Model olarak AlexNet'in geliştirilmiş versiyonu olan EAN (Geliştirilmiş AlexNet) kullanılmıştır. Bu model, %99,32 doğruluk oranı ile beyin tümörlerini sınıflandırmada yüksek performans göstermiştir [35].

III. TARTIŞMA VE SONUÇ

Bu çalışmada, 2020-2024 yılları arasında beyin tümörlerinin tespitinde Makine Öğrenmesi (ML) ve Derin Öğrenme (DL) tekniklerinin kullanımına dair sistematik bir literatür taraması gerçekleştirilmiştir. Beyin tümörü tespitinde ve sınıflandırmasında kullanılan çeşitli ML ve DL yöntemlerinin mevcut durumu ve bu yöntemlerin performansı değerlendirilmiştir. İnceleme, çeşitli dergi ve konferanslardan elde edilen 20 birincil çalışmanın detaylı analizini içermektedir. ML tekniklerinden en çok tercih edilenler arasında Destek Vektör Makineleri (SVM), K-en Yakın Komşular (KNN) ve Naïve Bayes algoritmaları bulunmaktadır. Öznitelik çıkarımı adımında gri seviye birlikte oluşum matrisi (GLCM) ve uzamsal gri seviye bağımlılık matrisi (SGLDM) gibi yöntemler kullanılmıştır. DL teknikleri arasında ise Convolutional Neural Networks (CNN), Deep Neural Networks (DNN) ve U-Net en yaygın olarak kullanılanlardan olmuştur. DL teknikleri, daha büyük veri setleri üzerinde çalışarak daha derin ve karmaşık ilişkileri öğrenme kapasitesine sahiptir. DL tekniklerinin değerlendirildiği çalışmalardan biri olan Khan ve diğerleri (2022) tarafından gerçekleştirilen çalışmada, Harvard Medical veri setinde %100 doğruluk oranı elde edilmiştir. Ancak, bu sonucun aşırı uyum (overfitting) gibi durumların etkisi altında kalabileceği değerlendirilmektedir. Geliştirilmiş AlexNet (EAN) ve NASNet, diğer çalışmalarda öne çıkan mimariler olmuştur. EAN %99,32, NASNet %99,6 doğruluk oranı elde etmiştir. VGG16 için %97,16 ile %99,86, InceptionV3 için %92,8 ile %99,88 arasında doğruluk oranları elde edilmiştir. Makine öğrenmesi teknikleri arasında en başarılı sonuçlar KSVM-SSD (Kernel Support Vector Machine-Social Sürü Optimization) kullanılarak elde edilmiştir. BRATS 2018, 2019, 2020 için %99,2, %99,36, %99,15 doğruluk oranları elde edilmiştir. Naïve Bayes ve DNN gibi sınıflandırıcılar da oldukça iyi performans göstermiştir. DL tekniklerinin genel olarak ML tekniklerine göre daha yüksek doğruluk oranları elde ettiği görülmüştür. CNN tabanlı yöntemler %90-98 doğruluk oranlarına ulaşırken, ML tabanlı yöntemler %85-95 aralığında doğruluk göstermiştir. Çalışmalarda yaygın olarak kullanılan veri setleri arasında BRATS (Brain Tumor Segmentation) veri seti, Kaggle veri setleri ve hastanelerden elde edilen MRI görüntüleri yer almaktadır. Veri arttırma teknikleri, veri setlerinin çeşitliliğini arttırmış ve modellerin genelleme yeteneklerini iyileştirmiştir. Döndürme, genişlik ve yükseklik kaydırma, yatay ve dikey çevirme en yaygın veri arttırma

teknikleri arasındadır. Veri arttırma uygulanan çalışmalarda %99 civarı doğruluk oranları elde edilmiştir. Gelecekteki çalışmalar için, daha büyük ve çeşitli veri setlerinin kullanılması, veri arttırma teknikleri ile veri setlerinin zenginleştirilmesi ve hibrit ML-DL modellerinin oluşturulması önerilmektedir. Geliştirilen modellerin hastane ortamında ve gerçek hayatta uygulanarak test edilmesi büyük katkı sağlayacaktır. Sonuç olarak, ML ve DL teknikleri, beyin tümörü tespitinde önemli ilerlemeler sağlamış ve tıbbi teşhis süreçlerini daha hızlı ve hassas hale getirmiştir. Bu teknolojik gelişmeler, hastalara erken teşhis imkanı sunarak tedavi süreçlerinin daha etkili yönetilmesine katkıda bulunmakta ve yaşam kalitesini artırmada önemli bir rol oynamaktadır.

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AN APPROACH BASED ON COMBINING DEEP LEARNING MODEL AND ENSEMBLE TECHNIQUE IN AIDS CLASSIFICATION

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Abstract – AIDS is a disease that's seen quite often these days and can be serious if it's not treated. HIV the virus that leads to AIDS, can weaken the immune system of the infected individual, leading to susceptibility to infections and a compromised ability to fight certain types of cancer. This condition causes heart disease, kidney problems, infections and neurological disorders, which are among the critical health conditions. These types of diseases can have fatal consequences. Therefore AIDS should be diagnosed as early and accurately as possible. In this study an architecture was created by combining the GRU a deep learning model, and the Voting Classifier model an Ensemble technique to accurately classify AIDS disease. GRU model has high processing rate on sequential data. The Voting Classifier model is a type of Ensemble method that combines multiple machine learning classifiers to obtain safe results. In the development of the model, a dataset comprising approximately 35.000 entries with 22 features was utilized. The dataset was trained with GRU and Voting Classifier architecture. Following the completion of the training it was found that individuals with AIDS could be accurately distinguished achieving a 97.84% accuracy rate on the test data set.

Keywords – HIV virus, AIDS disease, Deep learning, Ensemble Technique.

1- Introduction

AIDS is a serious disease caused by a virus known as HIV [1]. It is also known as the advanced stage of the infection caused by the HIV virus which affects the immune system. AIDS disease which is frequently encountered today, weakens the immune system in the human body making it vulnerable to external factors, and if left untreated, it can be a fatal disease. The HIV virus that causes AIDS can be transmitted through blood, sexually, by injection, and from mother to baby during birth. AIDS disease affects people negatively in many ways such as immune system failure, opportunistic infection, lack of resistance to some types of cancer, neurological disorders, heart diseases and kidney disease [2][3][4][5]. As far as is known since the beginning of the virus, approximately 76 million people in the world have been infected with this disease and approximately 33 million people have died. [6]. According to data obtained from the World Health Organization AIDS has become more common and dangerous, especially in low and middle-income countries [7].

In order to prevent all these negative situations, this study aimed to classify AIDS as accurately as possible. Various machine learning methods and neural networks have been used to classify AIDS disease [8][9]. To identify the disease a dataset predominantly derived from laboratory measurements was utilized. Examining the features obtained as a result of the measurement together allows forming an opinion about AIDS disease. The data set used went through a two-stage training. Firstly the dataset was trained with the GRU model

which is a recurrent neural network cell. The results are subsequently integrated into the Voting Classifier through the utilization of the GRU Wrapper. The method used in the training is shown in Figure 1.

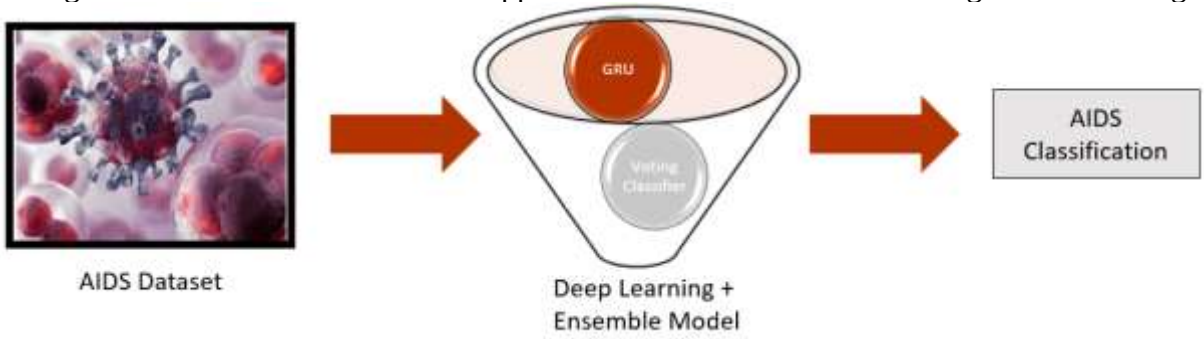


Figure 1 Classification Algorithm with Deep Learning + Ensemble Method

2- AIDS DISEASE

AIDS is a type of disease caused by the HIV virus. This virus targets the immune system and usually proliferates in lymph nodes and lymphoid tissues, leaving the body vulnerable to infections, chronic diseases and some types of cancer. To do this it targets CD4+ cells. In some cases it can also negatively affect the nervous system and cause some neurological disorders. That's why early diagnosis is very important. When diagnosing the disease the CD4+ cell count is usually checked and the disease is diagnosed [10][11]. If treatment is not started on time AIDS can become fatal. In some studies the survival rate of patients infected with AIDS was calculated to be around 60% [12]. AIDS disease consists of four stages. The formation stages are shown in Figure 2.

Figure 2 Stages of AIDS Disease Development

1- This phase is the acute phase covering the first few weeks. It has symptoms similar to flu. At this stage attacks begin on CD4 (helper T cell), an important cell of the immune system.
2- Symptoms decrease and the CD4+ cell count gradually decreases.
3- Some symptoms become visible and the body's immune system begins to weaken.
4- Quite strong infections begin to appear. This condition may also be accompanied by some types of cancer. A critical decrease in CD4+ cell numbers is observed.

Early diagnosis and treatment is very important in AIDS disease. ART treatment type can be applied for the treatment of AIDS disease. With ART treatment the proliferation of the HIV virus is controlled and the patient's quality of life is increased.

2- LITERATURE REVIEW

In this section of the study information on AIDS detection, the data set, the methodology used and the results obtained from the study are presented in a table.

Tablo 1 Literature Table

Referance number	Dataset	Method	Result
[13]	A data set obtained from Data World was used.	Different machine learning and deep learning methods were used. LSTM gave the best results.	%97.65 acc.
[14]	CICIDS2017	10 popular supervised and unsupervised machine learning algorithms have been tested. k-NN-AIDS, DT-AIDS and NB-AIDS gave the best results.	K-NN = %99.49 acc, NB = %98.86 acc, DT = %99.49 acc
[15]	PHIA	XGBoost algorithm was used.	90% F1 Score for women and 92% F1 Score in men.
[16]	A dataset was used from the EDHS repository of the Central Statistical Agency (CSA), which is used for both training and testing purposes.	XGBoost algorithm was used. Eight established machine learning models were used (GB, SVM, KNN, ET, DT, AB, RF and LR).	For GB; %87,67 acc, %87,32 F1 Score.
[17]	EHR data from the Melbourne Sexual Health Center (MSHC) was used.	A number of linear and nonlinear machine learning models have been created that include regression algorithms, including MLR and ENR.	HIV (AUC = 0,72).
[18]	The DHS-HIV/AIDS dataset from the Central Statistical Agency (CSA) was used.	GB, KNN, RF, ET, MLP and BFS method were used for feature selection.	For GB; %87 F1 Score.
[19]	4855 HIV-1 datasets from ChEMBL were used.	15 classification models were used (SVM, DT, KNN, etc.).	For SVM; %83,07 acc
[20]	Data from HIV-1 CRF01 were used.	A deep learning model using CNN has been developed.	%98+ specificity, %92+ Sensitivity.

3- DATASET AND METHOD

3.1 DATASET

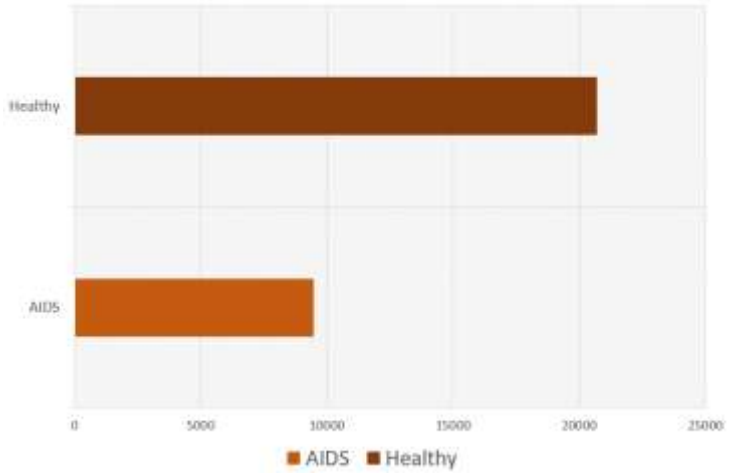
To accurately classify the AIDS disease a dataset consisting mostly of data from laboratory settings was used. The dataset used was obtained from the Kaggle platform and is publicly available. There are a total of 22 features in the dataset. Analyzing these features together plays an important role in the classification of AIDS disease. The dataset used consists of exactly 30.375 data.

Tablo 2 Dataset Components

Dataset Components	
CD40	It indicates the number of CD4 cells in a person's initial white blood cells.
CD420	It indicates the person's CD4 cell count within 20 weeks.
CD80	It indicates the number of CD8 cells in a person's initial white blood cells.
CD820	It indicates the person's CD8 cell count within 20 weeks.
Offtrt	Indicates whether ART treatment is applied to the person.
Treatment Status	It determines whether the person uses medication or not. (0: ZDV drug, 1: others).
Semptom	Indicates the person's symptom indicator.
Strat	It indicates whether the person has previously received ART treatment and, if so, whether it has been for longer than 52 weeks.
Str2	It contains information labeled as 0 and 1 as to whether the person has ever received ART treatment before.
Gender	It is the person's gender status.
Race	It contains two classes where people are divided according to their race (0,1).
Preanti	It indicates the person's condition and viral load before starting treatment.
Z30	It indicates whether the person has used the medicine called ZDV within 30 days.
Oprior	It indicates whether the person uses any medication other than ZDV.
Karnof	It contains data where the person is labeled on the Karnofsky scale between 0 and 100.
Medication	It indicates whether the person generally uses medication or not.
TRT	It provides information about the treatment the person receives. ZDV, ZDV + DLL, ZDV + ZAL, DLL alone.
Homo	It classifies the person with two labels, 0 and 1, according to homosexuality.
Hemophilia	It is the concentration of hemophilia in a person's blood sample.
Weight (WTGK)	Indicates the person's weight.
Age	Indicates the person's age.

Time	It refers to the time it takes until the person does not show the expected result during the clinical study.

The graph of the number of healthy individuals and individuals with AIDS in the data set used is given in Table 3.



Tablo 3 Dataset content distribution table

The matrix created to determine the relationship between variables in a data set is called correlation matrix. This matrix indicates how each value in the data set is related to the others. In other words it represents linear dependence. The correlation matrix of the data set used for accurate classification of AIDS disease is as shown in Figure 3.

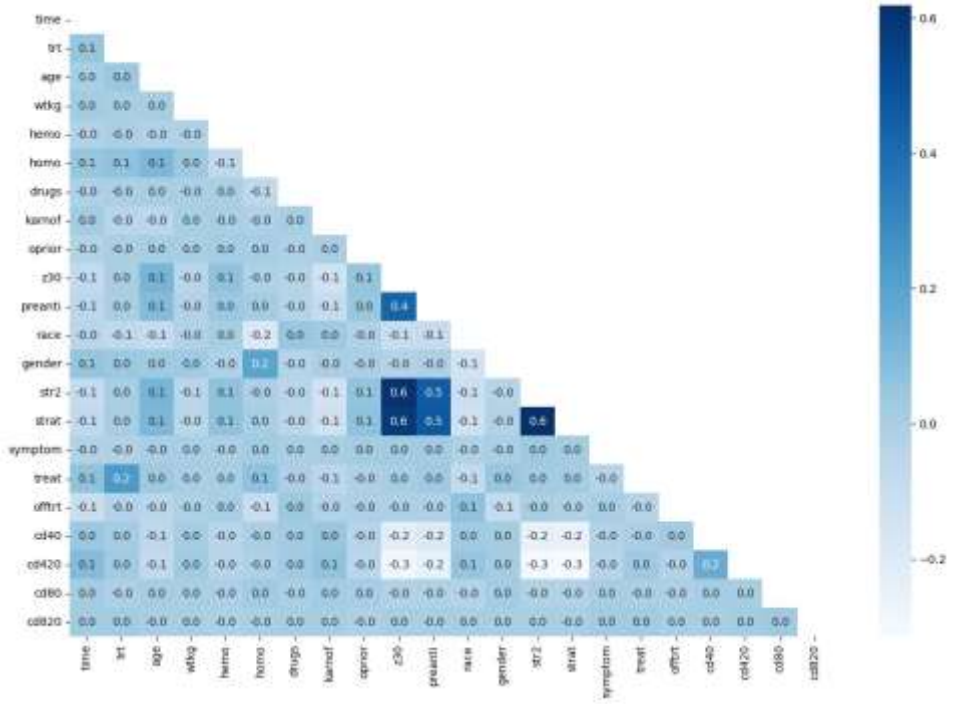


Figure 1 Correlation Matrix

3.2 METHOD

In this study an architecture that uses GRU a deep learning method and Voting Classifier an Ensemble technique, is proposed to accurately classify AIDS disease. The GRU method a type of RNN, can work

successfully on serial data. The GRU method is advantageous because it has a high learning ability in a long context, keeps the flow of information under control by incorporating a gate mechanism, has a less complex structure compared to other models, and completes training quickly. On the other hand, Voting Classifier an Ensemble method in the field of machine learning, increases efficiency by using different models together and using the results obtained from the models together. When diverse models are combined, the strengths of one model can be leveraged to compensate for the weaknesses of another thereby closing the gap. This stabilizes the model and reduces the likelihood of overfitting. For these reasons, GRU and Voting Classifier methods were used together in this study to detect AIDS disease.
In this study the following steps were carried out in order to classify AIDS disease as accurately as possible.

1- The raw data set is processed and made ready for training.
2- The GRU model is defined and the model is compiled.
3- Other machine learning models (including LR, RF and SVM) are defined.
4- With a GRU Wrapper structure LR, RF and SVM models are trained with the outputs from the GRU model.
5- LR, RF and SVM models are combined in a Voting Classifier structure.
6- The performance metrics of the model created as a result of the training are calculated.

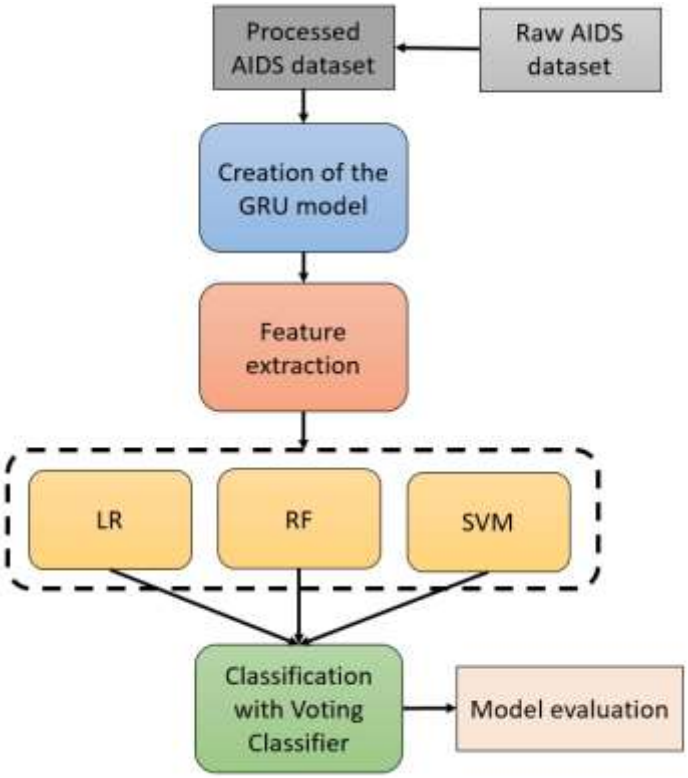


Figure 2 Architecture of the Proposed Method

The layer information of the GRU method used in the classification architecture, whose general architecture is given in Figure 4, and the parameters of the Voting Classifier classifier are given in Figure 5. GRU model is created by using a combination of layers such as Embedding, GRU, DropOut and Dense. Voting Classifier consists of the previously created GRU model, LR, RF and SVM models. While voting the results the 'Soft' type of the Voting Classifier structure was used. When calculating the results the average of the

class predictions made by each model is taken. This increases the likelihood that the model will be more accurate.

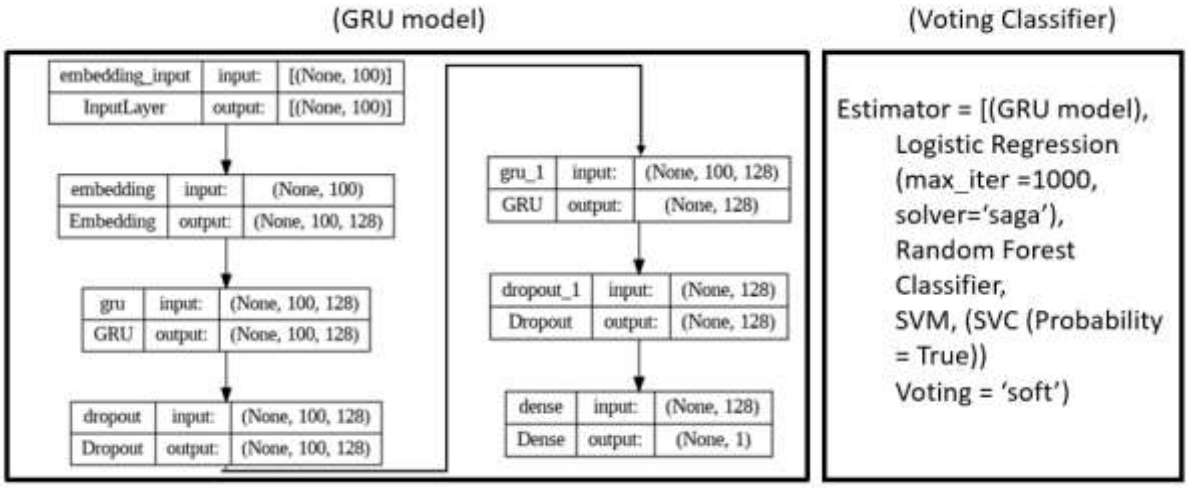


Figure 3 Layers and Parameters of the Recommended System

The general features of the computer used in the classification of AIDS disease are given in Table 4.

Table 4 Computer Properties

CPU	AMD Ryzen 9 5900X
GPU	RTX 3070
RAM	32 GB
OS	Windows 11 Pro

4- EXPERIMENTAL RESULTS

The Complexity Matrix obtained as a result of the training provided by the deep learning and ensemble technique used in the classification of AIDS disease is shown in Figure 6. With the complexity matrix created the Accuracy, Precision, Recall and F1 Score values of the model were calculated with the TN, TP, FN and FP values of the matrix. Calculated performance metrics are stated in Table 5.

Table 5 Performance Metrics

Accuracy	0.97
Precision	0.96
Recall	1.0
F1 Score	0.92

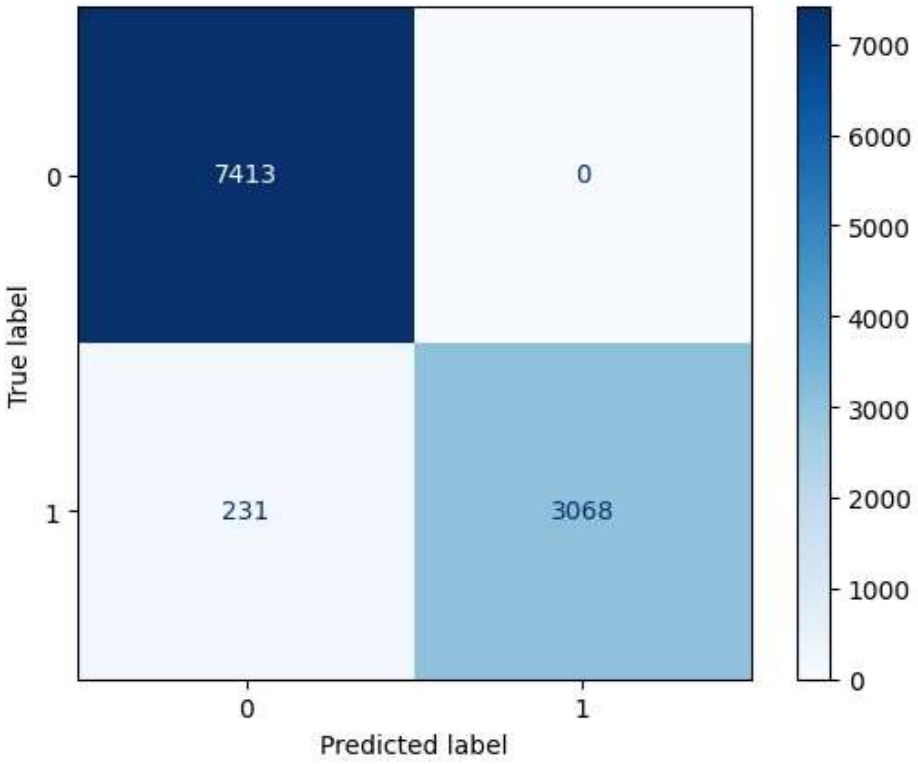


Figure 4 Confusion matrix

5- DISCUSSIONS AND CONCLUSION

In this study GRU a neural network-based method and Voting Classifier method an Ensemble technique, were used together to accurately classify AIDS disease. As far as we know GRU and Voting Classifier methods have not been used together in the classification of AIDS disease. This proposed method was applied to the AIDS disease dataset which is publicly available on the Kaggle platform and consists of 22 features, many of which were collected in the laboratory environment. The created architecture achieved a significant accuracy rate of 97.84% in the test data of the data set used. This rate is an important rate for the classification of AIDS disease.

Abbreviation table

Acc	Accuracy score
AIDS	Acquired Immune Deficiency Syndrome
ART	Antiretroviral Therapy
BFS	Breadth First Search
CNN	Convolutional Neural Networks
DLL	Didanosine
DT	Decision Tree
ENR	Elastic-Net Regresyon
ET	Extra Tree algorithm
GB	Gradient Boost
GRU	Gated recurrent units
HIV	Human Immunodeficiency Virus
K-NN	K-Nearest Neighbor
LR	Logistic Regression
MLP	Multi-layer Perceptron
MLR	Multivariate Logistic Regression

NB	Navie Bayes Algorithm
RF	Random Forest
SVM	Support Vector Machine
ZAL	Zalcitabine
ZDV	Zidovudie

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Modal parameter differences of TBDY-2018 and RYTEIE-2019 regulations in the blended brick wall model

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Abstract – Masonry structures are generally encountered in historical structure but masonry structures are still used today, both decoratively and depending on the conditions of use. Especially masonry blended brick walls are widely used today. Earthquake-resistant design of newly constructed masonry structures and determination of the safety of existing structure stock can be made in accordance with the provisions of the current Turkish Building Earthquake Regulation (TBDY-2018). However, since these risk determinations are a long-lasting and high-cost process, the Risky Risk Report published in order to eliminate this situation. With the Principles for Identification of Risky Buildings (RYTEIE-2019), it can be determined whether existing buildings are risky in a short time and at low cost. It is known that there are differences in both regulations that will affect modal parameters. These differences need to be investigated in different geometries and structure types with different intended uses. As a result of the study, the blended brick wall model was found to be more rigid according to the TBDY-2018 regulation. As a result, it is thought that the RYTEIE-2019 regulation will give safer results and it is recommended to take the RYTEIE-2019 regulation into consideration in blended brick walls to be newly constructed, also in terms of economic life of masonry blended brick walls.

Keywords –Blended brick wall, TBDY-2018, RYTEIE-2019, Modal parameters, Masonry structures

I. INTRODUCTION

Masonry structures have load-bearing systems created by placing structure materials such as stone, brick, adobe, briquette and wood on top of each other and combining them with their own weight and mortar. They are a type of structure that has been preferred for residential or service purposes since ancient times [1,2]. In stone and brick masonry structure types, which have economical features such as ease of material supply and thermal insulation, walls are constructed with thick walls to ensure a certain stability. These structural parts, which we call brittle materials, show very early deformation under earthquake forces. Thus, the wall elements that crack under the influence of shear force are damaged after a while in such a way that they cannot carry the vertical loads. The strength of the material used, the strength of the adhesive mortar, and good quality workmanship are defined as prerequisites for earthquake-resistant masonry construction [3,4]. Masonry structures are widely used in our country, which is located on an important earthquake zone, and are exposed to earthquake forces along with vertical loads throughout their lifetime. Earthquakes that have occurred in recent years have caused different structural damages in masonry structures [5,6,7]. By evaluating the developments in earthquake engineering and the information obtained in the field studies carried out after the earthquakes, the earthquake regulation in force was updated and the Turkish Building Earthquake Regulation (TBDY-2018) was published and entered into force in 2018 [8]. In order to determine more quickly whether the existing building stock is sufficiently resistant to possible earthquake risks and to solve the problem of

unplanned urbanization, especially in big cities, the "Law on the Transformation of Areas at Disaster Risk" No. 6306 has come into force. The Principles for the Detection of Risky Buildings (RYTEIE-2019) prepared within the scope of this law and the rules and methods to be used in detecting risky buildings have been published [9]. [10].

It is known that there are differences in both regulations that will affect modal parameters. These differences need to be investigated in different geometries and structure types with different intended uses. The aim of this study is to investigate the effect of the calculation conditions given in TBDY-2018 and RYTEIE-2019 regulations on the modal parameters of the blended brick wall model. Knowing the modal parameters allows the response of the structure to be predicted as a function of external stimulation. These parameters therefore constitute a kind of dynamic “identity card” of the structure that can be used for verification, calibration or diagnostic purposes of computational models and provide a baseline in long-term structural monitoring.

II. Materials and Method

Blending brick takes its name from the area where the brick is shaped, dried and fired. All stages of blending brick, also called wedge brick, from raw material preparation to packaging, take place in this area called blending. It is a form of production that is based on human power and is traditional and primitive compared to today's technology. Although it is far behind today's mass production methods, Blended brick is still a preferred material in terms of its firing color, natural appearance and place of use and purposes. It is used in the restoration and repair of many buildings. Again, many architects include designs solved with blended bricks in their designs. The production of blend brick has continued until today, as it is a sought-after material in modern architecture and landscaping [11].

Blended brick is a document that completely bears the traces of the past. It is a reflection of the past, shaped by human hands, combining labor with culture, and occupying an aesthetic place among historical values. Many works made with blended bricks centuries ago are still usable today. It is among the materials frequently used in buildings of historical value.

The blend brick used in the study is given in figure 1 along with its dimensions.

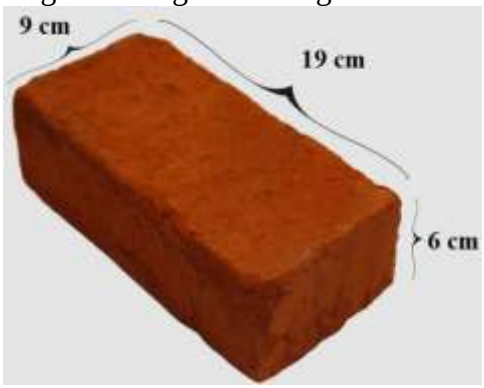

Fig. 1 The blend brick

Blended brick walls are quite common today. It constitutes a large part of the historical buildings in particular. Additionally, blended brick walls are still seen in rural areas. In addition to all these, it is used for architectural and decorative purposes. [12-20] studies have been conducted on blended brick walls, which also contributed to this study. Examples of blended brick walls are given in figure 2.

Fig. 2 Examples of blended brick wall

Finite element method was used in the study. SAP2000 software was used in the finite element modeling and analysis part. In the analysis part, modal analysis method was used. Resources [21-24] were used for the theoretical infrastructure of the methods. During the modeling phase, [25-28] resources were used.

The length of the masonry blended brick wall model is 20 meters. Wall thickness was taken as 20 cm. The wall height is 2.5 meters. The 3D finite element model of the blended brick wall is given in figure 3.

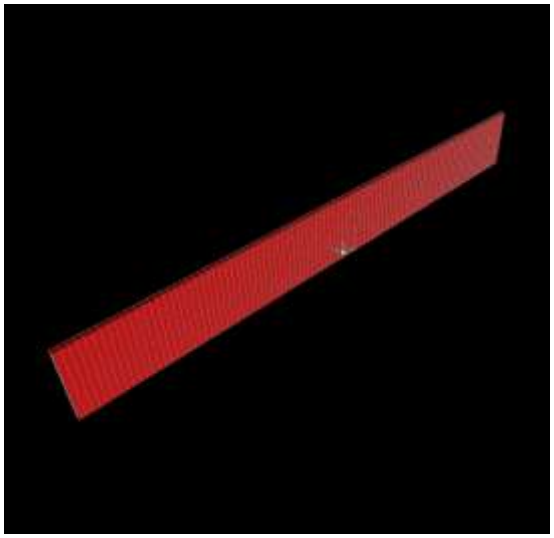

Fig. 3 The 3D finite element model of the blended brick wall

According to TBDY 2018, *"The type of wall materials will be determined visually by removing the plaster of a part of the wall surface. In order to determine the properties of the wall material, at least two wall sample samples will be taken from the building and its strength will be determined by applying compressive strength tests. The lowest characteristic compressive strength of solid brick masonry walls is defined as* f_k*=1.4MPa, and the Elasticity Modulus* E_{duv}*=750*f_k*."* Poisson's ratio is 0.2. Unit volume mass was taken as 2000 kg/m^3 [8].

III. RESULTS

As a result of the modal analysis, the mode shapes of the first five modes of the blended brick wall model created according to TBDY 2018 are given in figures 4,5,6,7,8.

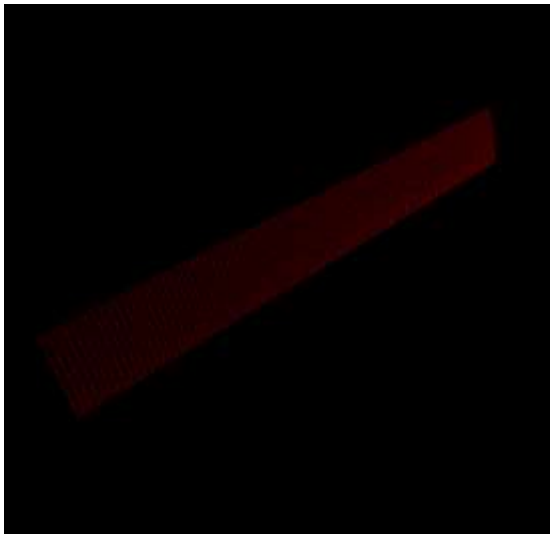

Fig. 4 1. Mode (Period value= 0,920568 s)

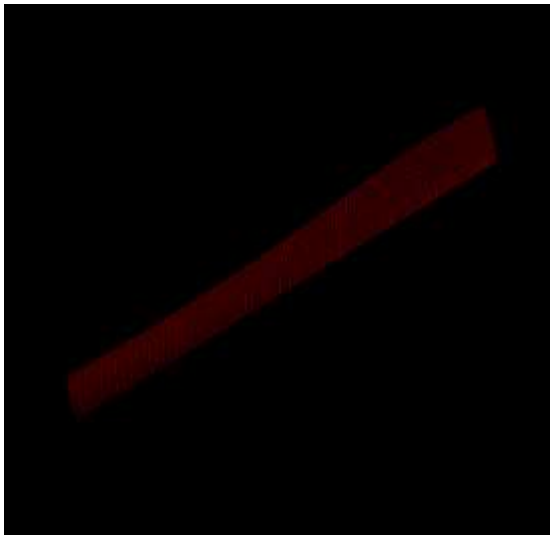

Fig. 5 2. Mode (Period value= 0,882172 s)

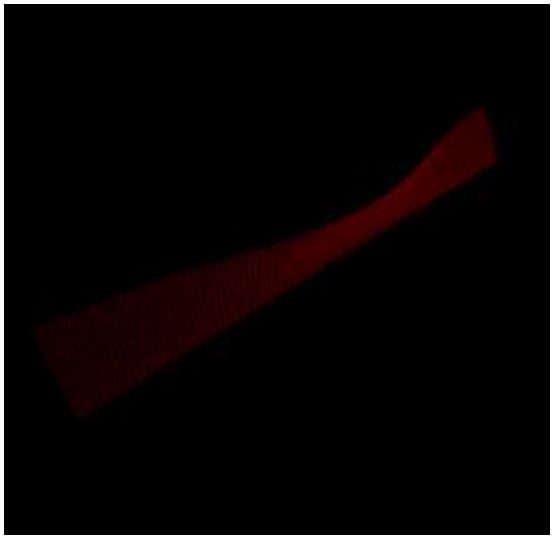

Fig. 6 3. Mode (Period value= 0,785742 s)

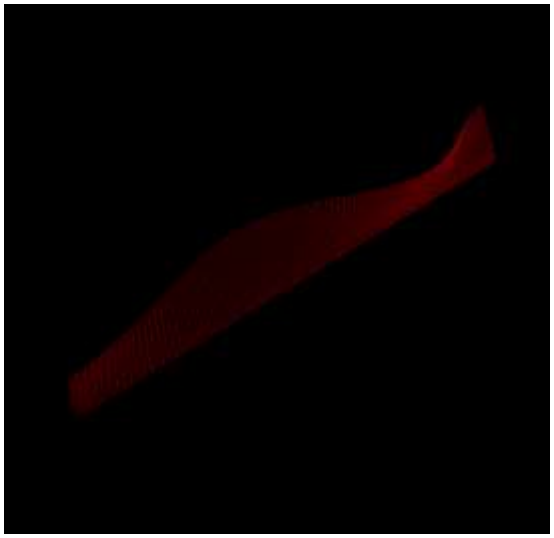

Fig. 7 4. Mode (Period value= 0,669653 s)

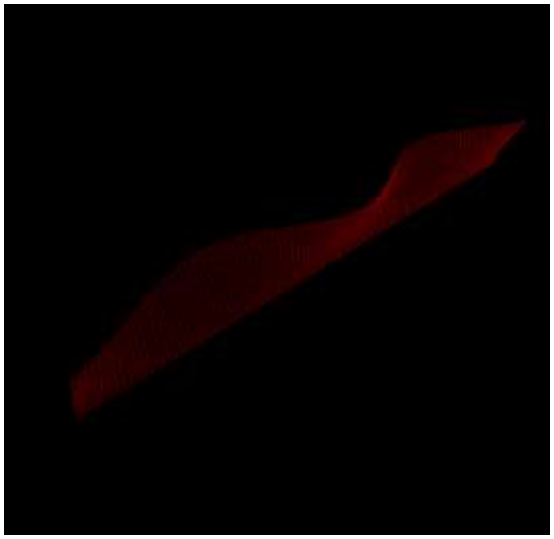

Fig. 8 5. Mode (Period value= 0,558950 s)

According to RYTEIE-2019, *"The type of wall materials will be determined by removing the plaster of a part of the wall surface, at least on one interior and one exterior wall. Apparent quality normal values will be used for the pressure, shear, diagonal tensile strength and specific gravity values of walls constructed with cement reinforced mortar and masonry units. For Solid Brick or Blended Brick masonry walls, the strength value is defined as* f_m*=1.4MPa and the Elasticity Modulus is defined as* E_m*=600*f_m*. Visible quality will be considered Poor for walls where mortar discontinuity or structural cracks are documented by photographs. The lowest characteristic compressive strength of solid brick masonry walls is defined as* f_k*=1.4MPa, Elasticity Modulus* E_{duv}*=750*f_k*."* Poisson's ratio is 0.2. Unit volume mass was taken as 2000 kg/m^3 [9].

As a result of the modal analysis, the mode shapes of the first five modes of the blended brick wall model created according to RYTEIE-2019 are given in figures 9,10,11,12,13.

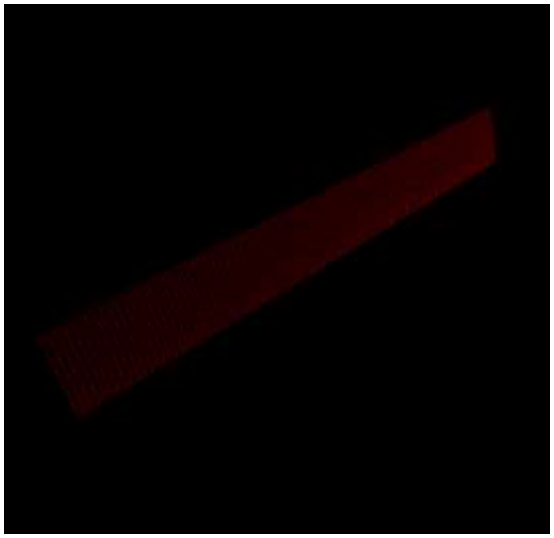

Fig. 9 1. Mode (Period value= 0,823381 s)

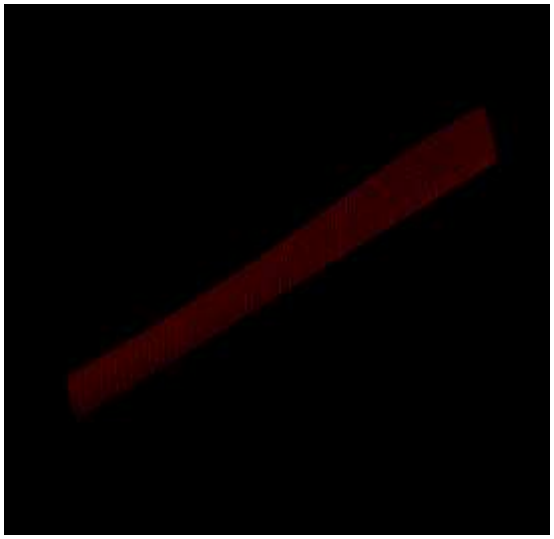

Fig. 10 2. Mode (Period value= 0,789039 s)

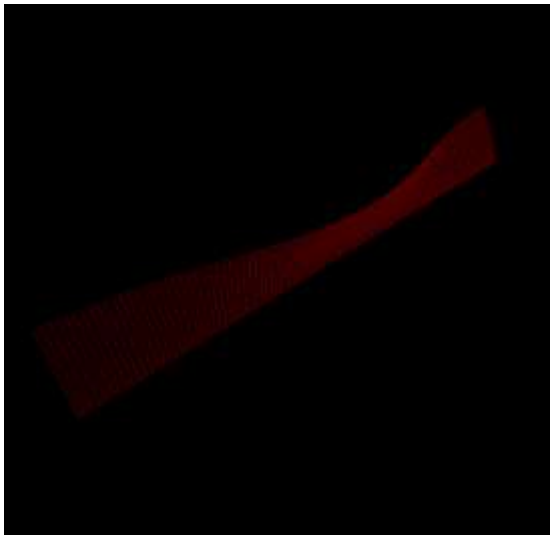

Fig. 11 3. Mode (Period value= 0,702789 s)

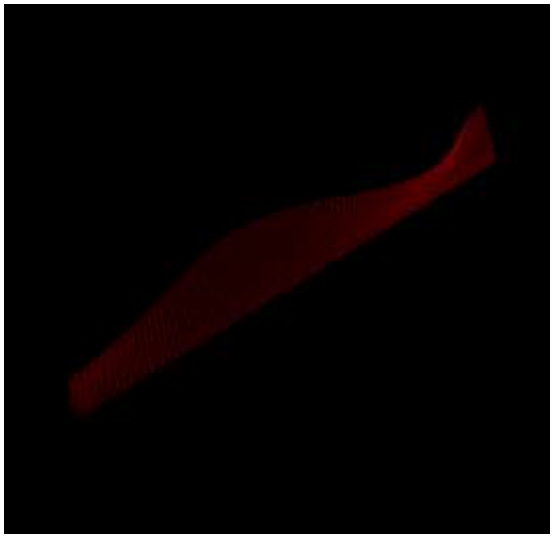

Fig. 12 4. Mode (Period value= 0,598956 s)

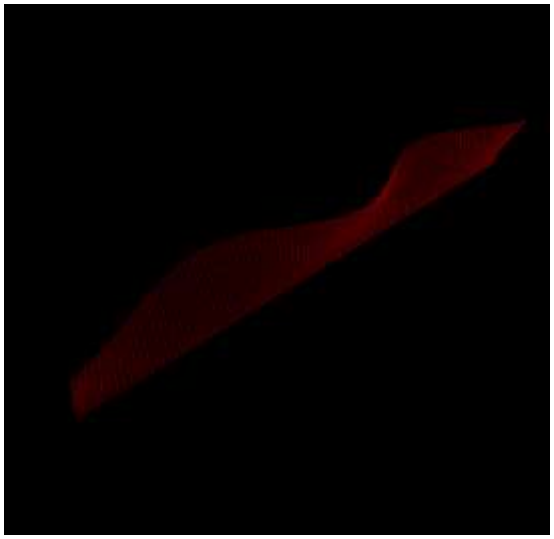

Fig. 13 5. Mode (Period value= 0,499940 s)

The results of the period values according to TBDY 2018 and RYTEIE-2019 are given comparatively in Table 1.

Table 1. Comparison of TBDY 2018 and RYTEIE-2019 period values

	Mode 1	**Mode 2**	**Mode 3**	**Mode 4**	**Mode 5**
TBDY 2018	0,920568	0,882172	0,785742	0,669653	0,55895
RYTEIE-2019	0,823381	0,789039	0,702789	0,598956	0,49994
Difference (s)	0,097187	0,093133	0,082953	0,070697	0,05901
Difference (%)	10,55729	10,55724	10,55728	10,55726	10,55729

The results of the mode shape according to TBDY 2018 and RYTEIE-2019 are given comparatively in Table 2.

Table 2. Comparison of TBDY 2018 and RYTEIE-2019 mode shapes

	Mode 1	**Mode 2**	**Mode 3**	**Mode 4**	**Mode 5**
TBDY 2018	Translational	Torsional	Torsional	Torsional	Torsional
RYTEIE-2019	Translational	Torsional	Torsional	Torsional	Torsional

IV. CONCLUSION

When examined for the first 5 modes, differences were seen between TBDY-2018 and RYTEIE-2019, equal in percentage in all modes. This difference is approximately 10.56%. According to the results of the period data, since there was no change in the geometry and mass of the blended brick wall, the stiffness value decreased by 10.56% in RYTEIE-2019 compared to TBDY-2018. The biggest difference between the two methods in the numerical calculation part is in the calculation of the elasticity modulus. The elasticity module in RYTEIE-2019 is requested to be accepted as 20% lower than TBDY-2018. It is understood that the results obtained are parallel to this demand. When the mode shapes are examined, they do not show significant change in the calculation results according to both regulations.

In light of all these results obtained, it is clearly seen that RYTEIE-2019 accepts the blended brick wall model as less rigid than TBDY-2018. Here, it is understood that the RYTEIE-2019 regulation acts more safely and is closer to the decision on possible reinforcement or demolition. The reason for this situation is the statement in RYTEIE-2019: *"Values given as apparent quality normal will be used for the pressure, shear, diagonal tensile strength and specific gravity values of walls built with cement-reinforced mortar and masonry units."* In TBDY-2018, it is required to calculate the strengths through direct tests. It is understood that having both regulations in force at the same time is a confusing situation. In addition, it is known that the 10.56% stiffness difference in the blended brick wall model is significant. It is understood that a lot of experimental work is needed for new regulations in order to make the percentage differences more sensitive. In addition, it is understood from the analytical analysis that for the blended brick wall model, a 20% decrease in the elasticity modulus should not be assumed to affect the stiffness by 20%. No mistakes should be made based solely on the k=E.I formula. Boundary conditions must be taken into consideration when calculating stiffness. It is recommended to take the RYTEIE-2019 regulation into consideration in order to eliminate confusion, stay on the safe side and in terms of the economic life of blended brick walls.

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Modal parameters of the blended brick well model according to TBDY-2018 and RYTEIE-2019

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Abstract **–**It is a known fact that earthquakes damage not only buildings but also infrastructure and superstructure facilities. For this reason, the seismic performance of all building types is of vital importance. It is known that seismic performance losses are experienced in various building types with the effect of earthquakes. Due to the masonry wells structures, which are frequently seen especially in rural areas, it is possible to receive great damage in the face of environmental and forced vibrations. Earthquake-resistant design of newly constructed masonry structures and determination of the safety of existing structure stock can be made in accordance with the provisions of the current Turkish Building Earthquake Regulation (TBDY-2018). However, since these risk determinations are a long-lasting and high-cost process, the Risky Risk Report published in order to eliminate this situation. With the Principles for Identification of Risky Buildings (RYTEIE-2019), it can be determined whether existing buildings are risky in a short time and at low cost. It is known that there are differences in both regulations that will affect modal parameters. These differences need to be investigated in different geometries and structure types with different intended uses. As a result of the study, it was seen that the blending brick well model was more rigid in TBDY-2018. As a result, it is thought that the RYTEIE-2019 regulation will give safer results and it is recommended to take the RYTEIE-2019 regulation into consideration in blended brick wells to be newly constructed, also in terms of economic life of masonry blended brick wells.

Keywords –Blended brick well, TBDY-2018, RYTEIE-2019, Modal parameters, Masonry structures

I. INTRODUCTION

Masonry structures have load-bearing systems created by placing structure materials such as stone, brick, adobe, briquette and wood on top of each other and combining them with their own weight and mortar. They are a type of structure that has been preferred for residential or service purposes since ancient times [1,2]. In stone and brick masonry structure types, which have economical features such as ease of material supply and thermal insulation, walls are constructed with thick walls to ensure a certain stability. These structural parts, which we call brittle materials, show very early deformation under earthquake forces. Thus, the wall elements that crack under the influence of shear force are damaged after a while in such a way that they cannot carry the vertical loads. The strength of the material used, the strength of the adhesive mortar, and good quality workmanship are defined as prerequisites for earthquake-resistant masonry construction [3,4]. Masonry structures are widely used in our country, which is located on an important earthquake zone, and are exposed to earthquake forces along with vertical loads throughout their lifetime. Earthquakes that have occurred in recent years have caused different structural damages in masonry structures [5,6,7]. By evaluating the developments in earthquake engineering and the information obtained in the field studies carried out after the earthquakes, the earthquake regulation in force was updated and the Turkish Building Earthquake Regulation (TBDY-

2018) was published and entered into force in 2018 [8]. In order to determine more quickly whether the existing building stock is sufficiently resistant to possible earthquake risks and to solve the problem of unplanned urbanization, especially in big cities, the "Law on the Transformation of Areas at Disaster Risk" No. 6306 has come into force. The Principles for the Detection of Risky Buildings (RYTEIE-2019) prepared within the scope of this law and the rules and methods to be used in detecting risky buildings have been published [9]. [10].

It is known that there are differences in both regulations that will affect modal parameters. These differences need to be investigated in different geometries and structure types with different intended uses. The aim of this study is to investigate the effect of the calculation conditions given in TBDY-2018 and RYTEIE-2019 regulations on the modal parameters of the blended brick well model. Knowing the modal parameters allows the response of the structure to be predicted as a function of external stimulation. These parameters therefore constitute a kind of dynamic “identity card” of the structure that can be used for verification, calibration or diagnostic purposes of computational models and provide a baseline in long-term structural monitoring.

II. Materials and Method

Blending brick takes its name from the area where the brick is shaped, dried and fired. All stages of blending brick, also called wedge brick, from raw material preparation to packaging, take place in this area called blending. It is a form of production that is based on human power and is traditional and primitive compared to today's technology. Although it is far behind today's mass production methods, Blended brick is still a preferred material in terms of its firing color, natural appearance and place of use and purposes. It is used in the restoration and repair of many buildings. Again, many architects include designs solved with blended bricks in their designs. The production of blend brick has continued until today, as it is a sought-after material in modern architecture and landscaping [11].

Blended brick is a document that completely bears the traces of the past. It is a reflection of the past, shaped by human hands, combining labor with culture, and occupying an aesthetic place among historical values. Many works made with blended bricks centuries ago are still usable today. It is among the materials frequently used in buildings of historical value.

The blend brick used in the study is given in figure 1 along with its dimensions.

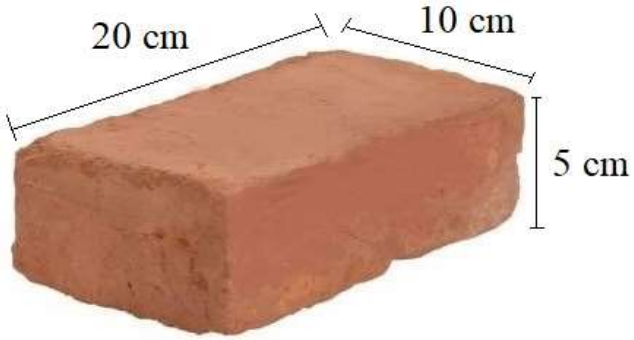

Fig. 1 The blend brick

Blended brick wells are often seen in rural and arid regions. In addition, many of them are historical buildings and their construction dates are known to be very old. The study by Dinc [12]; It is the source where the function of protecting the monuments of original water wells is discussed for the first time in chronological terms. The researcher, during the Konya Museums Directorate; In connection with the well hydraulics, he brought an experimental insight into the deteriorations in interaction with water, which he observed in İnce Minare, Karatay and Sırça Madrasahs. One of the most important functions of the wells, which has been forgotten, is based on their use in managing the soil safety stress due to the damping of the waves during the earthquake. As a result of the earthquake movement, which can be defined as a kind of energy discharge, different types of wave propagation occur at different frequencies. Water hinders the progress of some wave types in the ground layer. As S waves propagate, they shear the rock transversely

perpendicular to the direction of travel. However, the fluid will not rebound or return to its original state when transverse shearing or buckling is attempted. Therefore, S waves cannot propagate in liquid parts of the Earth [13]. [14-16] studies have been conducted on blended brick wells, which also contributed to this study. Examples of blended brick wells are given in figure 2.

Fig. 2 Examples of blended brick well

Finite element method was used in the study. SAP2000 software was used in the finite element modeling and analysis part. In the analysis part, modal analysis method was used. Resources [17-21] were used for the theoretical infrastructure of the methods. During the modeling phase, [22-25] resources were used.

The depth of the masonry blended brick well model is 5 meters. The well model is made of single layer blend brick and laid horizontally. Wall thickness was taken as 9 cm. The diameter of the well is 1 meter. The 3D finite element model of the blended brick well is given in figure 3.

Fig. 3 The 3D finite element model of the blended brick well

According to TBDY 2018, *"The type of wall materials will be determined visually by removing the plaster of a part of the wall surface. In order to determine the properties of the wall material, at least two wall sample samples will be taken from the building and its strength will be determined by applying compressive strength tests. The lowest characteristic compressive strength of solid brick masonry walls is defined as* f_k*=1.4MPa, and the Elasticity Modulus* E_{duv}*=750*f_k*."* Poisson's ratio is 0.2. Unit volume mass was taken as 2000 kg/m^3.

III. RESULTS

As a result of the modal analysis, the mode shapes of the first five modes of the blended brick wall model created according to TBDY 2018 are given in figures 4,5,6,7,8.

Fig. 4 1. Mode (Period value= 0,699614 s)

Fig. 5 2. Mode (Period value= 0,699614 s)

Fig. 6 3. Mode (Period value= 0,161240 s)

Fig. 7 4. Mode (Period value= 0,144123 s)

Fig. 8 5. Mode (Period value= 0,144123 s)

According to RYTEIE-2019, *"The type of wall materials will be determined by removing the plaster of a part of the wall surface, at least on one interior and one exterior wall. Apparent quality normal values will be used for the pressure, shear, diagonal tensile strength and specific gravity values of walls constructed with cement reinforced mortar and masonry units. For Solid Brick or Blended Brick masonry walls, the strength value is defined as* f_m*=1.4MPa and the Elasticity Modulus is defined as* $E_m=600f_m$*. Visible quality will be considered Poor for walls where mortar discontinuity or structural cracks are documented by photographs. The lowest characteristic compressive strength of solid brick masonry walls is defined as* f_k*=1.4MPa, Elasticity Modulus* $E_{duv}=750f_k$*."* Poisson's ratio is 0.2. Unit volume mass was taken as 2000 kg/m3.

As a result of the modal analysis, the mode shapes of the first five modes of the blended brick wall model created according to RYTEIE-2019 are given in figures 9,10,11,12,13.

Fig. 9 1. Mode (Period value= 0,587327 s)

Fig. 10 2. Mode (Period value= 0,587327 s)

Fig. 11 3. Mode (Period value= 0,135361 s)

Fig. 12 4. Mode (Period value= 0,120991 s)

Fig. 13 5. Mode (Period value= 0,120991 s)

The results of the period values according to TBDY 2018 and RYTEIE-2019 are given comparatively in Table 1.

Table 1. Comparison of TBDY 2018 and RYTEIE-2019 period values

	Mode 1	**Mode 2**	**Mode 3**	**Mode 4**	**Mode 5**
TBDY 2018	0,699614	0,699614	0,161240	0,144123	0,144123
RYTEIE-2019	0,587327	0,587327	0,135361	0,120991	0,120991
Difference (s)	0,112287	0,112287	0,025879	0,023132	0,023132
Difference (%)	0,160498503	0,160498503	0,160499876	0,160501794	0,160501794

The results of the mode shape according to TBDY 2018 and RYTEIE-2019 are given comparatively in Table 2.

Table 2. Comparison of TBDY 2018 and RYTEIE-2019 mode shapes

	Mode 1	**Mode 2**	**Mode 3**	**Mode 4**	**Mode 5**
TBDY 2018	Translational	Translational	Torsional	Translational	Translational
RYTEIE-2019	Translational	Translational	Torsional	Translational	Translational

IV. CONCLUSION

When examined for the first 5 modes, differences were seen between TBDY-2018 and RYTEIE-2019, equal in percentage in all modes. This difference is approximately 16.05%. According to the results of the period data, since there was no change in the geometry and mass of the blended brick well, the stiffness value decreased by 16.05% in RYTEIE-2019 compared to TBDY-2018. The biggest difference between the two methods in the numerical calculation part is in the calculation of the elasticity modulus. The elasticity module in RYTEIE-2019 is requested to be accepted as 20% lower than TBDY-2018. It is understood that the results obtained are parallel to this demand. When the mode shapes are examined, they do not show significant change in the calculation results according to both regulations.

In light of all these results obtained, it is clearly seen that RYTEIE-2019 accepts the blended brick well model as less rigid than TBDY-2018. Here, it is understood that the RYTEIE-2019 regulation acts more safely and is closer to the decision on possible reinforcement or demolition. The reason for this situation is the statement in RYTEIE-2019: *"Values given as apparent quality normal will be used for the pressure, shear, diagonal tensile strength and specific gravity values of walls built with cement-reinforced mortar and masonry units."* In TBDY-2018, it is required to calculate the strengths through direct tests. It is understood that having both regulations in force at the same time is a confusing situation. In addition, it is known that the 16.05% stiffness difference in the blended brick well model is significant. It is understood that a lot of experimental work is needed for new regulations in order to make the percentage differences more sensitive. In addition, it is understood from the analytical analysis that for the blended brick well model, a 20% decrease in the elasticity modulus should not be assumed to affect the stiffness by 20%. No mistakes should be made based solely on the k=E.I formula. Boundary conditions must be taken into consideration when calculating stiffness. It is recommended to take the RYTEIE-2019 regulation into consideration in order to eliminate confusion, stay on the safe side and in terms of the economic life of blended brick wells.

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Termal Şok Çevrim Sayısının DX54D Çeliğinin Mikroyapı ve Tane Boyutuna Etkisi

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Özet – Bu çalışmada EN 10346 standardında tanımlanan 1.0952 çelik numaralı DX54D düşük alaşımlı sıcak galvaniz kaplı çelik numunelerin sıfır altı termal şok döngülerinin tane boyutuna etkisi incelenmiştir. Bu amaçla galvanizli DX54D numuneler -40 ile +40 °C arasında 250, 500 750 ve 1000 döngü termal şok işlemine tabi tutulmuş ve işlemsiz DX54D numunesi ile karşılaştırılmıştır. Termal şok sonrası numunelerin mikro yapıları optik mikroskop ile incelenmiş ve ASTM E112 standardına göre tane boyutları değerlendirilmiştir. Yapılan mikroyapı incelemeleri soğuk termal şok işleminin mikroyapı tane boyutu üzerinde etkili olduğunu göstermiştir. Şöyle ki işlemsiz numunede haddeleme yönünde uzamış ferritik bir tane yapısından oluşmuştur. 250, 500 termal şok döngülerinde ise ferritik yapının korunduğu ancak haddeleme yönündeki uzamanın ortadan kalktığı tespit edilmiştir. 750 termal şok döngüsünde ise çok küçük boyutlu taneler ve yer yer çökelek tipi tanelerin yer aldığı tespit edilmiştir. 1000 termal şok döngüsünde haddeleme yönündeki uzamanın kalkmasına ek olarak küçük boyutlu taneler ve yer yer çökelek tipi tanelerin 750 döngüdeki gibi oluştuğu ancak bunlara ek olarak bazı tanelerde mikro çatlaklar ve çukurcuk oluşumlarının da yapıda yer aldığı tespit edilmiştir. Dolayısıyla soğuk termal şok etkilerinin belirgin olduğu minimum döngü sayısının 1000 çevrim olması gerektiği sonucunda verilmiştir. Tane boyutları bakımından değerlendirildiğinde ise termal sok çevrim sayısı artışı ile tane boyutlarında azalma meydana gelmiş olsa da belirgin farklılığın 1000 termal şoklu numunede elde edildiği ve İşlemsiz DX54 numunesine göre tane boyutunda %10 civarında bir azalmanın meydana geldiği tespit edilmiştir.

Anahtar Kelimeler – Çelik, Galvanizleme, Termal Şok, Mikroyapı, Tane boyutu

I. GİRİŞ

Çelikler esas olarak demir-karbon (Fe-C) alaşımlarından oluşturulmuş olmakla birlikte krom (Cr), nikel (Ni), Molibden (Mo), titanyum (Ti), Niyonyum (Nb) vb. diğer bazı elementlerin yapıya ilave edilmesi şeklinde tanılanabilir. Çelikler kimyasal içerik farklılıkları yoluyla oluşturulabilmelerine ilaveten ısıl işlem prosedürleri yoluyla da farklı türlere dönüştürülebilir. Dolayısıyla çeliklerin mekanik özellikleri içerdikleri başta C alaşım elementi olmak üzere diğer alaşım elementleri ve ısıl işlem prosedürlerine bağlı olarak geniş bir çerçevede üretilebilirler. Endüstride kullanılan çeliklerde aranan önemli parametrelerden biri maliyet olduğundan endüstriyel uygulamalarda genellikle <%1 C ve <%5 alaşım elementi içeren çelikler kullanılmaktadır [1].

Çeliklerin özellikleri, içerdiği elementlerin kimyasal bileşimi ve mikroyapısının etkileşimine dayanır. Çelikler genellikle ısıl işlemlerden etkilenir ve bu işlemlerle birlikte kimyasal bileşim, istenen sertlik, mekanik ve fiziksel özellikler, elektriksel davranış, korozyon ve yüksek sıcaklık direnci gibi nitelikler

kazandırır. Uygun kimyasal bileşime ve mikroyapıya sahip çelikler, soğuk şekillendirme işlemlerine de elverişlidir. Çeliklerin büyük bir kısmı östenitik olmadığından manyetik özellikler sergiler. Doğru kimyasal bileşime sahip çelikler, kaynak yöntemleri ile birleştirilebilir. Çoğu çelik türü metal kaplama, emaye kaplama, boyama ve plastik kaplama gibi işlemlere uygundur. Düşük alaşımlı çelikler, genellikle asitler ve korozif tuz çözeltilerinden etkilenirken alkalilere karşı dirençlidir [2]. Öte yandan özel alaşımlı çelikler ise yüksek korozyon direnci sunar [2], [3].

Dünyada çelik üretimi denildiğinde, Çin, Hindistan, Japonya ve Amerika Birleşik Devletleri gibi ülkeler başı çekmektedir. Çin, dünya çelik üretiminin yaklaşık %50'sini karşılayarak bu alanda lider konumundadır [4]. Hindistan ise son yıllarda yaptığı yatırımlar ve artan üretim kapasitesi ile dikkat çekmektedir. Japonya ve Amerika Birleşik Devletleri de yüksek kaliteli çelik üretiminde önemli birer oyuncu olarak yer almaktadır. Global çelik endüstrisi, sürekli olarak yenilikçi çözümler ve sürdürülebilir üretim yöntemleri arayışı içindedir. Gelişmiş geri dönüşüm teknikleri, enerji verimliliği sağlayan üretim süreçleri ve düşük karbon ayak izi bırakan teknolojiler, modern çelik üretiminde ön plana çıkmaktadır. Türkiye de bu küresel trendleri yakından takip ederek, çelik üretiminde hem kaliteyi hem de sürdürülebilirliği artırmayı hedeflemektedir. Dolayısıyla, Türkiye'nin 2023 yılı itibarıyla 33,7 milyon tonluk ham çelik üretimi, ülkenin çelik sanayisindeki güçlü konumunu ve potansiyelini ortaya koymaktadır. Dünyada ise 3500'den fazla çelik kalitesinin bulunması ve bu kalitelerin büyük bir kısmının son 20 yılda geliştirilmiş olması, çelik üretiminin ne kadar dinamik ve yenilikçi bir sektör olduğunu göstermektedir. Bu bağlamda, Türkiye'nin global çelik pazarındaki rolü ve önemi her geçen gün artmaktadır.

Çelikler, hava, su ve toprak gibi ortamlarda oksijenle temas ettiğinde hızla bozunmakta ve metal yüzeylerde pas oluşmaktadır. Korozyonun ilerlemesi, çeliğin kullanım ömrünü azaltarak uzun vadede hurdaya dönüşmesine neden olmaktadır [5]. Korozyon, metal ile çevresi arasında fiziksel etkileşime neden olup, metalin özelliklerinde ve fonksiyonlarında önemli kayıplara yol açan bir süreçtir [6]. Korozyonun önlenmesi için korozyon hücresini oluşturan elemanlardan en az birinin devreden çıkarılması gerekmektedir [7]. Korozyonu önlemek için kullanılan yöntemlerden biri de yüzey kaplamasıdır.

Metalik malzemelerin yüzeylerinin korozyondan korunması amacı ile uygulanan kaplamanın ilk anda içinde bulunduğu ortama, koruyucu olarak kaplandığı malzemeden daha dayanıklı olması gerektiği akla gelebilir. Bu yaklaşım çok doğru bir yaklaşım değildir. Çelik yüzeylere uygulanan kaplamaların ortama karşı çelikten daha dayanıksız olursa, çelik çözünmeden önce bu kaplama çözünecektir. Yani ana malzemeyi korumak için kaplama kendini feda edicektir. Bu yöntem ise korumada yöntemi her zaman etkisi sonuç vermektedir ve başarısızlık şansı çok azdır. Metalik kaplama yöntemlerinden biri olan çinko kaplama, galvanizleme olarak adlandırılır [6].

Çinko çelik ile birlikte bulunduğu ortamlarda daha önce çözünme eğiliminde olan bir elementtir. Çeliğin üzerine kaplama olarak uygulandığında ise ortam etkilerinin çeliği etkilemesine müsaade etmez, önce kendisi çözünerek çeliği korur. Demir esaslı malzemeler üzerine çinko birçok yöntem ile kaplama uygulanabilir. Galvaniz kaplama genellikle sıcak daldırma, elektroliz veya metal püskürtme prosesleri uygulanarak yapılmaktadır. Sıcak daldırma galvanizleme, günümüzde en yaygın kullanılan kaplama yöntemlerinden biridir [8].

Bu çalışmada kullanılan DX54D çeliği, düşük karbon içeriği ve mükemmel derin çekme özellikleri nedeniyle otomotiv ve beyaz eşya endüstrilerinde yaygın olarak kullanılan bir çelik türüdür [9]. Bu

çeliğin -40 ile +40°C arasındaki termal şoklara maruz kalması, malzemenin faz yapısında, mikro yapısında ve diğer karakteristik özelliklerinde önemli değişikliklere yol açabilir. Termal şok işlemi, malzemenin ani sıcaklık değişikliklerine maruz kalmasıyla meydana gelir ve bu da malzeme içindeki gerilmelerin artmasına neden olabilir. Artan termal şok döngüleri, malzemenin mikro yapısındaki fazların dönüşümlerini tetikleyebilir. Özellikle düşük sıcaklıklarda martensitik faz dönüşümleri, malzemenin sertlik ve kırılganlık özelliklerini etkileyebilir. Yüksek sıcaklıklarda ise, ferrit ve perlit fazlarının yeniden düzenlenmesi gözlemlenebilir. Termal şok döngülerindeki aralık arttıkça, bu faz dönüşümleri daha belirgin hale gelir ve malzemenin mekanik özelliklerinde, özellikle tokluk, çekme mukavemeti ve sertlik gibi özelliklerinde önemli değişiklikler gözlemlenebilir. Ayrıca, termal şokların mikro yapıya etkisi, malzeme yüzeyinde çatlak oluşumuna ve bu çatlakların yayılmasına neden olabilir, bu da malzemenin yorulma ömrünü olumsuz etkiler [10]. Çatlakların yayılması, malzemenin iç yapısındaki gerilim yoğunluklarını artırarak, malzemenin genel dayanıklılığını azaltabilir. Termal şok işleminin tekrarlanan döngüleri, mikro yapısal bozulmalara ve malzemenin iç gerilimlerinde artışa yol açarak, malzemenin genel performansını düşürebilir. Bundan dolayı bu çalışmada DX54D çeliğine uygulanan -40 ile +40°C arasındaki termal şok işlemleri, malzemenin faz ve mikro yapı değişikliklerini tetikleyip tetikleyemeceği tane boyutu üzerinde ne tür bir etkisinin belirlenmesi amacıyla numunler 250, 500, 750 ve 1000 çevrime tabi tutulmuş ve herhangi bir işlem uygulanmamış DX54D numunesi ile kıyaslanmıştır.

II. MATERYAL VE YÖNTEM

Çalışmada sıfır altı termal şoka uğratılmak üzere EN 10346 standardında tanımlanan 1.0952 çelik numaralı DX54D düşük alaşımlı sıcak galvaniz kaplı çelik kullanılmıştır.

Tablo 6.1. 1.0952 çelik numaralı DX54D çeliği kimyasal bileşimi

Malzeme	C	Si	Mn	P	S	Fe
1.0952	0,12	0,50	0,60	0,10	0,045	Kalan

Uygun ölçülerde kesilen numuneleri sıfır altı termal şok işlemini gerçekleştirebilmek için Huber markasının TC50 modeli kullanılmıştır. Bu cihaz -50 °C sıcaklığa düşme kapasitesine sahiptir. Numuneler -40 °C' de stabil hale getirilen alkol ortamında soğutma işleminin gerçekleştirildikten sonra şoklama işlemi için +40 °C' bulunan ısıtılmış su ortamına numuneler alınmıştır. Bu ortam değişikliği bir çevrim olarak kabul edilmiş ve numuneler 5 farklı çevrim sayısında sıfır altı termal şoklama işlemine maruz bırakılmışladır. Bu çevrimler, 250 çevrim, 500 çevrim, 750 çevrim ve 1000 çevrim olarak uygulanmıştır.

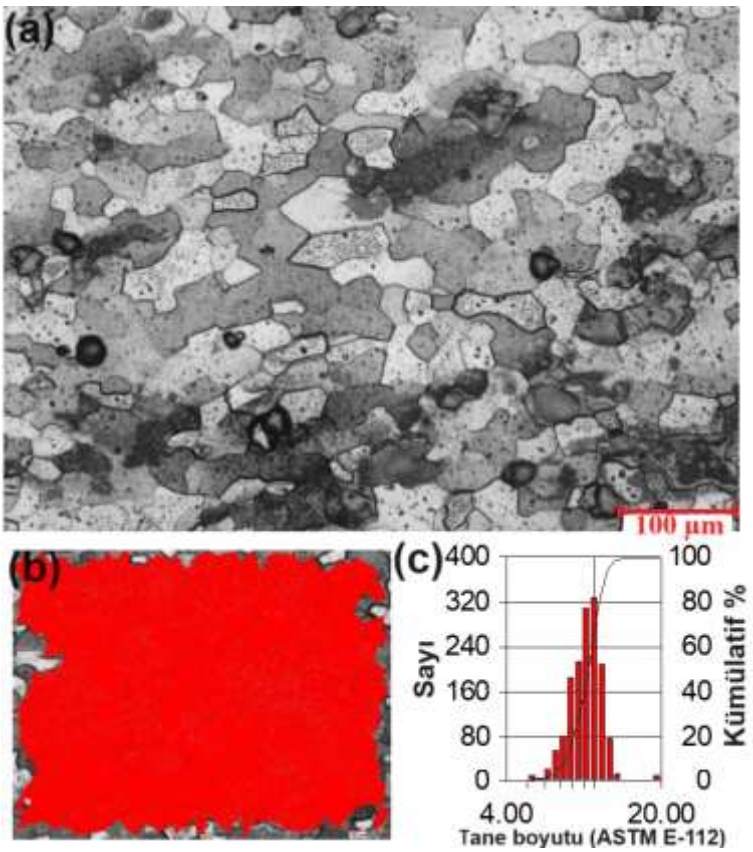
Mikroyapı incelemeleri gerçekleştirilecek numuneler sıcak bakalite alınarak geleneksel zımparalama işlemlerinde 400-1200 SiC zımpara kağıtlarından geçirilerek yapılmıştır. Partlatma işlemleri ise önce 2000 SiC zımparalardan geçirilmiş ardından 3 µm ve 1 µm Al_2O_3 sıvı parlatıcılar ile gerçekleştirilmiştir. Hazırlanan numunelerin mikroyapı incelemeleri NIKON MA2000 model optik mikroskop yardımıyla gerçekleştirilmiştir.

Şekil 6.1 Soğuk termal şok işlemlerinin gerçekleştirildiği Huber soğutma cihazı resmi

Tane boyutunun değerlendirilmesinde ASTM E112 standardına göre, tane boyutu numarası, optik mikroskop altında belirli bir büyütme seviyesinde görülebilen tane sayısına dayanır ve daha büyük tane boyutları daha düşük ASTM numaraları ile temsil edilir. Bu sistemde, tane boyutu numarası ile tane çapı arasında ters bir ilişki vardır. Örneğin, yüksek tane boyutu numarası daha küçük taneleri, düşük tane boyutu numarası ise daha büyük taneleri gösterir. Bu çalışmasında ASTM E112 standardı baz alındığından tane boyutları bu ters ilişkiye göre değerlendirilmiştir.

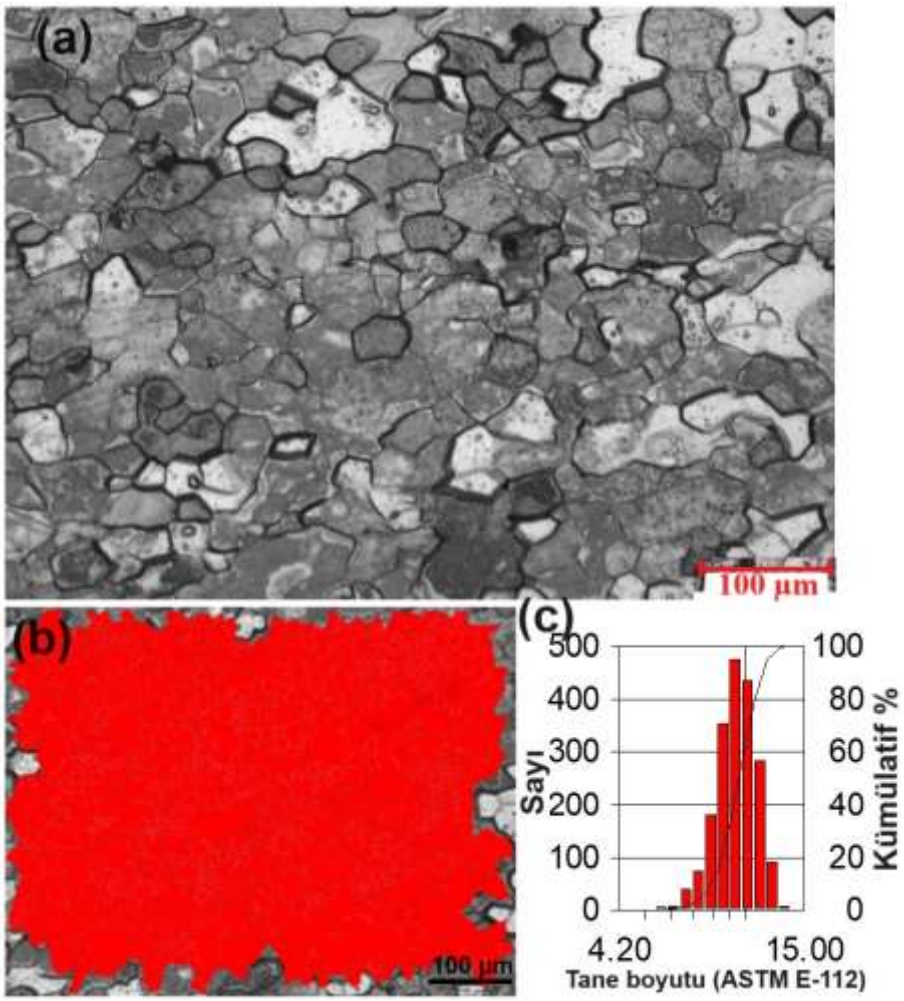
III. BULGULAR VE TARTIŞMA

Gerçekleştirilen mikroyapıları incelemeleri sonucu elde edilen optik mikroyapı görüntüleri ve ASTM E112 standardı esasları doğrultusunda yapılan tane boyutu ölçüm sonuçları Şekil 2- Şekil 7 aralığında gösterilmiştir.



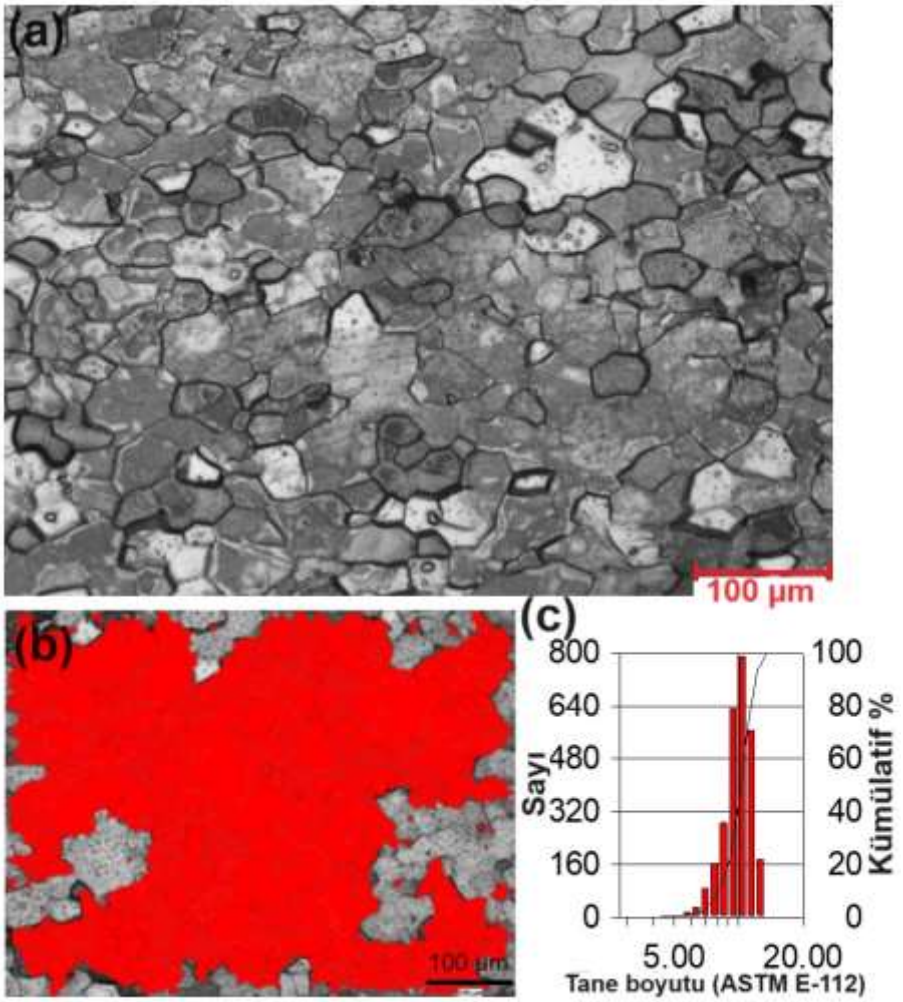
Şekil 2. İşlemsiz DX54 numunesinin a) optik mikroyapı resmi b)tane boyutu ölçümünü alınmasının gösterimi c) tane boyutu dağılımı grafiği.

İşlemsiz DX54 numunesinin optik resmi incelendiğinde ferritik bir mikroyapının olduğu ve tanelerin haddeleme yönünde uzanmış oldukları görülmektedir. İşlemsiz DX54D numunesinin üzerinden alınan Clemex analiz programı ile ASTM E-112 göre gerçekleştirilen tane boyutu analizinden bu numunenin ortalama tane boyutunun 8.55 olduğu tespit edilmiştir.



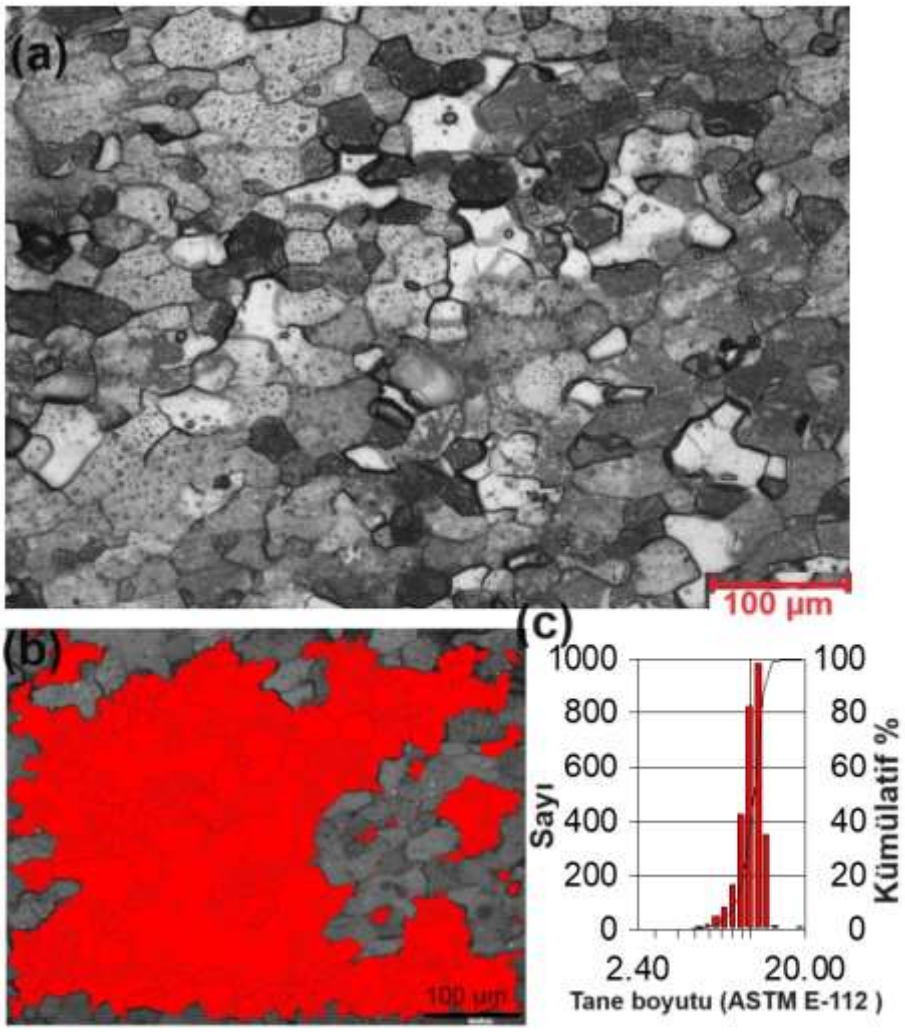
Şekil 3. 250 çevrim sıfır altı soğuk işleme maruz bırakılmış numunesinin a) optik mikroyapı resmi b)tane boyutu ölçümünü alınmasının gösterimi c) tane boyutu dağılımı grafiği.

250 çevrim sıfır altı soğuk termal yorulmaya maruz bırakılan numunenin optik resmi incelendiğinde işlemsiz numunede olduğu gibi ferritik bir mikroyapının olduğu ancak tanelerin haddeleme yönündeki uzanmalarının işlemsiz numuneye göre daha az oldukları görülmektedir. 250 çevrim numunesinin üzerinden alınan Clemex analiz programı ile ASTM E-112 göre gerçekleştirilen tane boyutu analizinden bu numunenin ortalama tane boyutunun işlemsiz numuneye yakın olduğu ve ortalama tane boyutunun 8.83 olduğu tespit edilmiştir.



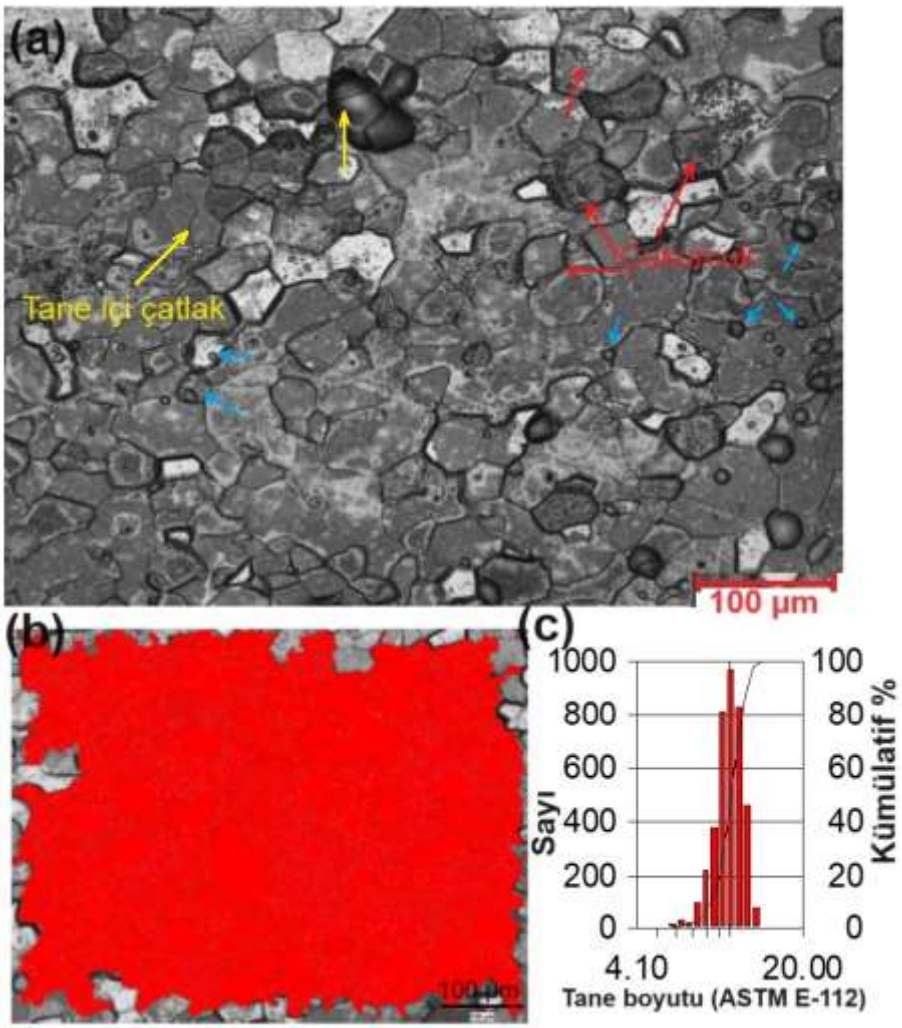
Şekil 4. 500 çevrim sıfır altı soğuk işleme maruz bırakılmış numunesinin a) optik mikroyapı resmi b)tane boyutu ölçümünü alınmasının gösterimi c) tane boyutu dağılımı grafiği.

500 çevrim sıfır altı soğuk termal yorulmaya maruz bırakılan numunenin optik resmi incelendiğinde 250 çevrime maruz bırakılan numunede olduğu gibi ferritik bir mikroyapının olduğu mikroyapı görünümünün bazı bölgelerinde çok küçük boyutlu taneler oluşmuş iken bazı bölgelerde ise büyük tanelerin varlığı dikkat çekmektedir. 500 çevrim numunesinin üzerinden alınan Clemex analiz programı ile ASTM E-112 göre gerçekleştirilen tane boyutu analizinden bu numunenin ortalama tane boyutunun 9,02 olduğu tespit edilmiştir. Bu durum sıfır altı termal çevrim sayısı artışı ile az da olsa tane boyutunda azalma meydana geldiğine işaret etmektedir.



Şekil 5. 750 çevrim sıfır altı soğuk işleme maruz bırakılmış numunesinin a) optik mikroyapı resmi b)tane boyutu ölçümünü alınmasının gösterimi c) tane boyutu dağılımı grafiği.

750 çevrim sıfır altı soğuk termal yorulmaya maruz bırakılan numunenin optik resmi incelendiğinde diğer numunelerde olduğu gibi ferritik bir mikroyapının olduğu ancak mikroyapı görünümünün bazı bölgelerinde çok küçük boyutlu taneler ve yer yer çökelek tipi tanelerin yer aldığı tespit edilmiştir. 750 çevrim numunesinin üzerinden alınan Clemex analiz programı ile ASTM E-112 göre gerçekleştirilen tane boyutu analizinden bu numunenin ortalama tane boyutunun 9,20 olduğu tespit edilmiştir. Bu durum sıfır altı termal çevrim sayısı artışı ile az da olsa tane boyutunda azalma meydana geldiği tespit edilmiştir.



Şekil 6. 1000 çevrim sıfır altı soğuk işleme maruz bırakılmış numunesinin a) optik mikroyapı resmi b)tane boyutu ölçümünü alınmasının gösterimi c) tane boyutu dağılımı grafiği.

1000 çevrim sıfır altı soğuk termal yorulmaya maruz bırakılan numunenin optik resmi incelendiğinde diğer numunelerde biraz farklı bir mikro yapının oluştuğu görülmektedir. Mikroyapı resmi diğer numunlerde olduğu gibi ferritik bir mikroyapının olduğu ancak diğer numunelerden fraklı olarak mavi oklarla gösterilen MC karbürlere benzeyen küresel yapıların, tane içi ve tane sınırlarında çukurcuk (pitting) oluşumlarının ve hatta bazı tane içlerinde sarı ok ile gösterilen bölgelerde mikro çatlakların oluştuğu görülmektedir. Bu durum 1000 çevrim etkisinin diğer numunelerden farklı olarak mikroyapıyı ciddi anlamda etkilediğini göstermektedir. 1000 çevrim numunesinin üzerinden alınan Clemex analiz programı ile ASTM E-112 göre gerçekleştirilen tane boyutu analizinden bu numunenin ortalama tane boyutunun 9.34 µm ile en küçük tane boyutuna sahip numune olduğu tespit edilmiştir. Bu durum sıfır altı termal çevrim sayısı artışı ile DX54 çeliğinin tane boyutunda küçülme meydana geldiği tespit edilmiştir.

IV. SONUÇLAR

Bu çalışma sonucunda DX54D çeliğine uygulanan -40 ile +40 °C soğuk termal şok işleminin mikroyapı ve tane boyutu üzerinde etkili olduğu görülmüştür. Şöyle ki İşlemsiz numunede ASTM E-112 standardına göre 8.55 olarak tespit edilen ortalama tane boyutu artan çevrim sayısına bağlı olarak bir küçülme meydan geldiği ve en belirgin etkinin gözlendiği 1000 çevrim termal yorulmaya maruz bırakılan numunede bu değerin işlemsiz numuneye göre %10'a yakın olduğu tespit edilmiştir. Bu duruma -40 ile +40 °C aralığındaki termal döngülerin tane sınırlarında gerilme birikimine neden olması gösterilebilir. 1000 çevrimli numuneki çatlak ve çukurcuk oluşumları gerilme birikimleri iddasını destekler niteliktedir.

Çünkü ısıtma-soğutma döngüleri tane boyutlarının yeniden düzenlenmesine ve tane sınırlarının hareket etmesine yol açabilir. Bu da tanelerin büyümesi veya küçülmesi gibi etkiler gözlenebilir. Tane küçülmesinin 250 çevrimde %5 civarında iken 1000 çevrimde %10 olması ve nispeten sınırlı olması, uygulanan termal yorulma işleminin -40 ile +40 °C aralığında uygulanmış olması ile ilgilidir. Bu sıcalıklar kriyojenik ısıl işlem sıcaklıkları (-196) ve yeniden kristalleşme sıcaklıklarına (500-600 °C) yakın olmaması dolayısıyla tane boyutlarında dramatik değişikliklere neden olmamasının bir sonucudur. Çünkü bu sıcaklık aralığı yeniden kristalleşme için yeterince yüksek değildir. Ancak, uzun vadede bu döngüler mikro yapı üzerinde kümülatif etkiler yapmasına bağlı olarak 1000 çevrimde %10'luk bir tane küçültme meydana getirmiş ve mikroyapıda değişikliğe neden olmuştur.

TEŞEKKÜR

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Effect of Fly Ash and Wood Ash on Setting Times and Compressive Strength of Cement Paste

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Abstract – Alternatives to cement that can be used in cement-based systems have an effect on mechanical performance, physical and durability properties, including normal consistency water requirement and setting times. For this purpose, in this study, the results of binary and single substitution of different proportions of fly ash (FA) and wood ash (WA) to cement were investigated. CEM-I 42.5R cement (PC), class F FA, WA and city water was used in the study. In the study, FA and WA were replaced with PC in pairs and singly in the range of 0-18% by mass. The normal consistency water requirement and setting times of the produced cement pastes were determined. Three 50x50x50 mm cube specimens were produced to represent each cement paste with the determined normal consistency water requirement and powder material ratios. After 28 days of lime-saturated water curing, the physical properties of the cube specimens were determined, followed by their compressive strength. The data obtained showed that FA and WA increased the water requirement and setting times at normal consistency. In single substitution mixtures containing the same proportion of WA and FA, WA has a greater effect on the water requirement at normal consistency and setting times. In these mixtures, the use of FA increased the setting times by 33 minutes at most compared to the reference mixture, while WA increased them by 147 minutes. As the amount of WA in the mix increases, the compressive strength decreases. In addition, the mixture with the highest porosity was the mixture containing 18% WA and this mixture had the lowest compressive strength. In the sole use of FA, the replacement rate is 6%, where the compressive strength also increases despite the increasing amount of normal consistency water.

Keywords – Fly ash, wood ash, setting times, normal consistency water, compressive strength, physical properties

I. INTRODUCTION

Directly linked to global population growth and economic growth, the cement and concrete industry is an important branch of industry serving the construction sector. Turkey is one of the top 5 cement producing and consuming countries in the world and accounts for approximately 2% of the world cement market. The most important component of the construction industry is cement. As an energy-intensive sector, cement production is responsible for a significant portion of global CO_2 emissions from industrial production [1]. Therefore, the sustainability of the search for alternative products to cement is important.

FA is one of the leading alternative products to cement [2]. In thermal power plants where lignite coal is burned, a large amount of gas is released by the combustion of pulverized coal during electricity generation. In this process, gases and micron-sized ash particles are also mixed into the atmosphere. These particles are prevented from entering the atmosphere with the help of electro filters. Volatile micron-sized industrial wastes are FA, which is currently used as an important industrial by-product in cement-based systems [3],

[4]. Fly ash is an alternative pozzolanic material to cement. Like all fine-grained pozzolanic materials with an aluminous and siliceous structure, it contributes to the formation of C-S-H gels during hydration. The contribution of FA to compressive strength is influenced by the fineness of the paticle rather than the amount used. FA particles ranging in size from 1-200μm are generally spherical. Its structure usually contains 85% SiO_2, Al_2O_3, Fe_2O_3, CaO and MgO. [5] , [6]. Depending on the grain structure of FA in concrete production, workability becomes easier, water and chloride permeability decreases, and resistance to chemical effects increases. However, FA used in excessive amounts reduces mechanical performance [6]. FA is known to prolong the setting time of concrete. The use of FA increases the water requirement and the setting times are prolonged accordingly. It is considered appropriate to use extra products to move the extended setting times to a safe range [7]. In particular, fine limestone powder is successfully used to increase the reaction rate of cement clinker and partially compensate for the retardation effect [8–10]. It is generally accepted that the use of 10% FA maintains the 28-day compressive strength of concrete at an acceptable level. The use of distilled water in FA-substituted cement systems is also an effective parameter compared to the use of municipal water [4]. FA-substituted concrete is more affected by curing time and curing conditions than conventional concrete [11]. It was also observed that the loss of compressive strength caused by the use of FA at an early age can be compensated by hot water curing [12]. In recent years, there has been a search for additional products not only for the use of FA, but also for the disadvantages of FA that need to be eliminated. The contribution of FA to the compressive strength of concrete can be increased by adding products such as nano silica [2]. Normal consistency and setting times are important preliminary evaluation criteria in the use of alternative products to cement. Because most of the physical, mechanical and durability criteria are directly or indirectly related to normal consistency and setting times. The pozzolanic products and admixtures used to improve setting time and consistency have important effects [13–17]. Especially in tuff and ash waste products, reducing the grain size can prolong setting times and increase compressive strength [18]. In applications where the use of lime is replaced with wood ash, an increase in air content and a decrease in setting times are observed [19]. It is known that Çayca tuff affects the setting times and compressive strength depending on the grain size. As the grain size decreases, setting times and compressive strength increases [18].

In this study, WA and FA were used both singly and in binary to produce cement pastes. The effect of the produced mixtures on the normal consistency water requirement and setting times according to the substitution status was investigated. In addition, physical properties were determined and compressive strength tests were performed with cube specimens after 28 days of water curing. As such, the study provides a comparison of FA, which is widely used in the search for a new product, and WA, which is used in this study.

II. Materials and Method

In this section, the design of 13 different cement pastes produced within the scope of the experimental study, the production process and the experimental studies applied are presented under subheadings. Figure 1 shows the work flow diagram.

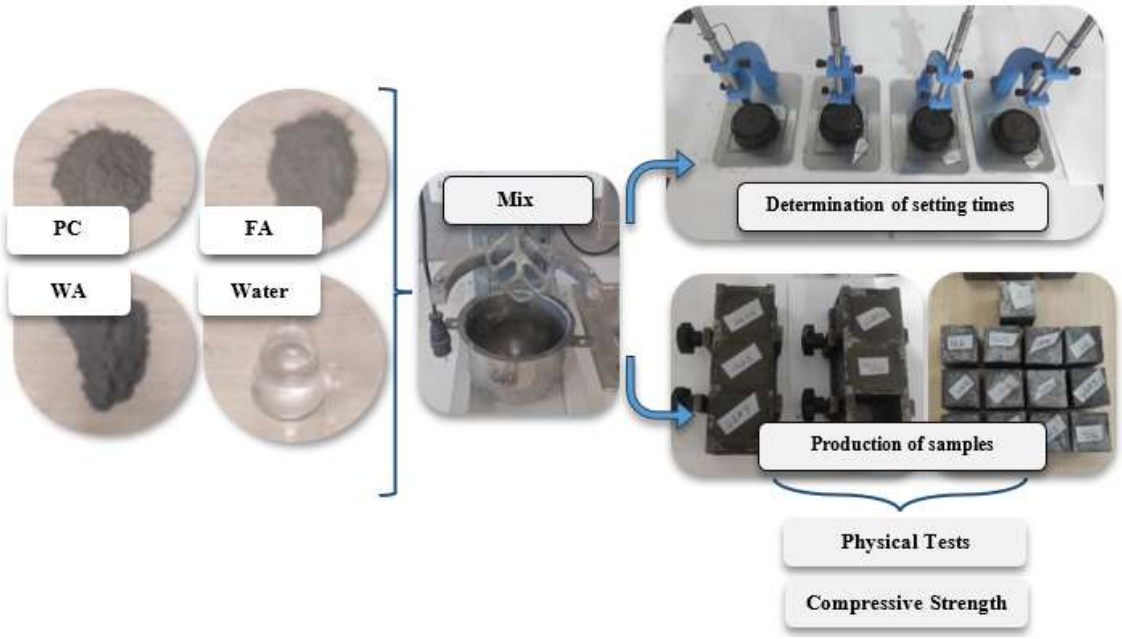

Fig 1. Workflow of the study

A. MATERIAL

Within the scope of the experimental study, 13 different cement pastes were designed. The basic powder material used in all cement pastes is CEM-I 42.5R cement (PC) [20]. Class F fly ash (FA) [21] and wood ash (WA) were substituted into the cement in proportions ranging from 0-18%. WA is the part of the wood burned for bread production that is sieved through a 0.0063 mm square mesh sieve after being reduced to ash. Tunceli municipal water was used as mixing water [22]. Technical specifications of PC and FA are given in Table 1. The determined specific gravities of PC, FA and WA were 3.15, 2.00 and 2.00, respectively.

Table 1. Properties of CEM-I 42.5R cement (PC) and fly ash (FA)

	PC (%)	**FA (%)**
CaO	63.57	2.32
SiO_2	19.34	60.94
Al_2O_3	3.75	20.66
Fe_2O_3	4.15	7.95
MgO	2.9	-----
SO_3	3.15	0.11
K_2O	0.81	---
Na_2O	0.41	1.56
Loss of ignition	1.92	1.92
Blaine (cm^2/g)	3804	3790

B. METHOD

The design of cement pastes produced by substituting FA and WA in the range of 0-18% to PC for a total of 500 grams of powder material is given in Table 2. In the mix designs, the amount of PC was replaced by FA and WA by mass. Cement pastes were coded according to this substitution ratio.

Table 2. Cement paste mix design

ID	PC (g)	FA (g)	WA (g)	Water (g)	W/B
FA0-WA0	500	0	0	156.0	0.312
FA6-WA0	470	30	0	159.0	0.318
FA12-WA0	440	60	0	159.0	0.318
FA18-WA0	410	90	0	154.0	0.308
FA0-WA6	470	0	30	171.4	0.343
FA0-WA12	440	0	60	190.0	0.380
FA0-WA18	410	0	90	225.0	0.450
FA2-WA4	470	10	20	175.5	0.351
FA4-WA2	470	20	10	178.0	0.356
FA9-WA3	440	45	15	166.5	0.333
FA3-WA9	440	15	45	187.0	0.374
FA3.6-WA14.4	410	18	72	217.0	0.434
FA14.4-WA3.6	410	72	18	182.0	0.364

W/B: Water /Binder

All experimental studies were carried out in the laboratory. Laboratory type mixer with 2dm^3 capacity, 0.01 precision balance and vicat probe were used in accordance with the relevant standards. While determining the normal consistency water requirement, the vicat probe was zeroed to the glass plate under the vicat ring and the vicat probe was released from the upper surface of the cement paste in a controlled manner. After 30 s, the penetration depth of the probe in the cement paste was determined. The mixture was prepared again by changing the amount of water each time until the penetration reached the relevant standard range (5-7 mm). After the normal consistency water requirement was determined separately for each cement paste, the setting start time and then the setting end time were determined with the same cement pastes. Suitable vicat needles were used separately for setting start and setting end times. The required penetration depth of the vicat needle for the setting start time is 4±1 mm from the glass plate under the vicat ring. When this distance is reached, the setting is considered to start. The end of the setting time is the penetration depth of the vicat needle max. 0.05 mm from the top surface of the cement paste [23]. Depending on the mix design of the cement paste whose water requirement was determined at normal consistency, 3 50x50x50 mm cube samples were produced for each cement paste. A total of 39 cube specimens were kept in lime saturated water at 20± 2 °C for 28 days. After standard water curing, oven dry unit volume weight and porosity ratio were determined with the cube specimens. In addition, compressive tests were performed with cube specimens by applying a compressive load of 1 kN/s with a universal compressive strength test press machine with a capacity of 250 kN [24].

III. RESULTS

The ratio of WA and FA substituted cement pastes in the powder material and setting times are given in Figure 2. Compared to the reference mix, the setting times increase with increasing WA and FA content. Cement paste containing 12% WA has the longest setting start and setting end times. The water requirement at normal consistency also increased for each increasing WA substitution compared to the reference mix (Table 2). In the case of FA-containing cement paste, the mix with 18% FA had a lower normal water demand than the mix with 12% FA. For cement pastes with only FA or WA substitutions, WA has a higher normal consistency water requirement. The setting times also show a similar trend to the normal thickening water requirement. The setting times of CEM I 42.5R cement paste are given in TS EN 197-1 [20]. The setting times of the reference mix meet the time interval given in the standard. When only FA-substituted groups are analyzed; cement paste with 12% FA substitution has the longest setting times compared to the

reference mix. In this mix, the start and end of setting times increased by approximately 16% and 19%, respectively, compared to the reference mix. Mixes with 12% and 18% FA substitution have a setting start time of 190 minutes. The increase in the amount of FA increases the setting start time by maximum 30 minutes and the setting end time by 33 minutes. For cement pastes containing only WA, these results are 142 and 147 minutes respectively. Double substitution was applied in the last 5 mixes shown in Figure 2. In these cement pastes, the increase in FA content brings the setting times closer to the FA range, while the increase in WA content increases the setting times. As in similar studies, the increase in the normal thickening water requirement of FA increases the setting times.[25] .

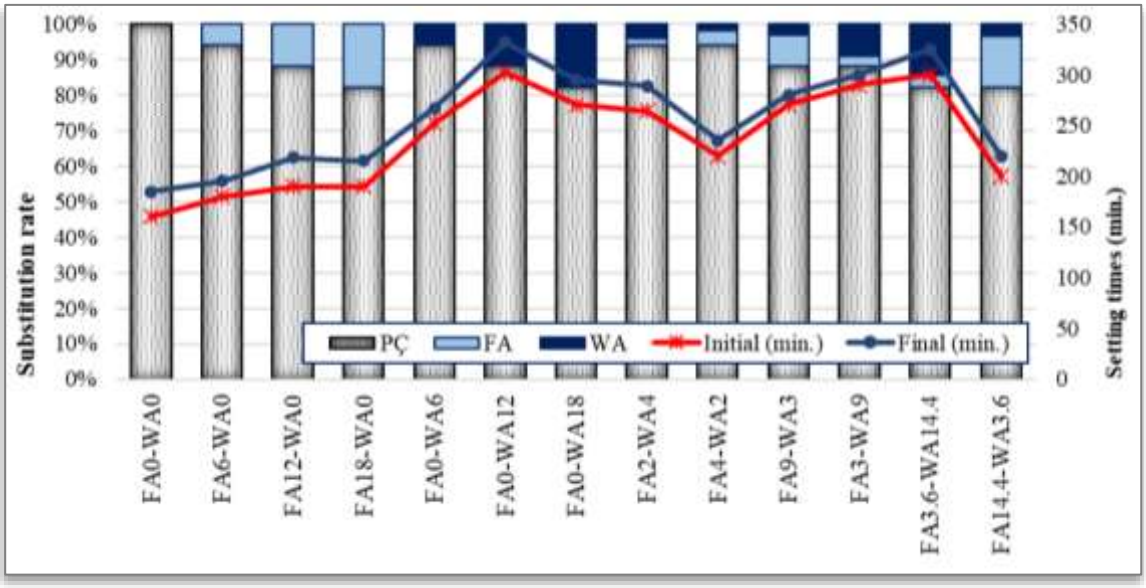

Fig 2. Setting times (min.) results

The variation of oven dry unit volume weight and porosity of cement pastes depending on FA and WA usage ratio is given in Figure 3. The lowest porosity value of the study was obtained in the FA18-WA0 mix where the highest amount of FA was used. In this cement paste, the porosity rate decreases by about 3% compared to the reference mix. These results are in line with the studies where the effect of FA usage on porosity was obtained [26].

The use of WA increases the porosity of the cement paste. Porosity continues to increase from the reference mix to the FA0-WA18 mix, with the highest porosity value of 45.2%. The highest porosity for the double substitution case is 42.5% for the FA3.6-WA14.4 mix.

The oven dry unit volume weight is 1,692 tons/m^3 for the reference mix. The oven-dry unit weight values of FA6-WA0 and FA2-WA4 mixtures are higher than the reference mix. Also, the unit weight of FA12-WA0 and FA18-WA0 mixes decreased by 0.002 t/m^3 and 0.009 t/m^3, respectively, compared to the reference mix. The unit weight decreases with increasing WA content in the cement paste. The lowest unit weight belongs to the FA0-WA18 mix. In this cement paste, the variation of the oven dry unit weight compared to the reference mix is about 21%.

When the results of compressive strength tests with cube specimens are analyzed; the highest and lowest compressive strengths belong to the reference and FA0-WA18 mixtures, respectively. The effect of 6, 12 and 18% substitution of FA on compressive strength is +2.32 MPa, -0.52 MPa and -9.72 MPa, respectively. The effect of FA on compressive strength compared to PC is also related to the amount of water in the mixture, as in similar studies. Therefore, its effect on compressive strength can be improved by water reducing admixtures [27]. With increasing WA substitution, a loss in the compressive strength of the cube specimens occurs in the range of 27-71%. When double substitution cases are analyzed; the highest and lowest compressive strengths of both FA and WA substituted mixtures belong to FA4-WA2 and FA3.6-WA14.4 mixtures, respectively.

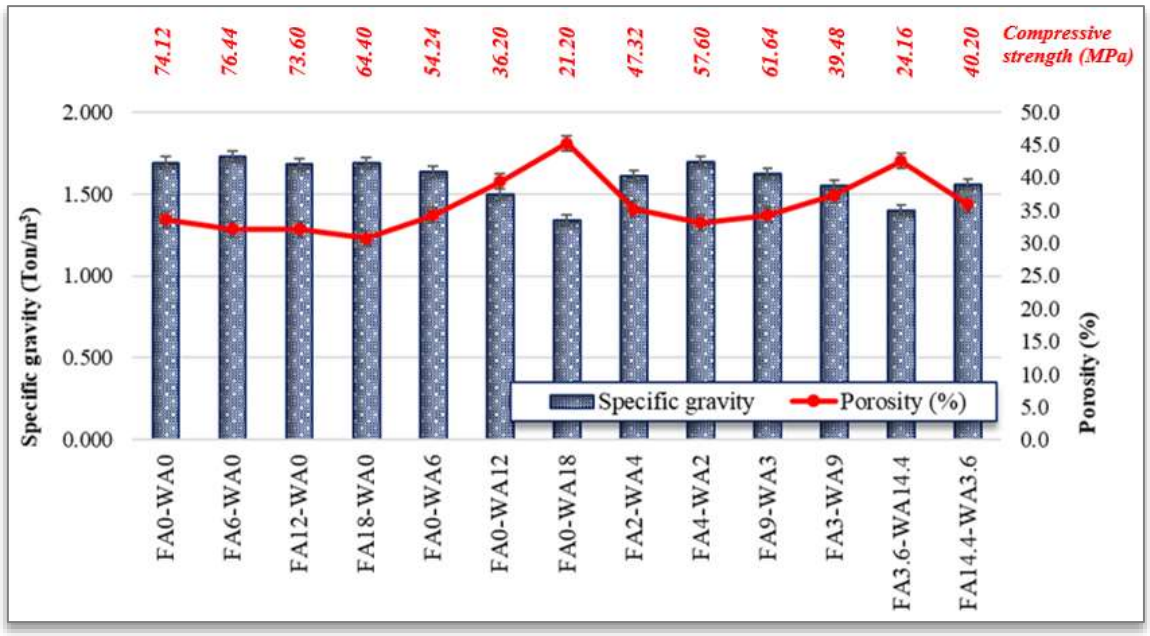

Fig 3. Specific gravity, porosity and compressive strength results

IV. CONCLUSION

In this study, FA and WA were substituted to PC at different ratios as binary and single substitutes. In this way, 13 different cement pastes were produced and the water requirement and setting times of all cement pastes at normal consistency were determined. In addition, 3 cube specimens were produced for each cement paste and their physical properties were determined after 28 days of water curing and compressive strength tests were performed. The results of all experimental studies can be summarized as follows;

- In the case of single substitution, where only FA or WA is substituted, WA has a higher water requirement for normal consistency. Setting times are similarly affected by the water requirement for normal consistency.
- The use of WA and FA results in longer setting times. Cement paste with 12% WA has the longest set start and set end times. Cement paste with 12% FA substitution increases the setting start and setting end times by about 16% and 19%, respectively, compared to the reference mix. The increase in the amount of FA increases the setting start time by a maximum of 30 minutes and the setting end time by 33 minutes. For WA, these results are 142 and 147 minutes respectively.
- The FA18-WA0 blend with the highest amount of FA has the lowest porosity ratio. While the use of FA decreases porosity, the use of WA increases porosity. Porosity continues to increase from the reference mix to the FA0-WA18 mix, with the highest porosity value of 45.2%. For the binary substitution case, the highest porosity is in the FA3.6-WA14.4 blend (42.5%).
- The oven dry unit volume weight is 1.692 tons/m^3 for the reference mix. Only FA6-WA0 and FA2-WA4 mixes have higher drying unit weight than the reference mix. The unit weight decreases with increasing WA content in the cement paste. The lowest unit weight belongs to mix FA0-WA18 with a loss of about 21% compared to the reference mix.
- When the compressive strength test results are analyzed; the highest compressive strength belongs to the mixture with 6% FA substitution. The use of FA in the range of 6-18% changes the compressive strength in the range of +2.32 MPa-9.72 MPa. With increasing WA substitution, a loss of 27-71% occurs in the compressive strength of the cube specimens. When the binary substitution cases are analyzed; the highest and lowest compressive strengths belong to FA4-WA2 and FA3.6-WA14.4 mixtures, respectively. In these mixtures, increasing WA content decreases the compressive strength.

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Emerging Trends in Free Space Optical Communication: Photonics Integrated Circuits and Lithium Niobate Technologies

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Abstract **–**The domain of free space optical communication (FSOC) represents an innovation which may transfer information rapidly over normal coaxial and RF/microwave paths, regardless of their limitations. FSOC offers rapid data transfer rates as high as 10 Gbps over only a distance of a few kilometres through the use of light waves to carry data between the two points. It offers a variety of upsides, such as resiliency to electromagnetic interference, high security, and unauthorized spectrum usage. FSOC has proven helpful in difficult settings, such as military and remote regions. It provides low latency and outstanding security, and it additionally integrates nicely with applications that use AI. The latest advances in FSOC involve the research and development of lithium niobate (LiNbO3) and photonic integrated circuits (PICs), which increase scale and modulating performance (OAM, CAP). This paper provides an overview of FSOC technology, its applications, challenges, and emerging trends, highlighting its potential to revolutionize communication systems. Future work might look at bromine photonics to make optical communication systems even better.

Keywords – Free Space Optical Communication (FSOC), Artificial Intelligence Integration, Photonic Integrated Circuits (PICs), Lithium Niobate on Insulator ($LiNbO_3$) Technology, Orbital Angular Momentum (OAM) Modulation, Bromine Photonics

I. INTRODUCTION

In such communication structures only the high-speed information transmission is demanding as it has become a trend. The recent explosion of subscriber numbers and the advent of new generation services such as Videos upon request, wireless internet access, televisions with smart technology, 5G technology connectivity for mobile devices, etc. have boosted rapid transfer of data as well as receiving requirement at access points. To date, the access points are coaxial and RF/microwave link interconnected. Low bandwidth, high cost of deployment and insecure data transmission thus adds up to the limitations posed by these communication links in general as well. As is touch on above, optical fiber communication has great progress to 10 Gbps and today well over that in data speed with an attenuation of only 0.2 dB/km but still used debris such as copper wire for defined deposit networks, visual files truly modelling positional backyard peeked circuits coupled down a relatively bit! FSO Communication: FSO are considered to a viable solution as final-mile barrier throughout data connection through wave of light. FSO communication

systems are responsible to transmitting data over a distance of few kilometers at very high rates, up to 10 Gbps [1], between two-point callers. Logical, thin laser rays are utilized in the FSO communications systems. Since of its natural safety, clear tracks, or tolerance to electromagnetic radiation, its layout of space provides an excellent reuse value. Communication over FSO utilizes a frequency (the ISM band) that extends in excess of 300 GHz, that is once time ungoverned globally. FSO systems do not need require ITU permission as such. FSO systems improve performance of networks parameters and are just deployed and removed at any location of your choice. FSO communication involves optical frequencies—that is, those in the infrared (IR), visible, and ultraviolet (UV) light bands—to transfer data throughout an irrational propagating channel. The researchers are motivated to explore the advantages of optical networking within free-space channels through the advantages of FSO, were shown among which are its extremely high bandwidth, not licensed bandwidth, simple installation, secure direct line of sight (LOS) communication, low consumption of power (roughly. half of radio frequency), small dimensions (about. one out of ten of radio frequency antenna size), and several more. The operating idea behind fiber-based optical communication and FSO is the same. rather than using a fiber-optic cable, the data conveyed in FSO communications is transmitted over an illogical channel. The conventional fibre-optic communication network, excluding the fiber, is represented by the FSO communication system diagram in Figure 1.

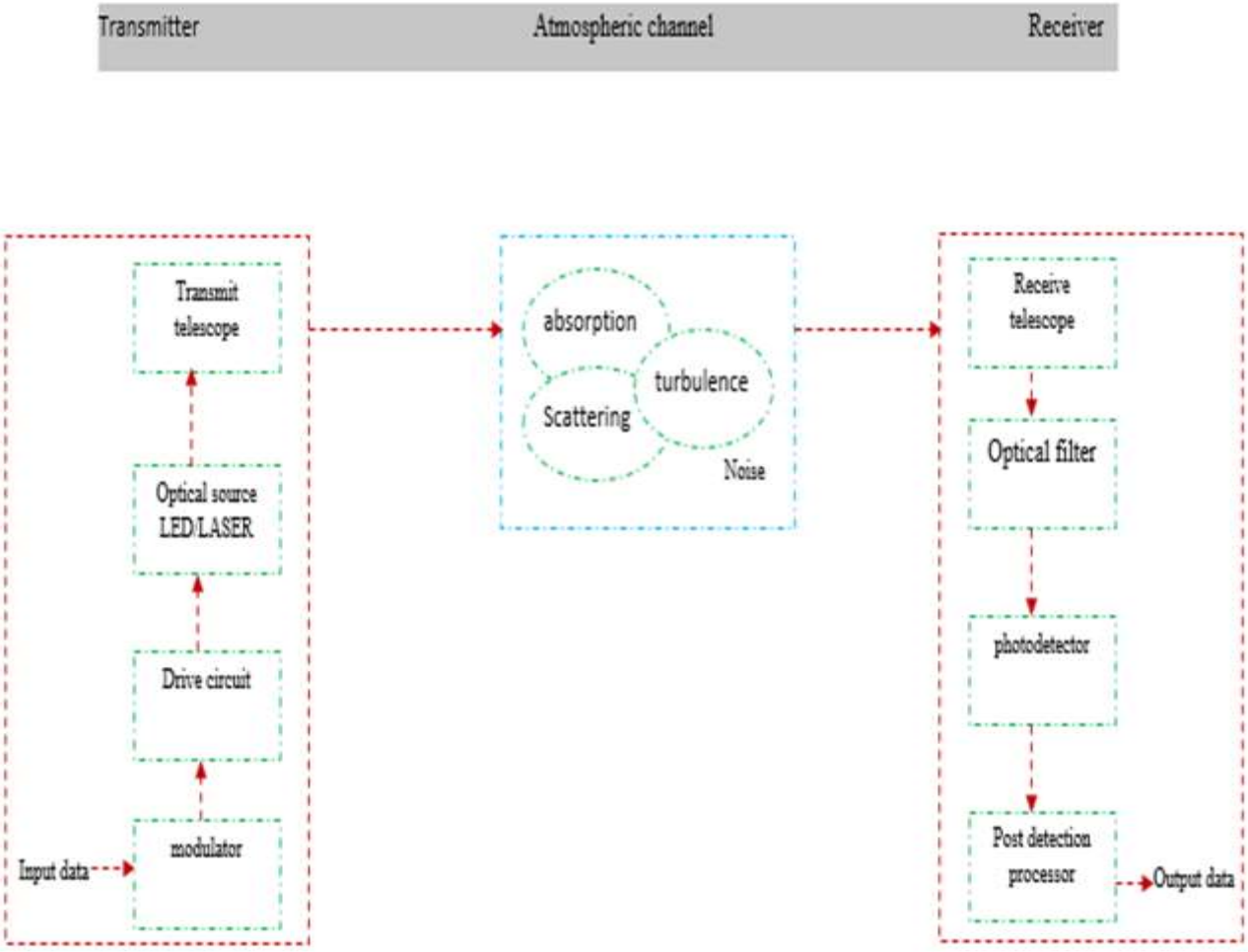

Fig 1. FSO communication system block diagram.

The block diagram of FSOC system contains three main parts: transmitter, channel, and receiver. The primary function of transmitter is modulating incoming signal into optical signals, which propagates Through atmosphere to receiver. Essential components are modulator, drive circuit and telescope, it is moveable part beam tracking, where channel is unpredictable conditions such fog, air etc, the receiver also recover transmitting signal, it filters the noise background to limited signal bandwidth and demodulator.

The potential challenger to substitute existing Radio Frequency (RF) networks of communication involves Free Space Optical Communication (FSOC). Because to the restricted dispersion of laser light, FSOC offers special benefits like high transfer rates, lower latency, and greater safety, that fall in line to the growing demand for fast-speed, safe, and trustworthy communication. Because FSOC does not require licensed spectrum, unlike RF networks, it could be implemented more readily and at a cheaper rate. This method is particularly efficient when needed when microwave communication is challenging, such as in faraway places & for defense purposes. An investigation of FSOC technology, its application, challenges, and fresh advances are the goals of the present research.

II. LITRATURE REVIEW FROM HISTORY TO TODAY

FSO is a frequently technique using a wireless medium for transmitting data in the shape of an optical pulse. The British inventor Alexander Graham Bell worked with the photophone, the first FSO communication, in 1880 [1]. He played the rays of the sun and sent them out a distance of approximately 213 meters in the course of his study. The justification for the study was the sound of speech at the transmitter was generating movements on a piece of glass. The frequencies are absorbed, displayed, and finally transformed into a voice signal by sunlight. While it was close to the phone as his greatest invention in history, it never became commercially viable. In 1935, the German army developed a photophone which utilized one infrared transmission bulb and a filament made of tungsten lamp. Within a few years, the creation of optical transmitting devices including lasers and LEDs has changed the future of FSO. In 1962, however, a TV signal was successfully transmitted over a distance of approximately forty-eight kilometres utilizing GaAs LED lighting. In the following year, 1963, US scientists sent a voice-modulated He-Ne laser as far as 190 kilometres. Yet, Nippon Electric Corporation (NEC) of Japan created the first industrial FSO link around 1970. The complete duplex 0.63 μm laser connection, lasting 14 km, joined Tamagawa and Yokohama [2]. After then, FSO has experienced gradual but steady improvement across defence and commercial fields. The rapid growth of optical electronics has contributed to a resurrection of the FSO, that has experienced rapid data traffic. A concise account of the The field of FSO demonstration using several variations and laser can be discovered in [3]. Yet, because of the many air disruptions and the broad dispersion point of the beam of light, the FSO's evaluation of performance was poor. The discovered of low- loss optical fibre around the year 1970 led a sudden shift in globe attention away from the FSO. Since that time, the only areas where FSO continues to be utilized are the defences [4],[5] and applications in space, including intersatellite and deep-space communications. The commercial use of the FSO had an enormous rise as more businesses showed excitement about small range of FSO and the creation of VLC (visible light communication) technologies [6]– [14]. Then The coming of Photonic Integrated Circuits (PICs) in 1980s brought great revolutionary changing to optical communication. PICs unable different optical components, like a lasers, modulators, and detectors, to be integrated a single chip, as decreasing size, weight, and control consumption. The starting arranges of PICs centred on joining basic optical components to discover out the feasibility of on-chip optical systems [15]. A new microchip has been developed that uses light to communicate. This could lead to faster and more efficient computer systems. Advances in using silicon in photonics technology is being used in data centres, space, and communication with satellites. Later, Lithium Niobate ($LiNbO_3$) became important in optical communication because of

its good electro-optic properties. It allowed for high-speed modulation techniques and data transmission. Using ($LiNbO_3$) in modulators improved the performance of optical communication systems, allowing for higher data rates and more reliable transmission.[16],[17],[18]. As time change advancements in thin-film $LiNbO_3$ electro-optic modulators on silicon, the best way for more compact and efficient FSOC systems. The integration of lithium niobate photonics, combining the modulation capabilities of $LiNbO_3$ with the compactness and integration opportunity of PICs. Combining PICs and $LiNbO_3$ has the potential to create highly efficient and compact FSOC systems, leveraging the strengths of both technologies [19]. After that integration of $LiNbO_3$ modulators on silicon photonics platforms, showcasing the potential for more compact and efficient FSOC systems. Research has shown that hybrid integrated devices can leverage the high-speed modulation capabilities of $LiNbO_3$ with the integration benefits of PICs, resulting in enhanced FSOC systems [21]. Finally, the integration of PICs and $LiNbO_3$ in FSOC systems holds promise for next-generation communication networks, including 5G and 6G. These technologies can support high data rates, low latency, and fabrications making them suitable for future wireless communication systems [22].

III. ADVANTAGES OF FSO IN AI

Free Space Optical Communication (FSO) represents a perfect approach to combining with artificial intelligence (AI) technologies due to it offers multiple significant benefits. First of all, FSO fulfils the need for rapid information processing and transfer in AI systems through its incredibly rapid information speeds. This ability is crucial to handling the enormous quantities of statistical information produced by algorithms that use AI, which enables efficient decision- making and analysis. security is a further significant advantage of FSO technological advances. compared to RF (radio frequency) communication, the FSO does not emit electromagnetic signals, therefore being naturally safe against capture. Secondly, FSO systems provide extremely fast interaction, which is essential to actual time artificial intelligence (AI) applications like autonomous cars and automation. By reducing delay in communicating information, FSO supports instantaneous response mechanisms, enhancing the reliability along with the security of AI-driven tasks in changing conditions. In critical AI applications where data security and confidentiality are essential, this feature is particularly useful. Since its ability to function in a less congested optically band as opposed in the RF region, FSO enables communication to occur with no interruption. The reliability and secure transmission of data is guaranteed by this trait, which is vital to preserving the confidentiality of AI systems that rely on ongoing information flow. In closing least, FSO systems are highly scalable, able to adapt to meet rising bandwidth requirements as AI algorithms develop and produce more datasets. This capacity is in pace with the increasing information technology and logical needs of AI applications across a range various industry, include factories, cities with smarts, healthcare, and other.

Table 1. Applications that are currently under development:

Application	Definition	Limitations	Challenge	Solution
Intra-Chip Communication	Chips for computers including optical links can boost processor performance and information speed of transfer.	Integration of electrical systems and reduction	avoiding a dispersion caused by heat and maintaining dependable transfer of signal at tiny sizes.	Enhance reliability as well as performance with advanced cooling techniques and photonic integrated circuits.
Underwater Autonomous Vehicles (UAVs)	UAVs are communicating with each other to plan cooperative oceanography research and data collection.	Extreme radiation absorption and scattering in the water.	Keeping reliable interaction in adaptable undersea conditions.	adaptive protocols for communication plus green or blue laser may be employed to enhance signal reliability.
6G Networks	FSO has been utilized by future wireless networks to offer extremely rapid transfer speeds and low delay.	Integration using the present network while preserving reliability.	handling an extensive variety of apps and an elevated user density.	Provides advanced modulation, and correction of errors, and mixed RF and FSO technologies.
Inter-Planetary Communication	Space exploration use optical communication lines among Earth along with other planets.	huge distances and different universes' atmospheres.	Allowing trustworthy, latency-free communications throughout long distances.	To maintain constant interaction, making use of adapting optics, high-power lasers, and precise alignment.
AI-driven Smart Cities	integrating AI to managing and improving of metropolitan infrastructure and services, particularly protection and transport.	limited band along with potential photonic source interaction.	issues about interference with signals or intercepted information in open spaces form a safety viewpoint.	For better performance and privacy, use multi-beam optical networks and encryption methods.

IV. EMERGING TRENDS

Major advancements in the field is currently inspired by recent advances in free-space Optical Communication (FSOC) together with photonics integrated circuits, particularly using lithium niobate. Listed below are some significant developments:

A. PHOTONICS INTEGRATED CIRCUITS

PICs reduce the dimension and price for optical communication systems and boosting efficiency through the integration of several photonic features onto just one chip. PICs are particularly helpful for FSOC due to their ability for efficiently handling data at a rapid pace.

B. LITHIUM NIOBATE

Due to its excellent electro-optic characteristics, lithium niobate has been a widely utilized materials for electro-optic modulation devices. Greater compatibility with PICs, or has been rendered feasible by the development of lithium niobate on insulator ($LiNbO_3$) the internet, resulting in: Greater Tuning Effectiveness: Internet Achievement: Small and Flexible Solutions.

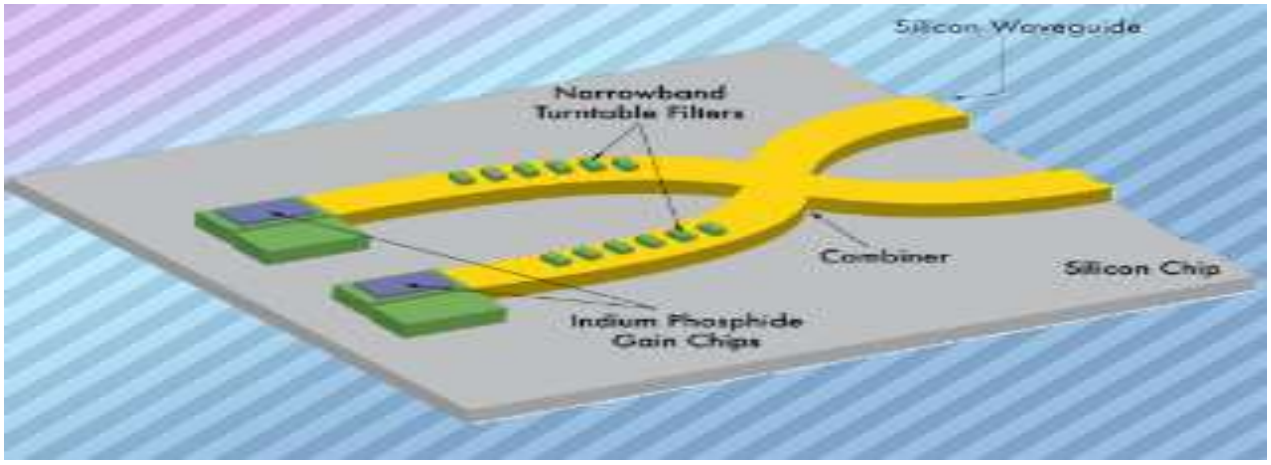

Fig 2. Photonics integrated circuit (PICS)

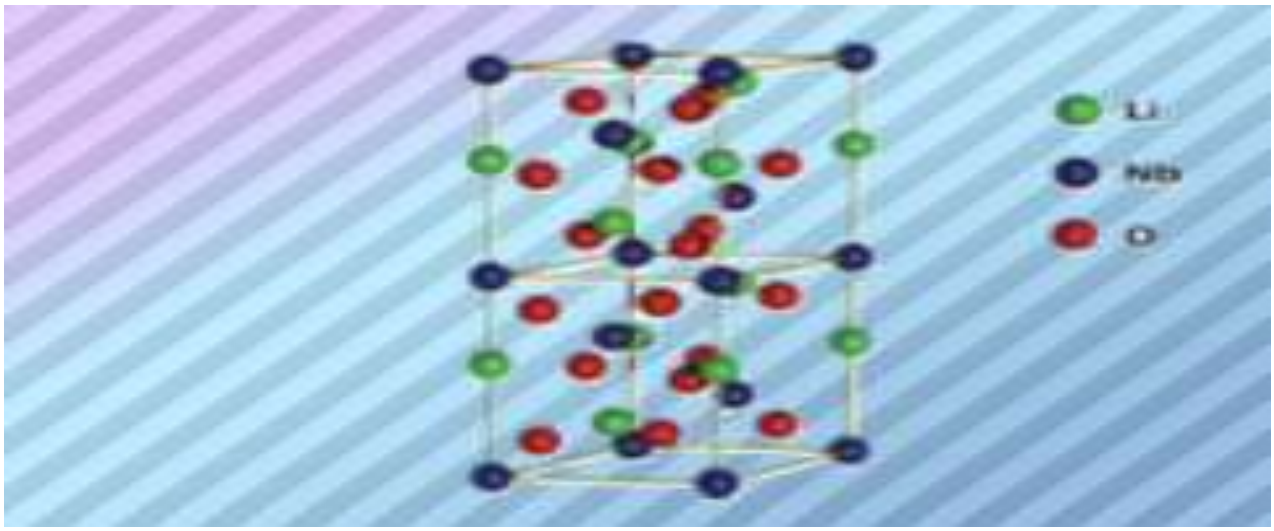

Fig 3. Crystal structure of lithium niobate ($LiNbO_3$)

V. COMPARATIVE ANALYSIS OF PHOTONICS INTEGRATED CIRCUITS (PICS) AND LITHIUM NIOBATE ($LiNbO_3$) FOR OPTICAL COMMUNICATION SYSTEMS

The following table examines lithium niobate ($LiNbO_3$) alongside photonics integrated circuits (PICs) based on the following parameters: throughput, data rate, energy consumption, error bit rate, and delay.

Table 2. PIC vs. $LiNbO_3$ Performance Comparison.

Parameter	Photonics integrated circuit (PIC)	Lithium niobite ($LiNbO_{3)}$
Latency	Low (sub-nanosecond)	Low (nanosecond)
Error Bit Rate	Low	Low
Energy Consumption	Low to moderate	Moderate to high
Data Rate	High (up to Tbps)	High (up to Gbps)
Throughput	High	High

VI. DISCUSSION

C. LATENCY

Usually, photonics integrated circuits (PICs) provide sub-nanosecond latency as well as which makes them extremely low. Low processing of signals delay and the inherent features of light propagation within photonic devices are the primary causes for this. PICs' efficient structure minimizes additional delays and their incredibly fast speed that light travels (about 300,000 km/s in vacuum) ensures quick data transfer, which makes them perfect for applications needing real-time data processing and communications. By comparison, Lithium Niobate ($LiNbO_3$) devices can also achieve a low latency, though a specific design and device architecture will influence how well they function. Latency numbers often fall around the milliseconds range. $LiNbO_3$s low latency performance is owed to its electro-optic features, which allow fast modulation and switching. But in comparison with other methods, the physical dimensions of production processes can lead to minor delays.

D. ERROR BIT RATE

According on the specific modulation techniques (such OAM, CAP) and correction of errors methods used, PIC error bit rates can be very low. Sophisticated modulation and coding techniques improve data transmission dependability by significantly reducing bit error rates. Sophisticated on-chip signal manipulation abilities help PICs reduce mistakes even more. $LiNbO_3$ devices also exhibit low error bit rates, which can be related to the specific modulation and error correction techniques utilized. Low rates of error remain achieved in part because the superior optical qualities of the material and the high-performance factor of $LiNbO_3$ modulators. Error effectiveness, however, could possibly be impacted by differences in the device's construction and operational conditions.

E. ENERGY CONSUMPTION

PICs typically have less energy consumption because photonic components are more effective. Unlike electrons, photons dissipate less energy when they pass through the waveguides since they do not produce a lot of heat. In addition to this characteristic and the capacity to combine multiple

functions onto a single chip, PICs have a lower total power consumption, which renders them suitable for energy-effective applications. But even though lithium niobate devices are powerful and can manage high power operation, they usually require more energy, particularly when high power modulation devices are used. The total amount of energy consumed rises due to the demand for external driving electronics and greater voltage demands on modulation. $LiNbO_3$ is still a reliable option in spite of this for application where high performance is of greater importance than energy efficiency.

F. DATA RATE

PICs are able to handle data at extremely rapid rates, often in excess of several terabits per second (Tbps). The ability to multiplex multiple light wavelengths (known as wavelength division multiplexing, or WDM) within only one waveguide is largely to blame for this ability. PICs have been established for an emerging technology in high-bandwidth communication networks, which greatly boost bandwidth via merging fast speeds modulators and detector. On the other hand, lithium niobate possesses a capacity to keep up huge information rates, usually reaching a few hundred Gigabits per second (Gbps). Rapid modulating allows rapid transfer of data through their excellent electro-optic characteristics. Yet, the data frequency generally lower than the maximum available without PICs since there are drawbacks in multiplexed possibilities or the challenging task of combining multiple fast-speed devices.

G. THROUGHPUT

PICs can provide excellent throughput given its high data transfer and the capacity to effectively combine a lot of photonic functions on a single chip. PICs were excellent in data-intensive applications because of their rapid speed modulation, and within the chip the process, with thick wavelength multiplexing, each of them ensures excellent data throughput. On the opposite hand, lithium niobate devices additionally generate high throughput, though figures that rely upon how the structure is built and operated. The product's exceptional throughput effectiveness may be ascribed to its exceptional clarity and high-power signal processing characteristics. However, for them to accomplish the similar throughput as PICs, more complex and power-intensive plans might be needed.

VII. CONCLUSION & FUTURE WORKS

As PICs as well as Lithium Niobate ($LiNbO_3$) devices are put together, it quickly becomes obvious that every innovation having its own benefits and drawbacks with regard to a variety of various considerations. PICs may achieve outstanding information rates, reduced energy consumption, along with extremely low latency as well as thereby rendering such an ideal match with modern, higher-performance optical communication platforms. Lithium Niobate devices, on the reverse hand, suffer from somewhat greater latency and greater use of energy yet provide excellent results, particularly in the areas of modulation rate and throughput. Upcoming investigations into this field will be mostly investigational because to the not enough established research in bromine photonics. It requires the risk of unanticipated outcomes while might additionally contribute to exciting discoveries and advancements. However, it could make an appropriate field of research for those who are motivated on investigating new materials and their use in photonics as well as optical communication.

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Enerji sektöründe Kadınlar; cinsiyet eşitliği ve temel sorunlar üzerine kısa bir değerlendirme

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Özet – Enerji sektörü tarihsel olarak her zaman erkek egemen bir alan olmuştur ve işgücü, nüfusu genellikle temsil etmez. Kadınlar küresel işgücünün yaklaşık %40'ını oluşturmalarına rağmen geleneksel enerji sektörünün yalnızca %16'sında bulunur. 29 ülkeden (22 IEA üyesi) 2018 yılında elde edilen verilere göre, enerji sektöründe ortalama olarak %76 daha az kadın çalışmaktadır. Bu ülkeler arasında enerji sektöründe becerilere bağlı olarak ortalama cinsiyetler arası ücret farkı yaklaşık -%15'tir. Enerji dışı sektörde ise -%13'lük daha küçük bir ücret farkı bulunur. Sektörün sürdürülebilir temiz enerji kaynaklarına doğru dönüşümü, daha fazla cinsiyet çeşitliliği için altın bir fırsat olarak görülmektedir. Kadınlara göre nispeten daha ayrıcalıklı olan erkeklerin, enerji alanındaki cinsiyet eşitsizliği konusunda daha az endişe duyması CEO'ların cinsiyet çeşitliliğinden yana örnek bir tavır sergilemesiyle bu durum tersine çevrilebilir ve erkeklerin de bu gündemi kadınlar kadar benimsemesine yardımcı olabilir. Bu çalışma, istihdamdaki cinsiyet eşitsizlikleri, kariyer gelişimi ve ücretler hakkındaki çalışan ve firma özelliklerine ve pazar yapısına ilişkin nicel verilerin kısa bir değerlendirmesini sunmaktadır. Ayrımcı uygulamaların sonuçlarının ortaya konulması sayesinde bunlara yönelik politikaların geliştirilmesi, tamamlayıcı çalışmaların oluşturulması ve doğrudan etkilenen sektör işveren ve çalışan barışının sağlanması öncelikli hedefler arasında olmalıdır.

Anahtar Kelimeler – Enerji, Cinsiyet Eşitliği, Kadın işgücü, Toplumsal Cinsiyet Eşitliği, Enerji Sektörü

I. GİRİŞ

Toplumsal cinsiyet eşitliği, erkek ve kadın bireylerin toplum ve yasalar karşısında eşit haklara sahip olması ve yararlanmasıdır. Ancak, toplumsal cinsiyet hiyerarşik bir yapıya sahiptir ve diğer eşitsizlik yaratan durumlar gibi (ekonomik ve sosyal) eşitsizlikler de geliştirebilir. Küresel işgücü de bunlardan en önemlisidir ve kadınlar yaklaşık işgücünün %40'ında varlık gösterirken, geleneksel enerji sektöründeki payları yalnızca %16'dır. Yönetim seviyeleri için rakamlar daha da düşüktür. Kadınların enerjiyle ilgili yeni istihdam seçeneklerinden yararlanma becerisi, belirli eğitim, öğretim ve istihdam türlerine erişimlerini sınırlayan sosyal engellerle kısıtlandığından, sosyal eşitlik politikalarının, ekonomik optimizasyonun enerji sektörü planlamasının ötesine geçmesi çok önemlidir.

Enerji sektöründe istihdam dünyanın her yerinde son derece erkek egemendir. 2012 yılında BM Kadın Birimi, fosil yakıta dayalı sektörde teknik personelin %6'sını, karar alıcıların %4'ünü ve üst yönetimin yalnızca %1'ini kadınların oluşturduğunu belirtmiştir [1]. Aradan geçen yıllarda çeşitli ulusal ve ulusal düzeydeki girişimler, kadınların enerji sektörüne katılımını geliştirmek için gösterilen çabalara rağmen, kadınlar hem geleneksel (fosil yakıta dayalı) hem de temiz ve yenilenebilir enerji sektörlerinde yeterince temsil edilmemektedir [2]. Küresel olarak kadınlar şu anda yenilenebilir enerji işgücünün yalnızca %32'sini ve fosil yakıta dayalı sektörün %22'sini temsil etmektedir [3]. Kadınlar, bilim, teknoloji, mühendislik ve matematik (STEM) eğitimi gerektiren işlerde (%28), STEM dışı teknik işlere (%35) ve idari pozisyonlara (%45) kıyasla Yenilenebilir Enerjide özellikle daha az temsil edilmektedir [3]. Kanada, ABD, İspanya,

Almanya ve İtalya gibi Ekonomik İşbirliği ve Kalkınma Örgütü (OECD) ülkelerinden elde edilen veriler, bu sektördeki işlerin yalnızca %20-25'inin kadınlara ait olduğunu ve bunların çoğunlukla daha düşük olduğunu belirtmiştir [4]. Bu durum, kadınların bahsedilen ülkelerdeki üniversite öğrencilerinin %50'sinden fazlasını ve işgücünün neredeyse yarısını temsil etmesi gerçeğiyle keskin bir tezat oluşturur [3]. Avrupa'da enerji sektörü işgücünün çoğunluğu erkeklerden (%77,9) oluşmakta olup, kadınlar yalnızca %22,1'i temsil etmektedir. Aynı eğilim, kadınların da yeterince temsil edilmediği yenilenebilir enerji sektörü için de geçerlidir. Yenilenebilir enerji sektöründe kadınlar imalat (araçlar için yakıt, kirlilik kontrol ekipmanı), inşaat (binaların güçlendirilmesi gibi) ve enerji üretimindeki pozisyonların %30'dan azını temsil etmektedir. Bu alanlardaki daha vasıflı işler (metal işçileri, yalıtım uzmanları, tesisatçılar ve boru tesisatçıları, elektrikçiler, ısıtma ve soğutma uzmanları) çoğunlukla erkek egemendir. Mühendislik, finans ve işletme hizmetleri (daha iyi ücretli işlerin yoğunlaştığı yerler) gibi diğer sektörler de erkeklerin hakimiyetindedir. Yenilenebilir enerji sektöründe çalışırken kadınlar genellikle yönetim ve iletişim başta olmak üzere daha düşük vasıflı işlerde çalıştırılmaktadır.

Kadınların enerji sektöründe karşılaştıkları engeller, çalışma hayatının diğer alanlarında karşılaştıklarıyla genellikle benzerdir. 2021 yılında dünya çapında nükleer enerji sektöründe çalışan 8.000'den fazla kadına anket uygulayan Nükleer Enerji Ajansı tarafından yapılan çalışmaya göre, sektörde kadınların karşılaştığı belirtilen temel engeller arasında ücret şeffaflığı ve adalet eksikliği, işyerinde cinsel taciz, kadın rol modellerinin eksikliği ve özellikle hamilelik ve aileyle ilgili görevlerle ilgili olarak iş-yaşam dengesine yardımcı olacak tedbirlerin bulunmaması olarak sıralanmıştır. Tüm engellerin cinsiyetler arası ücret farkları ve kariyer gidişatları üzerinde olumsuz etkisi olduğu belirlenmiştir. Bu bulgular, tarihsel olarak çoğunlukla erkekleri istihdam eden ve aynı zamanda kadınları işte tutma konusunda zorluklarla karşı karşıya kalan diğer sektörlerin bulgularıyla tutarlıdır.

Ancak enerji sektörünün son 20 yılında yavaş ancak istikrarlı dönüşüm süreci nedeniyle yeni fırsatlar ve zorluklar da gelişmektedir. Özellikle yenilenebilir enerji ve geleneksel olmayan enerji kaynakları gibi alanlarda gelişen yeni iş tanımları, işgücü dağılımında cinsiyet eşitliği konusunun tekrar gözden geçirilmesini gerektirmektedir. Özellikle, yenilenebilir enerji sektöründeki gelişmeler, yenilikçi çözümlerin ve yeni iş modellerinin benimsenmesini ve çeşitli kademelerde yetenek havuzundan daha fazla kadının katılımını gerektirecektir.

İş stratejisi, insan kaynakları ve yetenek yönetimi meselesi olarak ortaya çıkan cinsiyet farkının, kadınların bu rollerden uzak durmalarından mı, yoksa "erkekler kulübü"nde kendilerine yer bulamamalarından mı kaynaklandığını söylemek çok kolay değildir. Yüzlerce bağımlı ve bağımsız değişkenin yeraldığı bu durumda, sektör, firma, çalışan ve yerel ve bölgesel ekonomik şartların gözönüne alınması ve buna göre değerlendirmelerin yapılması elzem görünmektedir. Tek bir modellemenin yapılması mümkün olmadığı gibi özellikle enerji sektöründe cinsiyet eşitliğinin kabullenilmesi ve pratik olarak uygulanması da kolay olmayacaktır.

Enerji sektöründe kadınların karşılaştığı sorunlar birkaç nedenden dolayı diğer sektörlerdekinden farklılık gösterir. Genellikle ülkeler herhangi bir iyileştirici sonucu olmasa da sektörel boyutta bu konuyu araştırmaktadır. EIA gibi daha büyük organizasyonlar da geniş örneklem alanı ile bu tip raporlama çalışmalarını gerçekleştirmektedir. 2023 yılında EIA tarafından OECD LinkEED projesi kapsamında Avusturya, Fransa, Almanya, Portekiz ve İspanya'dan toplanan bilgilerden yararlanılarak yapılan raporlama çalışmasında enerji sektöründe istihdam ve ücretler, üst düzey yönetim, girişimcilik ve inovasyon alanlarındaki cinsiyet farklılıklarına ilişkin ayrıntılı veriler değerlendirilmiştir [5].

Değerlendirilen veriler ülkeler için farklı yıl aralıklarındadır; Avusturya (2000-2018), Fransa (2002-2018), Almanya (2002-2018), Portekiz (2002-2017) ve İspanya (2006-2018). Enerji sektöründeki firmalar, enerji dışı sektör olarak adlandırılan diğer firmalarla sistematik olarak karşılaştırılmıştır. Enerji dışı sektördeki firmalar tüm örneklemdeki firmaların %98'ini temsil etmektedir. Enerji firmaları istihdam açısından enerji dışı firmalara göre ortalama %50 daha büyüktür ve ücretler %9 daha yüksektir.

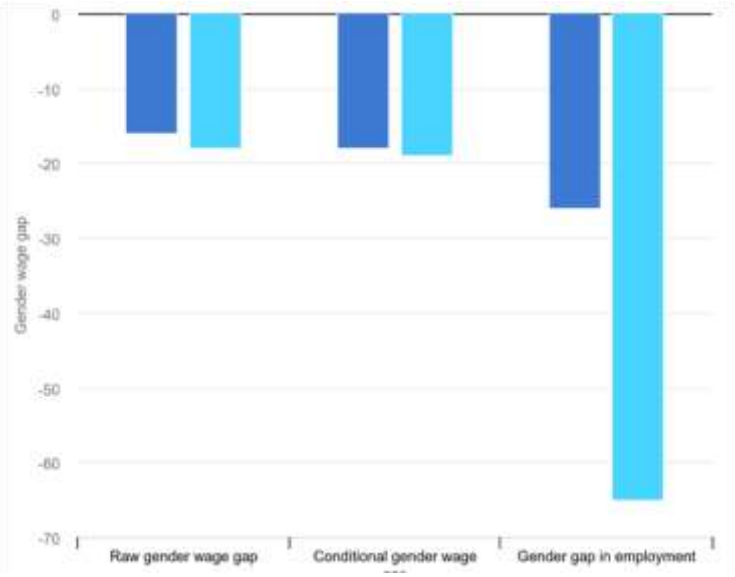
Bu çalışmada OECD ve IEA tarafından enerji sektöründe varolan cinsiyet eşitsizliğine dair raporlama sonuçları ile ülkemizdeki durum kısaca değerlendirilecek, yakın ve uzak vadede mümkün olabilecek geliştirmeye yönelik öneriler sunulacaktır.

II. ENERJI SEKTÖRÜNDE CINSIYET EŞITLILIĞI SORUNU VE KARIYER BOŞLUKLARI

Enerji sektöründe erkeklere kıyasla önemli ölçüde daha az kadının çalıştığı bilinen bir gerçektir. Kadınlar 95 ülkede işgücünün yarısını temsil etmelerine rağmen gayri safi yurt içi hasılanın (GSYİH) yalnızca %37'sine katkıda bulunmaktadır. Bu oran EIA 2023 raporunda %40 olarak belirlenmiştir (Şekil 1). Dünya Ekonomik Forumu'nun (WEF) Küresel Cinsiyet Eşitsizliği Raporu'na göre, Cinsiyet eşitliği, kişi başına düşen GSYİH, rekabet gücü ve insani kalkınma arasında yüksek korelasyon göreceli olarak, fark enerji dışı sektördekinden iki kat daha büyüktür [6]. ABD'de kadınlar enerji sektöründeki işlerin yalnızca %27'sini elinde tutarken, genel ekonomideki işlerin neredeyse yarısına sahip oluyor. Kadınların nispeten düşük katılım oranları, tüm enerji sektörlerinde tutarlı olup, elektrik üretiminde %33 gibi yüksek bir seviyeye kadar değişmektedir [7].

EIA tarafından hazırlanan raporda da görüldüğü gibi, enerji sektöründeki bulgular, diğer sektörlere kıyasla kadınların kariyer hareketliliği ve ilerlemesinde boşluklar olduğunu ve bunun da işgücünün hem ilgisini hem de elde tutulmasını etkileyeceğini ortaya koymaktadır. Bu durumun olağan sonuçları olarak, enerji sektöründe ilerleyemeyen kadın rol modelinin olmaması ve mentor sayısının azalmasını sağlayacaktır. Ayrıca enerji sektöründe çalışan ancak, kariyerlerinde ilerleme olmayan kadınlar sektör değiştirmeye mecbur kalacaktır.

Enerji sektörü, kadınların eğitim, sağlık, çocuk bakımı gibi otomatik olarak kendilerine atfedilen sosyal hizmetlerden uzaklaşarak daha "erkeksi işlere" doğru evriminde en iyiyi sergileyen prototiplerden biridir. ABD'deki şeyl gazları sayesinde petrol ve gaz sektöründe çalışan kadın sayısının 2004-2011'de 78.400 (%64) artması da bu görüşü doğrulamaktadır [8].



Şekil 1. Sektörlere göre ortalama cinsiyete dayalı ücret ve istihdam farkları

Dengesizlik doğrudan işe giriş seviyesinden başlamaktadır: Petrol ve doğalgaz sektörüne giren kadınların yalnızca %27'si mezuniyetten hemen sonra işe başlarken, %25'i çalışma hayatının ortalarında ve %17'si ise üst düzey ve idari seviyelerden başlamaktadır.

Aynı şekilde kadınlar da enerji sektörünün girilmesi mümkün olmayan ayrıcalıklı bir kulüp olduğunu ve kültürünün paylaşılmasına izin verilmediğini belirtmektedir. Kadın enerji profesyonellerinin %71'i erkek egemen bir şirket kültürünün varlığına inanmaktadır (9). Hatta ABD'nin eski İçişleri Bakanı Sally Jewell, 1981'de petrol ve doğalgaz sektörünü tamamen terk etmesinin nedeninin offshore'da çalışabilecek uygun işlerin olmaması şeklinde ifade etmiştir [9].

Enerji sektöründe iş pozisyonlarına hem yatay hem de dikey ölçekte bakıldığında zaten düşük olan kadın oranı daha da azalır: Petrol mühendislerinin sadece %13'ü,genel/operasyon/yatırım müdürlerinin %7'si ve geri kalan tüm yöneticilerin %20'si kadındır [10].

Enerji ve madenlerde giriş seviyesi çalışanların %40'ını kadınlar temsil ederken, üst düzey yönetim kademesinde bu oran %16'ya düşer [11]. Birleşik Krallık'ın en büyük 100 enerji şirketinin %61'inin yönetim kurulu üyeleri erkektir. En büyük 200 elektrik şirketinde yönetim kurulu üyelerinin yalnızca %5'i ve üst düzey yöneticilerin %14'ü kadındır [12]. Ancak elektrik ve yenilenebilir enerji sektöründe cinsiyet çeşitliliği daha iyi korunmaktadır: Kadınlar Petrol şirketlerinin %7 ve %8'ini elinde tutarken, yenilenebilir enerjide bu oran %17'dir [9].

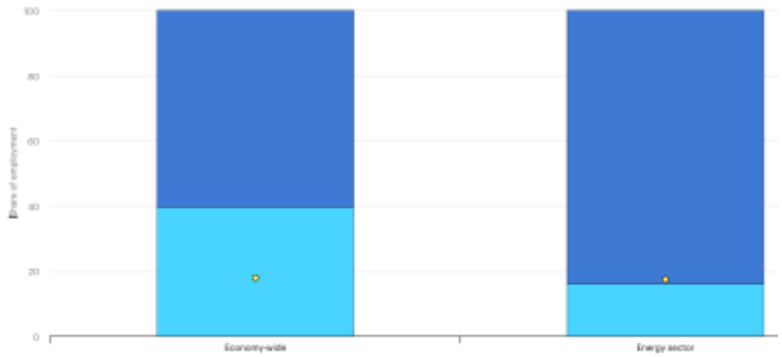
Kadın ve erkeklerin kazandığı ortalama saatlik ücret ile ikramiye arasındaki fark, İngiliz hükümeti tarafından "cinsiyete dayalı ücret farkı" olarak tanımlanır. 2017 yılında yayınlanan bir rapora göre, Birleşik Krallık'ta cinsiyetler arası ücret farkı 1997'den bu yana yarı yarıya azalmasına rağmen tam zamanlı çalışanlar arasında hala %9,1'dir [13].

Enerji firmalarında ücret priminin göreceli önemi, çalışanların üretkenliğe ilişkin ortalama performansı, sermaye yoğunluğu veya kâr, firmaların ücret belirleme gücü ve ücret belirleyen kurumların doğası gibi çeşitli faktörleri yansıtabilmektedir. Benzer vasıflara sahip çalışanlar için ücretleri rakiplerinden farklı belirleme yeteneği, firmaların cinsiyet gibi demografik özellikler de dahil olmak üzere farklı özelliklere sahip çalışanlar arasında ayrımcılık yapma potansiyelini önemli ölçüde artırır ve enerji sektöründeki potansiyel önyargıları değerlendirmek için oldukça önemlidir.

Petrol ve gaz sektörü, %7,4'lük cinsiyete dayalı ücret farkının, en büyük olduğu alandır [14]. Cinsiyete dayalı istihdam dengesizliği olan ilk on sektör arasında petrol ve gaz, kadın istihdam oranı %22 ile 9. sırada yer alır [15].

Bu bulgular, sadece petrol ve doğalgazın ötesinde enerji sektöründe de cinsiyet dengesizliğinin ve nedenlerinin sorgulanmasını da gerektirir. EIA tarafından hazırlanan ve beş ülkedeki sektörel verilere göre, kadın çalışanların ücretleri erkek çalışanlara göre neredeyse %20 daha düşüktür ve fark enerji dışı firmalara göre biraz daha büyüktür (Şekil 2). Bu fark, firmalar içindeki beceri seviyelerindeki cinsiyet farklılıklarının bir fonksiyonu olmadığını göstermektedir. Birleşik Krallık'ta ise Energy & Utility Skills'e göre Ulusal İstatistik Ofisi (ONS), enerji ve kamu hizmetleri sektöründeki mevcut cinsiyet farkının ciddi olduğunu, erkeklerin kadınlardan %15,4 daha fazla kazandığını belirtmiştir. Özellikle cinsiyetler arası en büyük ücret farkı enerji sektöründe (%19) ve gaz şebekelerinde (%17) görülmüştür [13].

En büyük petrol şirketlerinden birisi olan Shell, kadın-erkek ayrımı yapmadan aynı düzeyde ücret ödemesine rağmen, cinsiyetler arası ücret farkı hala %2,2'dir. Yüksek ücretli işlerde çalışan kadın çalışanların oranı, üst düzey yönetici olmak için gereken teknik ve ticari deneyimin, kadın yönetici adaylarında eksik olabileceği önyargısı nedeniyle, oldukça azdır. Teknik ve ticari işler daha fazla ücret getirdiği için erkekler kadınlardan daha fazla kazanmaktadır. Dolayısıyla bu sektörel yoğunlaşma, 2015 yılında ABD'de cinsiyetler arası ücret farkının en büyük açıklayıcı faktörlerinden biridir [16].



Şekil 2. Firmalar, enerji dışı ve enerji sektörleri içinde ve arasında ortalama cinsiyete dayalı ücret farkları (16).

Kadınlar tüm dünyada olduğu gibi Türkiye enerji sektöründe de yetersiz temsil edilmektedir (Şekil 3). PETFORM, ELDER, EÜD tarafından yapılan ve enerji sektöründen 565 beyaz yakalı kadının katılım gösterdiği araştırmaya göre kadınların %73'ü enerji sektöründe bulundukları için mutlu olduklarını belirtmiştir ancak çalışan sayısı diğer sektörlerden bile daha düşüktür (Şekil 3) [17].

Kaynak: Türkiye'de enerji sektöründe faaliyet gösteren 31 firmadan alınan verilerle oluşturulmuştur.

Şekil 3. Türkiye enerji sektöründe istihdam rakamları

III. CINSIYET EŞITSIZLIĞININ BAŞLICA NEDENLERI VE BAZI ÇÖZÜM ÖNERILERI

Kadınların enerji işgücü piyasasına düşük katılımını açıklayan nedenlerden bazıları şunlardır:

- Enerjiyle ilgili eğitimde ilk öğretimden başlayarak önyargı ve taraflı yönlendirmeler nedeniyle gelişen cinsiyet eşitsizliği nedeniyle uygun becerilerin eksikliği.
- Bazı çalışma konularının ve çalışma alanlarının ya 'dişil' ya da 'eril' olarak kurgulanması, örneğin enerji alanı erkek alanı olarak görülmesi.
- Kadın bilim insanı/mühendis rol modellerinin eksikliği ve üst orta eğitim sırasında bilim odaklı rehberlik ve mentorluk programlarının eksikliği.
- Okullardaki fen öğretimi yaklaşımının modası geçmiş özelliği ve bunun öğrencilere çekici gelmemesi.
- enerji sektörünün erkek alanı olarak algılanması ve devam eden toplumsal cinsiyet stereotipleri.
- kadınları öngörülemeyen çalışma programı veya acil seyahat içeren işleri üstlenmekten caydıran iş-aile yaşam dengesini sağlamanın zorluğu.
- Kadınlara yönelik kariyer geliştirme fırsatlarının ve mentorluk programlarının yetersiz olması olarak sıralanabilir (https://eige.europa.eu/gender-mainstreaming/policy-areas/energy).

Enerjide cinsiyet eşitsizliğinin çözümü sektörel ölçekte çözülebilecek bir sorun gibi görünse de temelinde toplumsal önyargı ve alışkanlıklar yatmaktadır. Bu durum aslında hem kadın hem de erkek bireylerde gelişim aşamasından itibaren yerleşik bir düşünce ve sonrasında davranış kalıbı haline gelir. Bu nedenle sektörde iş arama ve istihdam aşamasından önce çözülmesi gereken bir sorundur. Toplumsal cinsiyet eşitliği için kişilik oluşumu ve mesleki tercih aşamasına kadar bu bilincin çocuklara verilmesi ancak eğitim süreci ile gerçekleştirilebilir.

Kadınlara yönelik bir diğer önyargı ise “hırssızlık” söylemidir. Cinsiyet eşitliğinin desteklenmediği bir çalışma ortamında kadınların hırsları, kariyerlerinin en kritik dönemlerinde, yani 30-40 yaşları arasında erkeklere göre daha hızlı düşer. Bu nedenle umutsuzluğu ve körelmeyi yayan şey şirketin tutumu, ailenin desteği ve toplumsal beklentilerin karşılanma arzusudur [18].

Aynı şekilde her üç erkekten birisi kadınların bazı rollerin gerektirdiği esnekliğe sahip olamadığını düşünmektedir. Bunda erkeklerin ev ve çocuk bakımına kadınların başlıca sorumluluğu olduğunu düşünmesi ve bu nedenle daha az katkıda bulunmasının önemli bir rolü bulunur. Benzer şekilde kadınlar

da erkeklerin ev ve çocuk bakımında yeterli beceriye sahip olmadığını düşünmekte ve tüm sorumluluğu üstlenmeye çalışmaktadır.

Sonuç olarak, kadınların %75'i liderlik rollerini üstlenme isteği ve güvenini dile getirirken, %43'üne göre hem lider olmak hem de çocuk yetiştirmek mümkün değildir [19].

Bu ailesel ve toplumsal kısıtlamalar stereotiplerle daha da kötüleşmektedir. Uluslararası Öğrenci Değerlendirme Programı'nda (PISA) kızların erkekleri açık ara geçtiği ülkelerde bile, kendilerini bir bilim veya mühendislik kariyerinde hayal etmemiştir (19). Kızlar bu kararı isteyerek ya da bilmeyerek toplumsal cinsiyet ve toplumdaki çalışan kalıplarının etkisi altında almaktadırlar. Körfez ülkelerindeki durum, üniversite diplomasına sahip olmalarına rağmen sosyal/kültürel baskılar ve şirketlerin işe alımlarda erkekleri kadınlara tercih etme eğilimleri nedeniyle kendilerine enerji sektöründe yer bulamadıklarını göstermektedir [11].

Son 10 yılda ivmelenerek gelişen yeni enerji çağı kavramının baş aktörü olan yenilenebilir enerji kadınların enerji sektöründeki istihdamın artması konusunda önemli bir açılım alanı olarak görülmektedir. Uluslararası Yenilenebilir Enerji Ajansı (IRENA), 2019'da kadınların yenilenebilir enerji iş gücünün yalnızca %32'sini oluşturduğunu ve rollerinin büyük bir kısmının idari pozisyonlarda olduğunu belirtmiştir. Bu, toplam enerji sektöründeki (kadınların işgücünün yalnızca %25'ini oluşturduğu) cinsiyet ayrımından daha olumlu olsa da, önemli dengesizlikler devam etmektedir. Yine IRENA tarafından 2050 yılına kadar yenilenebilir enerji sektöründe yaklaşık 29 milyon iş olacağını tahmin etmektedir. Rüzgar ve güneş gibi yenilenebilir enerjiler daha yaygın bir güç kaynağı haline geldikçe ve iş piyasası büyüdükçe yenilenebilir enerji sektöründe kadınların iş potansiyelinin artması beklentisi de bir gerçektir.

STEM kaynaklarına ve eğitime artan erişim, kadınların enerji sektöründe hızla büyüyen, yüksek maaşlı kariyer fırsatlarına girmesine yardımcı olacaktır. IRENA, enerji iş gücündeki cinsiyet farkının kapatılmasına yardımcı olacak politika değişiklikleri önermektedir. Eşit eğitim fırsatları, iyileştirilmiş ebeveyn izni ve esnek çalışma saatleri, iyi bir başlangıç noktasıdır. Maaş şeffaflığı ve kariyer geliştirme fırsatları, bu alanda kadınlar için ağ oluşturma ve mentorluğu desteklemeye yardımcı olur.

Enerji sektöründe çalışan kadınların mobbing konusundaki cevapları/düşünceleri oldukça dikkat çekicidir. Kadınların yüzde 74,2'si en az bir kez mobbinge maruz kaldığını ifade etmiştir. Yüzde 19,2'si mobinge maruz kalmadıklarını belirtirken, yüzde 6,6'sı kararsız olduğunu belirtmiştir. Bu duruma karşı güçlü bir duruş sergilemek, kadınların daha fazla saha veya teknik iş üstlenebilmeleri için barınabilecekleri bir ortam yaratmak için zorunludur. Şirketlerin iş ve ev dengesini kurmak için daha fazla esneklik sağlaması gerekir. Cinsiyet açısından en eşit olan şirketler ebeveyn izni ve evde çocuk bakımı sağlarken, yarı zamanlı, esnek ve uzaktan çalışma, babalık izni veya uzatılmış doğum izni ve çocuk bakım desteği, araştırılması gereken diğer seçeneklerden yalnızca birkaçıdır.

Enerji sektöründe cinsiyetler arası ücret farkları enerji dışı sektöre göre daha fazladır. Enerji sektöründeki kadınların ücretleri, aynı beceriye sahip erkeklere göre yaklaşık %15 oranında düşüktür. Cinsiyetler arası ücret farkının büyük bir kısmı, firmalar içinde benzer becerilere sahip kadın ve erkekler arasındaki ücret farklılıklarıyla açıklanmaktadır, ancak ilginçtir ki, kadınların yoğunlaşması nedeniyle firmalar arası bileşenin enerji dışı sektöre göre belirgin şekilde daha fazladır.

Üstelik, cinsiyetler arası ücret farkının firmalar arası unsuru, enerji sektöründeki düşük vasıflı işçiler için özellikle önemliyken, beceri seviyesi ne olursa olsun, enerji dışı sektördeki işçiler için nispeten daha az önem taşır. Karşı olgusal bir araştırma, firmalar arasındaki ücret dağılımının, firmalar arasındaki cinsiyete dayalı ücret farkının açıklanmasında cinsiyet paylarındaki farklılıklardan daha büyük bir rol oynadığını ortaya koymaktadır.

Görev ve sorumluluklardaki farklılıkların tüm firmalarda cinsiyetler arası ücret farkı üzerinde önemli bir etkiye sahip olduğu tespit edilirken, enerji sektöründe pazarlık ve ayrımcılığın (ve dolayısıyla firma düzeyinde ücret belirleme uygulamalarının) rolü, enerji dışı sektör.

Enerji sektöründe kadınların her yaşta işgücü piyasasından ayrılma olasılığı erkeklere göre daha fazladır. Ayrıca enerji sektöründe çalışan kadınların sektördeki başka bir firmaya geçme olasılıkları erkeklere göre çok daha az, enerji sektöründen ayrılıp başka bir sektöre geçme olasılıkları daha yüksektir.

Harvard Business School'un 35 ülke ve 24 sektördeki 1.069 önde gelen firmayı analiz eden araştırması, cinsiyet çeşitliliğinin daha yüksek piyasa değeri ve gelirle ilişkili olduğunu göstermiştir. Ancak bu, yalnızca cinsiyet çeşitliliğinin yaygın olarak kabul edildiği ve büyük önem taşıdığına inanılan işletmelerde geçerlidir. Benzer şekilde, Morgan Stanley'in Dünya Endeksi'ndeki toplam 1.875 firmayı araştırması, daha fazla cinsiyet çeşitliliğine ve daha yüksek Bütünsel Eşit Temsil Puanına (HERS) sahip şirketlerin, daha az cinsiyet çeşitliliğine sahip şirketlerden %1,6 daha iyi performans gösterdiğini işaret etmiştir. Aynı çalışmada, Avrupa'daki cinsiyet çeşitliliğine sahip enerji şirketlerinin hisse fiyatlarının %23,7 oranında daha iyi performans gösterdiği de belirlenmiştir.

IV. SONUÇ VE ÖNERİLER

Bu kapsamda ilk sorun, enerji firmalarında kadın istihdam oranlarının nispeten düşük olması ve kadınların düşük ücretli firmalarda (sınıflandırma) ve mesleklerde (ayrışma) yoğunlaşması, sektördeki işe alım ve terfi uygulamalarının tarafsız olmadığını göstermektedir. Öncelikli olarak işe alım sürecinde makul ölçülerde (fiziksel performans gereklilikleri ve özel durumlar dışında) bilgi ve beceri düzeyine göre eşitlikçi davranışın önemi vurgulanmalıdır.

Enerji sektöründeki kadınların düşük istihdam oranının nedenlerinden birisi de STEM derecesine sahip kadın sayısının hala oldukça düşük olması, bu nedenle firmalar ve meslekler için potansiyel kadın başvuru havuzunun dolmamasıdır. Erkekler ve kadınlar arasındaki uzmanlaşma farklılıkları, en çok, kadın rol modellerinin eksikliğiyle daha da güçlendirilen cinsiyet normları ve beklentileriyle açıklanabilir. Böylece işe alım ve performans değerlendirmesinde şeffaflık ve adaletin sağlanmasına yönelik alınacak önlemler, enerji sektörüne hem daha fazla kadının çekilmesine hem de sektörde tutulmasına katkı sağlayacaktır. Özellikle yöneticiler arasında bilinçsiz cinsiyet önyargısı konusunda kurumsal eğitim, adil işe alım uygulamaları ve performans değerlendirmelerinin oluşturulmasında da önemli bir rol oynayabilir.

İkinci olarak, çalışma ortamının kalitesiyle ilgili unsurların sektördeki kadın çalışanların kariyer gidişatları üzerinde de önemli olumsuz etkileridir. Kadınların kariyer ve kişisel hedeflerini yakalamalarına ve dengelemelerine yardımcı olmak için ücret teşviklerinin ötesinde alınan önlemler hayati önem taşır. Bu tür önlemler arasında yeterli ebeveyn izni, uygun fiyatlı ve kaliteli çocuk bakımı, esnek çalışma düzenlemeleri sağlayarak iş-yaşam dengesinin iyileştirilmesine odaklanmanın yanı sıra mentorluk programları, kariyer rehberliği ve eğitim yoluyla daha destekleyici bir ortam oluşturulması da yer almaktadır.

Bilinçsiz cinsiyet önyargısı ve uygun işyeri davranışına ilişkin farkındalık oluşturmak, kadınlar ve erkekler için güvenli ve çekici bir işyeri sağlamanın da anahtarı olabilir. Ayrıca etkili cinsel taciz politikaları da hayati önem taşımaktadır.

Ve son olarak, enerji sektöründe benzer becerilere sahip kadın ve erkekler arasında ayrımcılık ve önyargılar nedeniyle oluşan nispeten yüksek ücret farkı, çalışanların (ve diğerlerinin) ayrımcı uygulamalara karşı korunmasının önemini göstermektedir.

Bazı ülkelerde hükümetler kotalar ve hedefler koyarak bu gelişim sürecine öncülük etmektedir. Norveç, borsada işlem gören şirketlerin yönetim kurullarında kadın kotası getirme kararının bir sonucu olarak, 2015 yılında borsada işlem gören şirketlerin yönetim kurullarında en çok kadının bulunduğu (%32) ilk ülke olmuştur. Fransa ve İtalya da 2011 yılında benzer kota kararlarını onaylamıştır. Ancak toplumdaki temel zihniyet değişmediği sürece doldurulamayacak kotalar koymak veya bu kotaları iş için yeterli vasıflara sahip olmayan kadınlar tarafından doldurmak yarardan çok zarar getirebilir. Norveç'teki kota uygulaması ile başarısız satın almalar, borç seviyeleri ve piyasa değerindeki kayıplar arasında yüksek bir korelasyon ortaya çıkmıştır. Hedeflerin belirlenmesi gibi gönüllü önlemlerin daha etkili olduğu söylenebilir. Birleşik Krallık, "2015 yılına kadar yönetim kurullarında %25 kadın" hedefini %26,1 olarak gerçekleştirmiştir.

Cinsiyet çeşitliliğinin diğer sektörlerde olduğu gibi enerji sektöründe de sağlanması, farklı bakış açılarının, deneyimlerin ve düşünce süreçlerinin karar alma sürecine dahil edilmesini teşvik eder. Bu bakış açısı çeşitliliği, karmaşık sorunların daha kapsamlı analizine ve yenilikçi çözümlerin geliştirilmesine yol açabilir. Cinsiyetle sınırlı olmayan, çeşitli üyelerden oluşan takımlar, geleneksel bilgeliğe meydan okuma ve kalıpların dışında düşünme eğilimindedir; bu, her takım için çok değerlidir! Bunun en önemli nedeni önyargıdır.

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Yenilenebilir Enerji ve Küresel İklim Değişikliği Etkisindeki Küresel petrol piyasalarında Güncel Durum ve Geleceğe Yönelik Öngörüler

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Özet – Uluslararası petrol ticareti, yenilenebilir enerji sektöründeki gelişmeler, küresel iklim krizi etkileri, net sıfır hedefleri ile yeni bir enerji dönemine girmeye hazırlanırken, Rusya'ya yönelik geniş kapsamlı yaptırımlar ve kritik Kızıldeniz nakliye koridorundan geçen tankerlere yönelik saldırılar nedeniyle altüst olmuştur. Bu nedenle yeni bir bölgesel savaş veya Covid gibi küresel ölçekteki olayların bu sektörü nasıl etkileyeceğine dair görüşler ve öngörüler de yeniden gözden geçirilmiştir. Bilinen ve yadsınamayan bir gerçek, enerji arz güvenliğinin küresel politika gündeminin temel direği olduğudur. Küresel arz ve talep dengeleri doğrultusunda Asya'nın ham ve petrol ürünlerinde artan yapısal açıkları ve Atlantik Havzası'nda sürekli genişleyen arz fazlası, küresel petrol piyasasında yeni ticaret yollarının oluşmasını da sağlamıştır. Doğuya doğru, OECD üyesi olmayan Asya'ya, özellikle de Çin ve Hindistan'a doğru yönelim, enerji geçişi hız kazandıkça petrol piyasası faaliyetlerini yönlendiren çok sayıda yeni zorlukla aynı zamana denk gelmiştir. Artan elektrikli araç kullanımı, ortaya çıkan temiz enerji teknolojileri ve daha kapsamlı verimlilik politikaları bir araya gelerek petrol talebi için çok daha yavaş bir büyüme yörüngesi çizmekte olup, özellikle IEA tarafından 2023-2030 tahmin döneminin sonuna doğru petrol arz ve talebinin yatay bir seyir izleyeceği şeklinde öngörüler yapılmaktadır. Bu çalışmada küresel iklim değişikliği ve yenilenebilir enerji sektöründeki gelişmeler etkisinde petrol piyasasında güncel durum, IEA ve EIA gibi kuruluşların geleceğe dair prospeksiyonları kısaca sunulmuştur.

Anahtar Kelimeler – Petrol Sektörü, Petrol, Yenilenebilir Enerji, Küresel İklim Değişikliği, Enerji

I. GİRİŞ

Bir sektörün, özellikle de petrol gibi küresel siyaset, politika ve ekonomi gibi birçok etkenin rol oynadığı, kritik bileşenlerin çok fazla olduğu bir alanın geleceğine dair öngörüler yapmak her zaman çok zordur. Tek yönlü bir bakış açısı veya yerel bir ticaret noktasındaki ya da petrol fiyatlarına yönelik tahminler de sınırlı doğruluk payına sahip olur. Ancak, petrol sektörünün 1850'lerde resmen başlamasından sonra bu öngörüler her zaman yapılmıştır ve yapılmaya da devam edecektir. Petrol sektörünün her alanında bu çalışmalar güncel durumu değerlendirmesi ve geleceğe yönelik planlamaların yapılması için elzemdir. Sadece ulusal petrol şirketleri değil BP, Shell gibi büyük petrol şirketleri, OPEC veya IEA, EIA gibi kuruluşlarca da öngörüler yapılmaya devam etmektedir.

Yapılan tahminler zaman içinde çoğunlukla yenilense de sektörde bu konuyla ilgilenenler genel olarak ikiye bölünmüştür. İlk grup "geçiş dönemi" diyenlerdir…Onlara göre, ulaşımın elektrikleşmesi, fosil yakıta olan

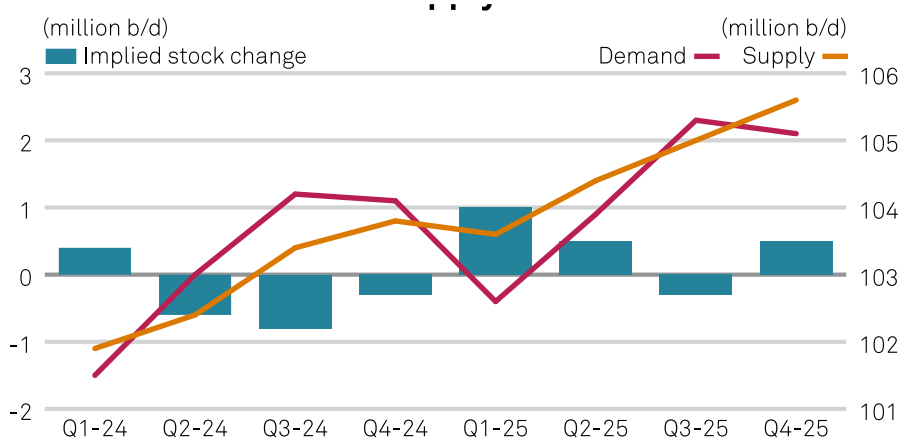
talebin katili olacaktır ve “Elektrikli araçlar yüzünden petrol ve doğalgaz yok olacaktır”. İkinci grup ise “sonsuz dek fosil yakıtçılar”dır. Onlara göre de ulaşımın elektrikleşmesi asla hedeflendiği gibi işlemeyecek ve onlarca yıl daha petrol ve doğalgaza talep olacaktır. Bu kapsamda birçok farklı rapor yayımlanmaktadır. Örneğin, BP raporu “Birincil enerji kaynağı olarak 2019’da %80 olan fosil yakıtların payı 2050 yılında %20 ile 55 arasına kadar kademeli olarak düşecek” demiştir. BP’ye göre, yenilenebilir enerjinin payı da aynı süreç içinde %10’dan, %35-65 arasına yükselecektir. Uluslararası Enerji Ajansı (IEA) ise küresel petrol talebinin günlük 102 milyon varille bu yıl rekor seviyelere yükseleceğini açıklamıştır. EIA (2022) “Bu, tüm elektrikli araç satışlarına ve fosil yakıtsız elektrik üretim kapasitesindeki büyük artışa rağmen olacak” diye de not düşmüştür. Oilprice analistleri, IEA’nın “genelde gelecek tahmini yapmaz ancak yaptığında da BP ile uyumlu yorumlar yapar” hatırlatmasını yapmıştır. Bloomberg ise elektrikli araçların parlak bir geleceği olduğuna inanan gruplardandır ve bu konudaki görüşünü “Fosil yakıtlardan uzaklaşmak, insanlığın tek geleceği” olarak açıklamıştır [1].

Başta OPEC olmak üzere petrol ve gaz sektörünün önemli temsilcileri, “temiz enerji”den daha çok “enerji”nin kendisine odaklanmış durumdadır. Oilprice’a göre, sektörün argümanları basitçe şu şekilde özetlenebilir: “İnsanların enerjiye ihtiyaçları var.”. Nasıl ve ne şekilde elde edileceği aslında önemli değil. Bu konuda küresel iklim değişikliği ile ilgili Paris Anlaşması gibi uluslararası organizasyonlar yapılmaya devam etse de en dramatik açık Rusya’nın Ukrayna’ya saldırması, Rusya’nın AB ‘ye gerçekleştirdiği yaptırımlar sonrasında yeniden kömüre dönüşle de kendini göstermiştir. Bunun tek anlamı, küresel iklim değişikliği konusunda devletlerin hassasiyetleri ve geleceğe yönelik planlamaları elbette var ancak tek öncelik enerji güvenliğidir.

Birçok etken altında, farklı otoriteler tarafından açıklanan geleceğe yönelik buluştuğu nokta, küresel petrol piyasalarının, yapısal değişimlerin petrol talebini ve ticaret akışlarını yeniden şekillendirmesi ve artan petrol arzının fiyatlar üzerinde baskı yaratması nedeniyle orta vadede çok sayıda zorlukla karşılaşacağıdır. Bölgesel ekonomik, siyasi dinamiklerin etkisi ve temiz ve enerji tasarrufu sağlayan teknolojilerin hızla yaygınlaşması, petrol talebi büyüme hızını kademeli olarak yavaşlatmak için önemli etkenlerdir ve IEA 2024 raporuna göre 2030'a yaklaşırken bir plato gelişmesi muhtemel görünmektedir. Gelişmiş ekonomilerdeki petrol talebi keskin bir şekilde düşerken, Çin ve Hindistan gibi Asya'daki gelişmekte olan ekonomiler küresel talep büyümesinin tamamını oluşturmaktadır [2].

IEA 2024 raporuna göre, OPEC+ dışındaki üreticilerin önderlik ettiği yükselen dünya petrol arzının, 2025'ten itibaren öngörülen talebi aşması beklenirken, doğal gaz sıvıları (NGL) ve kondensatlardaki artışın, 2024-2030 yılları arasındaki döneminde yeni kapasite artışlarının %45'ini oluşturacağı belirtilmektedir [2] (Şekil 1). Özellikle Suudi Arabistan, stratejisinde büyük bir değişiklik yaparak planlanan ham petrol

kapasite artışını askıya almıştır ve artık doğal gaz sıvılarını ve kondensatlarını genişletmeye odaklanacağını ifade etmiştir. Bu durum, küresel ham petrol üretim kapasitesindeki arz fazlasının kabul edildiği şekilde de yorumlanabilir. Küresel petrol sektörünün talep tarafındaki en büyük bileşeni olan petrokimyasalların artışı, büyük ölçüde üretimlerinde etkili olan NGL'lerin küresel arzındaki artışı olup, bunu takip etmektedir.



Note: Assumes extension of OPEC+ voluntary production cuts from June
Source: IEA monthly oil market report

Şekil 1. Uluslararası Enerji Ajansı (IEA) 2024 yılı petrol piyasasında arz/talep grafiği

Bu gelişme rafine ürünlere olan talep artışı nedeniyle rafineriler için yeni zorluklar da yaratacaktır. Dahası, enerji geçişi hızlanırken rafinerilerin azalan tüketim nedeniyle orta damıtıklar için farklı tüketici eğilimlerini karşılamak üzere ürün listelerini yeniden yapılandırmaları da gerekecektir. Bu durum özellikle elektrikli araçların (EV) pazar paylarını hızla artırdığı karayolu taşımacılığı yakıtları için geçerlidir [2].

Arz ve talep modellerindeki tüm bu yapısal değişimlerin ortasında, küresel petrol piyasası görünümü, zayıflayan makroekonomik beklentiler, enerji dönüşümünü hızlandırmaya yönelik yeni hükümet politikaları ve düzenlemeleri ve daha verimli teknolojileri ölçeklendirmek için benzeri görülmemiş düzeyde yatırım yapılması nedeniyle daha fazla belirsizlikle karşı karşıyadır. Bahsedilen bu zorluklara rağmen sektör, Rusya'nın Ukrayna'yı işgaliyle gelen enerji krizi ve öncesinde yaşanan Covid-19 salgını da dahil olmak üzere, büyük arz ve talep değişikliklerine uyum sağlayabildiğini de kanıtlamıştır.

II. KÜRESEL ARZ KAPASİTESİ GÜNCEL DURUMU VE DEĞİŞİMİ

Amerika Birleşik Devletleri ve Amerika kıtasındaki diğer üreticilerin öncülüğünde dünya petrol üretim kapasitesinin artırılmasının, 2023-2030 tahmin döneminde talep büyümesini geride bırakması ve Covid-19 dönemi hariç olmak üzere dünyanın yedek kapasitesini benzeri görülmemiş seviyelere çıkarması beklenmektedir [2]. Küresel ham petrol üretimi 2023'te %1 artarken, ABD, Brezilya ve İran'daki daha yüksek üretim OPEC+ üretim kesintilerini telafi etmiştir. 2022'de kaydedilen %5'lik büyümenin ardından,

küresel ham petrol üretimi 2023'te 2010-2019 ortalamasına uygun olarak +%1'e gerilemiş ve OPEC+ ülkelerinde önemli bir düşüş ve diğer ülkelerde güçlü bir büyüme yaşanmıştır. Kasım 2022'den 2023 sonuna kadar 2 mb/g üretim kesintisi duyuran OPEC+, yavaşlayan petrol talebi ve düşen petrol fiyatları bağlamında küresel petrol piyasasının istikrarını desteklemek için Mayıs 2023'ten 2023 sonuna kadar 1,65 mb/g'lik yeni gönüllü petrol üretim kesintileri getirmiştir. Bu kesintiler Haziran 2023'te 2024 sonuna kadar uzatılmış, sonuç olarak, ham petrol üretimi Suudi Arabistan'da %9,3 ve Rusya'da %1,5 azalmıştır ve her ikisi de küresel üretimin %12'sini oluşturmuştur. Bu arada, petrol üretimi OPEC+ olmayan ülkelerde, örneğin ABD'de (+2023'te %8,5), Brezilya'da (+%12), Çin'de (+%2,1), Norveç'te (+%6,4) ve hatta İran'da (OPEC+ kotalarından muaf, +%10) veya Nijerya'da (+%6) artmaya devam etmiştir [3].

Toplam arz kapasitesinin 2030 yılına kadar 6 mb/g artarak yaklaşık 113,8 mb/g'ye ulaşması önemli bir artış sürecini ifade etmektedir. Bu durum, fiyatları desteklemeyi hedefleyen mevcut OPEC+ piyasa yönetim stratejisinin de değişmesine neden olabilecektir.

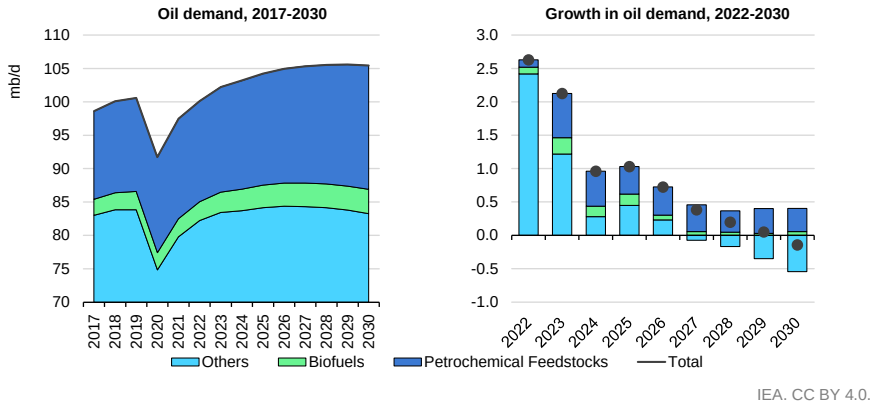
Bazı araştırmalarda ise petrol üretiminin 2030 civarında zirveye ulaşacağı belirtilir. Petrol üretimi, petrol zirvesinden çok sonra bile potansiyel olarak yüksek seviyelerde kalabilir ve böylece küresel CO_2 emisyonlarına ve iklim değişikliğine katkıda bulunmaya devam edebilir [4].

Daha düşük fiyat politikası ortamında, geleneksel olarak değişen piyasa koşullarına en hızlı yanıt veren ABD şeyl gaz sektörü de değişime zorlayacaktır. Endüstrinin yeni tedarik ortamına nasıl uyum sağlayacağı veya değişim geçireceği 2030 yılına kadar daha net bir görünüm kazanacak ve sonrasında küresel üreticiler ve tüketiciler için geniş kapsamlı sonuçlara neden olacaktır.
Suudi Arabistan planlanan ham petrol kapasite artışını 12 mb/g'den 13 mb/g'ye ertelemiş olsa da, devasa Jafurah gaz sahasının geliştirilmesi devam etmektedir ve 2030 yılına kadar OPEC+ kotalarına tabi olmayan hacimlerde, gaz sıvıları üretiminde neredeyse 1 mb/g'lik bir artışa neden olacaktır. ABD, Brezilya, Guyana, Kanada ve Arjantin gibi OPEC+ dışındaki üreticiler kapasite gelişimine öncülük etmeye devam ederken, net artışın %76'sı olan 4,6 mb/g'lik bir paya sahip olacaklardır [2]. Bununla birlikte, Suudi Arabistan, Birleşik Arap Emirlikleri (BAE), Irak, Afrika ve Asya üyelerinde düşüşler beklenmektedir. BAE ve Irak ham petrol kapasitesini artırırken, Suudi Arabistan NGL ve kondensat arzında önemli bir artışa hazırlanmaktadır. Rusya'daki kapasitenin, dev Vostok projesinin hızlanması ve olgun petrol sahalarındaki kayıpları telafi etmeye yardımcı olması nedeniyle uluslararası yaptırımlara rağmen yalnızca marjinal bir düşüş göstermesi tahmin edilmektedir [2].

Arzdaki bu artış, yukarı akış yatırımlarında istikrarlı bir büyümenin sonucudur. Küresel yukarı akış sermaye harcamaları, 2023'te %13 artarak sekiz yıllık zirve olan 538 milyar ABD dolarına ulaşmıştır ve 2024 yılında %7 daha artma trendindedir [1].

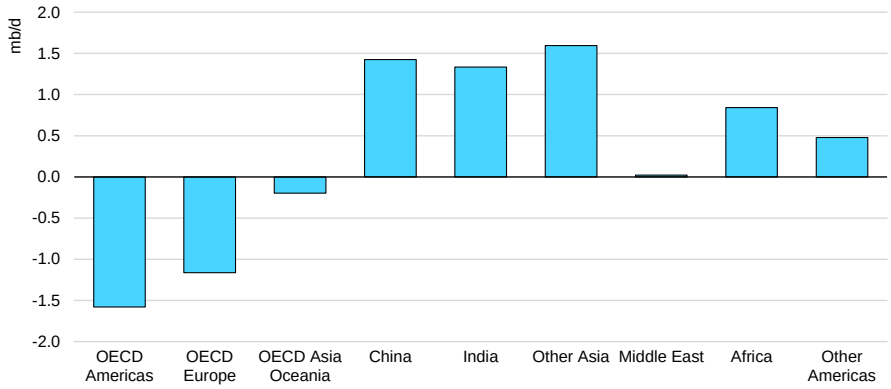
III. KÜRESEL PETROL TALEBİ VE YENİLENEBİLİR ENERJİ

Günümüzün piyasa koşullarına ve politikalarına göre, küresel petrol talebinin, yenilenebilir (temiz) enerji teknolojilerine geçişin hızlanmasıyla birlikte 2030 yılına kadar yaklaşık 106 mb/d'de sabitlenmesi ve yavaşlaması beklenmektedir [2]. Artan EV satışları ve araçların sürekli verimlilik iyileştirmeleri ile enerji sektöründe petrolün yenilenebilir enerji veya gazla değiştirilmesi, karayolu taşımacılığında ve elektrik üretiminde petrol kullanımının azalmasına neden olacaktır. Bununla birlikte, petrokimya sektöründen jet yakıtı ve hammadde kullanımının artması nedeniyle toplam petrol talebinin 2023 ile 2030 arasında 3,2 mb/d artacağı da tahmin edilmektedir (Şekil 2). Bu talep, özellikle Hindistan ve Çin olmak üzere Asya ekonomileri tarafından domine edilecektir. Petrol talebi, sanayi devriminden bu yana az ya da çok durmadan artmıştır ve en az 2030 yılına kadar da artmaya devam edecektir. 2019 yılının son çeyreğinde, küresel petrol talebi, başlıca Çin'de tüketim artışına bağlı olarak günde 1,9 milyon varil artmıştır, Covid 19 nedeniyle ani bir düşüş gerçekleşmiştir (https://www.theworldcounts.com/challenges/climate-change/energy/the-end-of-oil).



Şekil 2. Petrokimya sektörü etkisiyle artan küresel petrol talebi ve 2030 yılına kadar gelişim öngörüsü [2].

Talep tarafındaki iki önemli ülke olan Çin ve Hindistan'da durum muhtemelen aynı şekilde gelişmeyecektir, örneğin Çin'de, temiz enerji teknolojilerinin hızla yaygınlaştırılması ve yüksek hızlı demiryollarına yapılan büyük altyapı yatırımları ulaşım yakıtlarına olan talebi azalttıkça, talep tarafındaki büyüme petrokimya sektörü tarafından yönlendirilecektir. Hindistan'da ise, ulaşım yakıtları küresel yönelime tezat olarak keskin bir şekilde yükselecektir. Çin ve Hindistan dışındaki tüm OECD dışı Asya ekonomilerindeki birleşik kazanımların 1,6 mb/g ile daha da büyük olacağı tahmin edilmektedir. Asya ülkeleri birlikte düşünüldüğünde, gelişmekte olan Asya ekonomileri bu on yılda petrol talebi büyümesinin en önemli kaynağıdır (Şekil 3).



Şekil 3. 2023-2030 yılları arasında bölgelere göre petrol ihtiyacı tahmini [2]

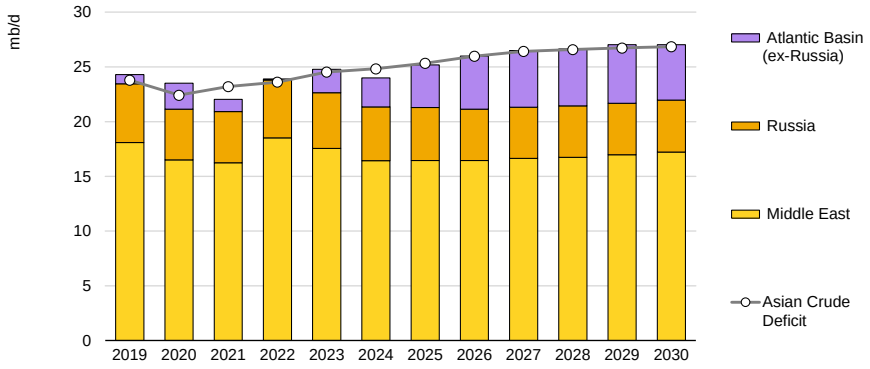
EV satışlarındaki gelişimi devam ederse önemli miktarda yakıt tasarrufu sağlayacaktır. Bu, 2030 yılına kadar günde 6 mb/gün benzin ve dizel talebinin azalması anlamına gelir (Şekil 3). Tüketici mobilite davranışındaki pandemi sırası ve sonrasındaki değişiklikler, uzaktan ve hibrit çalışmanın artık iyice yerleşmiş olması nedeniyle ulaşımda yakıt tasarrufuna günde 1 mb/mb daha katkıda bulunmaktadır [2]. Elektrik üretiminde kullanılan petrolün yerli gaz ve yenilenebilir kaynaklarla değiştirilmesi de gündemdedir ve küresel talebin sabit bir noktaya gelmesinde önemli bir rol oynama potansiyeli bulunur. Özellikle Suudi Arabistan'ın, enerji santrallerinde doğrudan ham petrol, akaryakıt ve gazyağı kullanımında 2030 yılına kadar günde yaklaşık 1 mb/d kesinti yapmayı öngören planları yanısıra Irak'ın elektrik santrallerindeki petrol yakımını daha küçük ölçekte de olsa azaltması bu değişim sürecini ortaya koyar [1].

IV. RAFİNERİLER VE ÜRETİM KAPASİTE DEĞİŞİMLERİ

Tarihsel gelişim sürecinin oldukça altında olmasına rağmen, küresel rafineri kapasitesinin 2023'ten 2030'a kadar 3,3 mb/g artacağı tahmin edilmektedir. Rafinerilerin kapasite artışları ise rafinerine olan talep gerisindedir. Yenilenebilir enerji ve elektrikli araçların artan pazar payları nedeniyle rafinerilerin farklı eğilimleri karşılamak için ürün çıktılarını kademeli olarak değiştirmeleri gerekecektir. Ayrıca, NGL'ler ve biyoyakıtlar gibi rafine edilmemiş yakıtlar, rafine ürün tedariklerine olan talebi ve ek rafineri kapasitesi ihtiyacını daha da zayıflatmaktadır. Rafine edilmemiş yakıt ürünlerinin, 2023-2030 döneminde öngörülen talep büyümesinin %75'inden fazlasını oluşturacağı ve bunun da Çin ve Hindistan'da olacağı tahmin edilmektedir [2]. Küresel polimer ve sentetik elyaf tüketimi istikrarlı bir şekilde artmaktadır ve petrokimya hammaddelerinin genel büyümenin temel taşları olacağı da söylenebilir. Özellikle LPG/etan kullanımındaki güçlü büyüme - 2023 ile 2030 arasında 2,5 mb/g artış - özellikle Amerika Birleşik Devletleri ve büyük Orta Doğu üreticilerinden gelen yeni NGL arzındaki önemli artışları yansıtmaktadır. Çin, petrokimyasallardaki büyümeye hakim olmaya devam ederken, hammadde ürünlerindeki 1,4 mb/g'lik kazanımlar ülkenin 2030'a kadarki genel artışına yakın olacaktır. Öte yandan, temiz enerji teknolojilerinin hızlı gelişimi, güçlü temel mobilite artışını da dengeleyecektir.

V. KÜRESEL PETROL TİCARETİNİN YENİ ROTASI,

Küresel petrol ticareti, Hindistan ve Çin önderliğinde Asya'nın ham petrol ve ürün arzındaki büyüyen yapısı ve Atlantik Havzası'ndaki ham petrol, NGL ve ürünlerin artan miktarı tarafından kontrol edilmeye devam edecektir. OPEC+ dışı ham petrol arzının artması, Rus ham petrol ihracatına yönelik yaptırımlar ve OPEC+ gönüllü kesintileriyle birlikte, 2024-2030 döneminde Atlantik Havzası'ndan Süveyş'in doğusuna daha yüksek hacimler geliştirebileceği öngörülmektedir [2] (Şekil 4).



Şekil 4. Asya kıtasının petrol ithalatı ve net ihracatı arasındaki ilişki grafiği

OPEC+ kesintileri sırasında Orta Doğu'dan gelen orta ekşi ham petrol kaybı, Brezilya, Guyana ve Kanada'dan gelen artan arzlarla kısmen telafi edilmiştir. Asya pazarları, Pasifik Kıyısı'na doğru genişletilen Trans-Mountain boru hattı aracılığıyla Kanada ham petrolüne de açılmıştır. Bununla birlikte, hafif tatlı ABD ham petrolünün zamanla artan bir şekilde Avrupa ve Afrika'ya ve Hindistan ile diğer Asya rafinerilerine doğru hareket etmesi de mümkündür. Petrol ürünleri için en büyük pazar olarak Asya, daha geniş bölgeden, özellikle Orta Doğu'dan daha fazla ürün tedariki için çaba göstermek zorunda kalacaktır. Atlantik Havzası'nın çoğunda yaptırımlara tabi olan Rusya'dan gelen tedarikler doğuya doğru ilerlemeye devam ederken, Afrika ve Latin Amerika da zamanla ithalat oranları artabilecektir. Avrupa'nın dizel ve jet yakıtı tedarikindeki açığı ve Kuzey Amerika'nın jet yakıtı ithalatına olan ihtiyacı, küresel rekabeti en çok orta damıtık pazarlara odaklanmasına neden olacaktır [2]. Talebin doğrudan ikameye daha az uygun olduğu havacılık ve deniz taşımacılığı gibi uzun mesafe taşımacılığı ile büyümeye devam edeceği de açıktır. Ancak burada yakıt verimliliği talep artışlarını giderek yavaşlatmaktadır.

VI. ELEKTRİKLİ ARAÇLAR VE PETROL TÜKETİM ORANLARINA ETKİSİ

Küresel elektrikli otomobil satışları muhteşem bir büyüme sergilemeye devam etmektedir. IEA'nın Küresel Elektrikli Araç Görünümü 2024'e göre, satışlar 2023'teki 14 milyondan 2024'te yaklaşık 17 milyona ve toplam satışların 2030'da 40 milyona ulaşacağı ve neredeyse her iki yeni otomobilden birinin elektrikli olacağı tahmin edilmektedir [2]. 2023'te EV satışlarının çoğunluğu Çin'de (%60) gerçekleşirken; Avrupa (%25) ve Amerika Birleşik Devletleri (%10) de bu pazarı geliştirmeye devam etmektedir. Bu hakimiyetin

devam etmesi ve 2030 yılına kadar Çin'de yollardaki neredeyse üç arabadan birinin elektrikli olması beklenmektedir. Aynı kapsamda, küresel olarak satılan tüm EV'lerin yarısından fazlası Çinli otomobil üreticileri tarafından üretilirken, bu rakam içten yanmalı motorlu (ICE) otomobiller için yalnızca %10'dur. Ancak, Çin'den gelen ucuz EV'lerin hızla pazar payı kazanması ve yüksek maliyetli Batılı otomobil üreticilerinin dışarıda kalması nedeniyle Çin ile Batı arasındaki ticari sürtüşmeler artmaktadır. Bu durum, Çin'in orantısız hükümet yardımlarıyla desteklenen yapısal kapasite fazlasını ihraç ettiği yönündeki suçlamalara yol açmıştır. Biden Yönetiminin Mayıs 2024'te Çin elektrikli araçlarına yönelik tarifeleri dört katına çıkarma kararı bunun bir örneğidir. Avrupa Birliği de Çin elektrikli araçlarına yönelik bir anti-damping soruşturması yürütülmektedir.

Bu olumsuz rüzgarlara rağmen, filoya daha fazla araç girdikçe petrol talebindeki tasarrufların artmasıyla elektrikli araç pazarındaki büyümenin hızlanmaya devam etmesini mümkündür [6]. Bu artış, iddialı sıfır emisyon hedefleri, devam eden sanayi politikası desteği ve istikrarlı bir şekilde düşen fiyatlar ile desteklenecektir. Çin büyümenin temel itici gücü olmayı sürdürürken, satışlar hem coğrafi olarak hem de yakıtlar açısından daha az yoğunlaşırken, dizel göreceli olarak önem kazanacaktır [2], [7], [8].

7. SONUÇLAR

Uluslararası Enerji Ajansı 12 Haziran 2024 de yaptığı açıklamada, dünyanın son on yılda büyük bir petrol kapasitesi fazlalığıyla karşı karşıya olduğunu ve bu durumun daha düşük fiyatları tetikleyebileceğini ve küresel petrol talebi zirveye ulaşırken OPEC'in pazar kontrolünü test edebileceğini belirtmiştir. Biyoyakıtlar da dahil olmak üzere küresel petrol talebinin, elektrikli araçlar, yenilenebilir enerji ve yakıt verimliliğindeki artış nedeniyle 2023'teki günlük 102 milyon varilden 2030 yılına doğru muhtemelen 106 milyon varil/güne yaklaşacağı tahmin edilmektedir [2].

Dünyada fosil yakıtlar yoğun bir şekilde kullanılmaya devam ederken, yenilenebilir enerji kaynakları birincil enerji tüketiminde nispeten küçük bir rol oynamaktadır. Biyokütle, küresel birincil enerji talebi paylarının yaklaşık %10'unu oluşturan en çok kullanılan yenilenebilir enerji kaynağıdır. Birçok hükümet 2050 için net sıfır emisyon hedeflerine bağlı kalsa da, OPEC yenilenebilir enerji kaynaklarının 2045'te toplam yakıt talebinin dörtte birinden daha azını oluşturmasını beklemektedir.

Toplam petrol talebinin, artan jet yakıtı ve petrokimya sektöründen gelen hammadde kullanımının desteğiyle 2023 ile 2030 arasında günde 3,2 milyon varil artacağı öngörülür, IEA, son yıllarda olduğu gibi petrol talebindeki büyümenin Asya'nın en büyük ekonomileri tarafından yönlendirileceğini, Çin'deki büyümenin petrokimya sektörü tarafından destekleneceğini, Hindistan'da ise ulaşım yakıtlarında önemli kazanımlar elde edileceğini belirtmiştir. Buna karşılık, gelişmiş ekonomilerdeki petrol talebinin yapısal

düşüşünü sürdürerek 2023'teki günlük 46 milyon varilden 2030'da 1991'den bu yana en düşük seviye olan 43 milyon varilin altına düşmesi de beklenmektedir.

Bir yıl önce IEA, küresel petrol talebinin 2022-2028 döneminde %6 artışla günde 105,7 milyon varile çıktıktan sonra 2030'da zirveye ulaşacağını öngörmüştü. S&P Global Commodity Insights, biyoyakıtlar da dahil olmak üzere küresel petrol talebinin 2034'te günde yaklaşık 109 milyon varil ile zirveye ulaşacağını, sonraki yıllarda kademeli bir düşüşle 2050'de ise yalnızca günde 100 milyon varilin altına düşeceğini tahmin etmektedir. Ayrı bir gelişmede IEA, 2024 küresel petrol talebi büyüme tahminini art arda üçüncü ayda da düşürerek günlük 100.000 varil/gün olarak açıklamıştır. IEA, 2023 talep tahminlerinin yukarı yönlü revizyonunun da yardımıyla dünya petrol talebinin bu yıl sadece 960.000 varil artarak günde ortalama 103,2 milyon varil olacağını öngörmektedir. COP28 tarafından belirlenen 2030 iklim hedefleri, EnerGreen'in de gösterdiği gibi, küresel sıcaklık artışını 2°C'nin oldukça altında tutmayı amaçlayan Paris Anlaşması hedefi ile uyumludur. Ancak, Ulusal Olarak Belirlenen Önlemler (NDC'ler) 2030 iklim hedeflerine ulaşmak için yeterli değildir. Yenilenebilir enerji kaynakları ve enerji verimliliği, EnerGreen'de küresel iklim hedeflerine katkıda bulunan tek kaldıraçlar değildir ve elektriklendirme ve verimliliğin rolü hafife alınmamalıdır.

Sonuçta, enerji ülkelerin vazgeçemeyeceği bir konudur ve küresel ısınma da dahil olmak üzere bunun gerisinde kalmaya mahkumdur.

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Selecting the Optimal Features of the Mushroom Data using Genetic Algorithms

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Abstract – Data pre-processing has an essential role in increasing the performance of the algorithms. It involves converting raw data into a suitable format for machine learning models and algorithms. This approach aims to enhance the accuracy and reliability of results by improving data quality. This involves addressing issues such as missing data, noisy data, dimensionality reduction, and feature selection. Feature selection strategies try to minimize the dimensionality of the data by identifying and selecting the most representative features while excluding the less representative ones rather than generating new data. In this study, we employ a Genetic Algorithm (GA) to choose the features of the mushroom data. The raw data, which is a classification problem, consists of 22 distinct features. Since the values in one of the features are identical for all samples, we removed this feature and used the other features. The fitness is measured by taking into account an Artificial Neural Network (ANN) performance with the selected features and the number of selected features. The GA chose eight features. The network that utilizes the chosen features exhibits slower learning than the one that utilizes all features. However, the network utilizing selected features attains the same amount of learning with longer training.

Keywords – Optimal Features, Mushroom, Genetic Algorithms

I. INTRODUCTION

Machine learning algorithms are used in many fields for various tasks such as classification [1], regression [2], and clustering [3]. Many factors affect the performance of the algorithms, such as their suitability to the data and the hyperparameters. Data pre-processing is another crucial factor that may affect the performance of the algorithm.

Data pre-processing transforms unprocessed data into a format appropriate for machine learning models and algorithms [4]. This method seeks to produce more accurate and trustworthy outcomes through data quality improvement such as removing the lack of data, removing the noisy data, normalizing the data and reducing the dimensionality of the data.

Reducing the data dimensions removes the noise in the data and speeds up the learning since it decreases the computational cost. Dimensionality reduction techniques such as principal component analysis [5], linear discriminant analysis [6], and autoencoders [7] aim to reduce the dimension of the data by creating new subfeatures. Feature selection techniques also reduce the dimension of the data; however, these techniques aim to determine and select the high-representative features and exclude the low-representative features instead of creating new data.

The literature introduces various feature selection methods [8], [9]. Genetic Algorithm (GA) [10], [11] is one of the good methods among them. GA is a population-based search method inspired by biological evolution principles. It usually performs well thanks to its capability of comprehensively searching the space, thereby finding the global optimum.

In this study, we use GA intending to decrease the number of features of mushroom data with a relatively high amount of features. The data has 20 categorical, 2 binary input features, and 1 binary target. The GA implementation decreased the number of input features to 8 by keeping the high prediction accuracy of all features.

This paper is organized as follows. The data are described in the next section. The material and methods are introduced in section 3. Then, the results and discussion are provided in section 4. Finally, some conclusions are presented in section 5.

II. DATA

The data are taken from the UC Irvine Machine Learning Repository [12]. It has 8124 samples and 22 features, including 20 categorical features and 2 binary features. It has one target with three categories: eatable, poisoned, and unknown. As the unknown is also regarded as poisoned, the data has two classes, including eatable and poisoned, thereby having a binary target.

We removed the 16th feature —weil-type— from the data as all samples have the same value in that feature. Therefore, we conducted our study with 21 features. The data is split into two parts: 70% training and 30% testing samples.

III. MATERIAL AND METHODS

As stated in the introduction, GA is a global search method used to select the optimal input features in this study. It uses mathematical strategies analogized from biological evolution operators such as crossover and mutation. Different encoding types have been introduced so far, e.g., binary encoding, real value encoding, and permutation encoding.

In this study, we used the GA with the permutation encoding since it is the most suitable for feature selection problems. As we have 21 features, the chromosome size is set to 21. The gene in an order represents the feature corresponding to that order. Each gene in the chromosomes can only be zero and one. If a gene is zero, the corresponding feature is not used; otherwise, if the gene is one, the corresponding feature is selected to use.

The population size of the GA is set to 50. The tournament selection is used with the tournament size of 2. A one-point crossover is used with a 90% crossover rate. The mutation rate is set to 10%. We measure the fitness of the chromosomes using the classification performance of an Artificial Neural Network (ANN) [13], [14] at the end of the training epochs and the number of selected features. In order to decrease the chance factor, the networks are run ten times for each fitness measurement, and their mean accuracy represents the accuracy for the corresponding chromosome.

Equation 1 provides the mathematical expression of the fitness, and the GA aims to minimize the fitness. Let the acc_af be the accuracy at the end of the training epochs of the ANN that is measured using all features in the data, and the af be the number of all features in the data. Let the acc_sf be the accuracy at the end of training epochs of the ANN that is measured using the features selected by the GA chromosome, and the sf be the number of selected features for the corresponding chromosome.

$$fitness = \frac{acc_af}{acc_sf} + \frac{sf}{af} \tag{1}$$

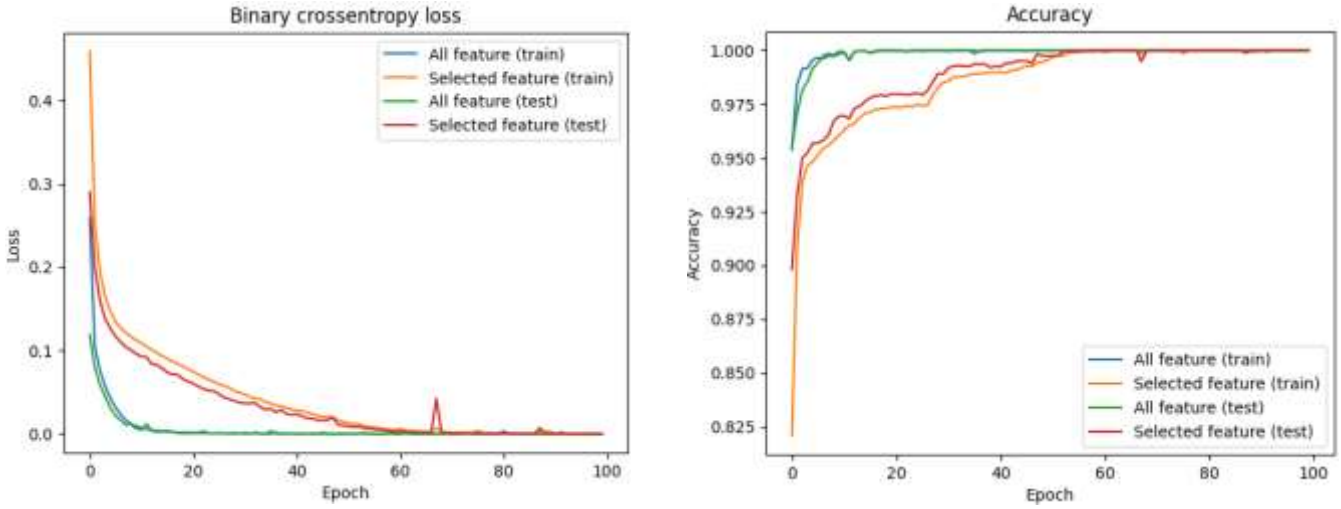
ANN is one of the most widely used machine learning methods. It has a layer-wise structure, including an input layer, one or more hidden layers, and an output layer. The layers have neurons. The number of hidden neurons is the same as the number of features. There is no rule to determine the hidden structure; therefore, it is usually determined by the user. The number of output neurons depends on the data.

In this study, the ANN has a variable input size that varies according to the chromosomes in the GA population, a single hidden layer with 16 neurons, and a single output neuron. The activation functions in the hidden and output layers are the Rectified Linear Unit and logistic sigmoid, respectively. The networks are trained using the Adam optimizer with 100 epochs and a mini batch size of 10. The hyperparameters of the networks were determined by the trial and error method.

IV. RESULTS

The GA system is run several times using the configuration defined in the previous section. As natural, the results differ from each other; however, some of the features selected are common for the runs. The best performance is the one provided by chromosome with a 1.3809 fitness value. Both networks with all features and selected features reach 100% training accuracy. However, the network using the features selected by the best chromosome achieves this learning with 8 features instead of 21. The selected features are odor, stalk-color-above-ring, stalk-color-below-ring, veil-color, ring-number, spore-print-color, population and habitat.

Figure 1 provides performance comparisons of the networks that use all features and selected features. The plots in Figure 1-a show the binary cross entropy loss for the networks, while those in Figure 1-b show their accuracy.



a. Binary crossentropy loss for training and testing data

b. Training and testing accuracy

Fig. 1 Learning performance of the networks that use all features and selected features

As seen in Figure 1, the network that uses all features learns the data faster than that uses selected features. However, in the end, both networks reach the same level of learning. The network that uses all features uses 13 features more than that uses the selected features. The difficulty of extracting these features should also be considered when comparing the networks. If this process is difficult, extracting only the selected features and training the network longer is enough for the network to perform well.

V. CONCLUSION

In this study, we use GA to select the mushroom data features. The original data is a classification problem with 22 features. We consider the data as if it has 21 features because one of the features is the same for all samples; thereby, we remove that feature from the data. Then, an ANN is fed with the selected features by the GA chromosomes. The ANN performance and the number of selected features measure the fitness of the chromosomes. The best chromosomes selected 8 features. The network that uses the selected features learns slower than that uses all features. However, it achieves the same level of learning with a lower number of features.

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Applications of the Knapsack Problem: Part 1-Expensive Cargo Airline Dispatch

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Abstract **–** Knapsack Problem (KP) is among the fundamental problems on the combinatorial optimization and industrial applications. The problem can be defined to select the items to fill the constant capacity with a maximum profit. It is the problem of packing the most profitable items into a knapsack. Many engineering problems can be modelled as KP. The cargo airline dispatch is an example of the application of the KP. As the number of items increases, the complexity of the problem also increases. Therefore, in this research the cargo airline dispatch problem is investigated with many items that are named as expensive cargo airline dispatch problem. The problem is solved with Genetic Algorithm and Binary Space Partition Tree Based Genetic Algorithm. The performance of these algorithms is compared and the impact of the number of items are also discussed in this research.

Keywords – Genetic Algorithm, Knapsack Problem, cargo airline dispatch, optimization, binary variable

I. INTRODUCTION

The Knapsack Problem (KP) is a problem of selecting items from a set N which has members $N = \{1, \dots, n\}$. Each item has two properties profit and weight [4]. As the items are added to the Knapsack its total weight increases until the maximum weight of c. In addition, as the items are added to the Knapsack total profit from the items increases. Therefore, the objective of the KP is to get maximum profit Knapsack. KP is mathematically defined as follows,

$$maximize \sum_{i=1}^{n} p_i x_i$$

$$subject\ to \sum_{i=1}^{n} w_i x_i < c$$

where the decision variable is $x_i \in \{0,1\}$, $i = 1, \dots, n$. The p and w are corresponding to profit and weight respectively; the c is the maximum capacity of the Knapsack. The aim is to get the highest profit from Knapsack. KP has many applications and is often used in models for real-world applications; some examples are cryptography [10], multimedia [11], timber industry [12], and satellite module layout design [13]. Different engineering problems lead to different modeling of KP. With some small modifications proposed on the KP, more and more problems are solved. By this way different variants of KP proposed. In [3] and [8], set-union knapsack problem is discussed as a variant of KP. In this problem, it is desired to achieve maximum profit among items assigned to certain clusters. In other words, it is aimed to obtain the highest profit among the items in each subset while preserving the diversity in Knapsack. In [6], knapsack problem with forfeits (KPF) is investigated and solved. In this problem, the selection of certain pairs is

undesirable, and a penalty is applied on the profit if these pairs are selected. In [7], two-dimensional (circular) knapsack packing problem is investigated. It is aimed to place objects of different sizes in a two-dimensional space. In this case, not only weight but also area is considered. An interesting example of KP is given in [9]. Here TSP and KP are used together and called the traveling thief problem. The problem is solved using multi-objective optimization algorithms.

The KP problem is the fundamental problem definition which can be altered to get variations of the KP to handle the real-world problem. As a real-world problem, the cargo airline dispatch problem is also considered in this research [5]. Unlike KP, the cost and profit of the cargo is directly related to the weight of the cargo. In other words, the cargo weight is directly related to the profit. Hence $p = kw$, where k is the rate of the profit. In this research for simplicity the parameters *k=1*. The mathematical definition of the airline cargo dispatch problem is given as;

$$maximize \sum_{i=1}^{n} w_i x_i$$

$$subject\ to \sum_{i=1}^{n} w_i x_i < c$$

where $p_i = w_i$ $x_i \in \{0,1\}$, $i = 1, \dots, n$. This research will examine both KP and airline cargo dispatch problems. In both problems, as the number of items increases, the complexity and difficulty of the problem increases. This is because the size of the decision space is equal to the number of items. As the number of items increases, the problem becomes more complex and difficult to solve. Therefore, each problem is named as expensive KP and expensive airline cargo dispatch problem (CDP) and is the basis of this research. The aim of the research is to investigate whether the solution can be obtained if the problem is made harder and how long it takes to obtain the solution. For this purpose, the search space size of both problems was increased from 250 to 100,000. In this respect, a different and relatively more difficult problem is analyzed.

This research is organized as four basis sections. After the introduction of the first section, in section 2 optimization algorithms are explained. In section 3 the results of the implementations will be presented and discussed. Finally in the final section the conclusion of this research will be given.

II. Coding: Optimization Algorithms

KP and CDP are considered in this research, and they are solved with binary encoded single objective optimization algorithms by using the Platemo platform [14]. The reader can find the codes for CDP to run on Platemo at 10.13140/RG.2.2.33962.84164.

A. Genetic Algorithm [2]

Genetic Algorithm (GA) is an optimization algorithm that is designed from biological evolution [2]. It is a population-based algorithm which is based on evaluating a set of possible solution candidates and evaluating their performances to decide their new value. The idea is to drag the population to the hopefully global optimum value. These members of the population are called chromosomes, and the assize of these chromosomes are equal to the size of the decision variables, or decision space dimension. The values of the chromosome vectors are binary. Hence for this coding perspective it is a binary optimization algorithm. The binary coding methodology in general for the optimization algorithms are preferred to select from a given set like in KP-based problems. The value 0 means “do not select” and 1 is for “select” the corresponding item. Preferring a different set of 1 and 0s are selecting for each member of the population. Hence the maximum number of members in the population is equal to 2^n, where n is the dimension of the decision space. Initially the randomly generated members are evaluated by using the objective function. In this research the objective function is to get the highest profit from the selecting

items under the constraint that total wight could not exceed the maximum weight which is defined as the half of the total weight of all the items. The maximization problem can easily convert to minimization problem by subtracting from the maximum capacity. Three operators are applied to these chromosomes. These are crossover, mutation and selection operators. The crossover operator is the mixing the chromosomes to form a new set of members or a new population. The chromosomes are divided into two parts and the distributed parts are merged to form a new chromosome. This process is called crossover. The parents are selected randomly (generally roulette method) and offspring is generated. Then mutation operator is applied. The idea of the mutation is to change a single value of a vector from 0 to 1 or 1 to 0. Finally, from these two populations the best members survived to the next generation. These operators are repeated until the termination constraints meets like maximum generation or tolerance value of the objective values.

B. Binary Space Partition Tree Based Genetic Algorithm [1]

Binary Space Partition Tree Based Genetic Algorithm (BSPGA) is proposed by Su et al. in 2019 [1]. The motivation of BSPGA is to improve the convergency speed of the binary GA to record all the generated members and be sure the there are no duplicated solutions exist in this database. The novel method is named as binary space partition (BSP) tree. The algorithm is a variant of GA so that it also evaluates three genetic operators. However, after the mutation operator two additional operators are defined before the selection operator. These two additional operators are BSP Tree Learning and Tree Construction. In learning phase offsprings do not generate any additional fitness evaluation. In the construction operator, all solution candidates insert all the solutions to the BSP tree in sequence and based on the Hamming distance and similarity same members only selected from the tree. Then the filtered offsprings with the main population are applied to the selection operator.

III. SIMULATION AND RESULTS

In this research two problem set are considered which are KP and CDP. The decision space of these algorithms is considered as 250, 500, 1000, 2000, 5000, 10000, 25000, 50000, and 100000. The implementations are repeated 10 times and statistical information for the objective value and runtime is recorded into tables. Two algorithm GA and BSPGA are compared based on these tables. Table 1 gives the objective values of the LP. The results statistically and numerically showed that even the BSPGA gives more complex and relatively improved version of GA remains underrate for these problems. As the number of decision variabes are increase the objective values are also increases as expected. As the problem complexity increases the difference between GA and BSPGA decreases. That means the improvement of the GHA against BSPGA decreases based on the results and statistics at the Table 1.

Table 1. The objective functions of the expensive KP.

Problem	D	BSPGA	GA
KP	250	3.9947e+3 (8.90e+1) -	3.3748e+3 (2.35e+1)
KP500	500	9.0866e+3 (3.23e+2) -	7.3905e+3 (1.14e+2)
KP1k	1000	1.9983e+4 (5.88e+2) -	1.5419e+4 (1.97e+2)
KP2k	2000	4.4537e+4 (7.50e+2) -	3.6172e+4 (3.96e+2)
KP5k	5000	1.2106e+5 (1.78e+3) -	1.0494e+5 (9.16e+2)
KP10k	10000	2.5160e+5 (1.88e+3) -	2.2746e+5 (1.73e+3)
KP25k	25000	6.5157e+5 (3.32e+3) -	6.1044e+5 (1.34e+3)
KP50k	50000	1.3265e+6 (7.32e+3) -	1.2645e+6 (2.48e+3)
KP100k	100000	2.6782e+6 (8.07e+3) -	2.5904e+6 (3.57e+3)
+/-/=		0/9/0	

Table 2 presents the expensive CDP. In this problem, the weight and the profit of the cargo is linearly dependent with each other. The similar performance difference is obtained in this table so that GA is outperforms against BSPGA. As the dimension increases the objective values increases and the difference between these two algorithm decreases. As the dimension increase the complexity of the problems are also increases.

Table 2. The objective functions of the expensive CDP.

Problem	D	BSPGA	GA
cKP	250	4.0708e+3 (3.74e+2) -	3.3973e+3 (4.45e+1)
cKP500	500	9.1378e+3 (2.83e+2) -	7.2910e+3 (5.92e+1)
cKP1k	1000	2.0010e+4 (6.59e+2) -	1.5415e+4 (3.16e+2)
cKP2k	2000	4.5160e+4 (1.13e+3) -	3.6053e+4 (6.75e+2)
cKP5k	5000	1.2127e+5 (1.49e+3) -	1.0473e+5 (1.13e+3)
cKP10k	10000	2.5151e+5 (1.64e+3) -	2.2601e+5 (1.36e+3)
cKP25k	25000	6.5049e+5 (4.60e+3) -	6.0858e+5 (2.46e+3)
cKP50k	50000	1.3254e+6 (3.63e+3) -	1.2641e+6 (2.43e+3)
cKP100k	100000	2.6824e+6 (4.07e+3) -	2.5953e+6 (6.14e+3)
+/-/=		0/9/0	

At this state the question of “What is the cost” for the BSPGA will be investigated as given in Table 3 based on the runtime of these two algorithms. It is expected that since the tree training and construction is added to the GA operators the BSPGA algorithm needs more resources that GA. Table 3 gives the runtimes for the CDP problems. As it is expected GA runs faster that BSPGA. Also, as the dimension increase the difference between two algorithms also increases. Since the tree structure is needed to be learned and constructed. As the dimension increases the necessary for the computational resources is increases.

Table 3. The runtime of the expensive CDP.

Problem	D	BSPGA	GA
cKP	250	2.5991e+0 (5.94e-1) -	1.9901e-1 (4.48e-3)
cKP500	500	2.9847e+0 (3.54e-2) -	2.6218e-1 (7.25e-3)
cKP1k	1000	3.2793e+0 (1.95e-2) -	4.7313e-1 (9.47e-3)
cKP2k	2000	3.8460e+0 (3.02e-2) -	9.4302e-1 (8.43e-3)
cKP5k	5000	7.7457e+0 (6.59e-2) -	2.5723e+0 (1.89e-2)
cKP10k	10000	1.3877e+1 (9.04e-2) -	4.7538e+0 (5.76e-2)
cKP25k	25000	2.4892e+1 (1.16e-1) -	1.1213e+1 (1.66e-1)
cKP50k	50000	4.0525e+1 (1.48e+0) -	2.3066e+1 (1.16e+0)
cKP100k	100000	7.3485e+1 (1.30e+0) -	4.6279e+1 (1.74e+0)
+/-/=		0/9/0	

IV. CONCLUSION

Knapsack Problem (KP) and its variant Cargo Dispatch Problem (CDP) are the problems of this research. Unlike other research the expensive KP and CDP are considered with up to 100.000 decision space dimension. That makes the problems expensive. Two optimization algorithms GA and BSPGA are applied to these problems. The solution indicates that GA gives superior performance against BSPGA under objective space statistical results and runtime. Even the BSPGA designed to be improved version of the GA; however, for these problem GA gives better performance. In addition, as the dimension of the decision space increases, the difference between GA and BSPGA decreases however, the runtime of

BSPGA against GA increased dramatically. The results suggested that GA still one of the fundamental algorithms for binary problems and other algorithms should be compared with GA.

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Effective Filtration Properties of CBRN Nanofiber Filters Designed by Electro-spinning Technique

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Abstract **–** Chemical warfare agents include chemicals with high poisoning potential, such as nerve agents, choking agents, blister agents, and blood-poisoning gases. Chemical warfare agents can be taken into the body through respiration, digestion, or skin. Respiratory protection is required to prevent inhalation of these hazards, which can be achieved through superior filtration technologies. Nanofibrous filters are designed as ultra-low particulate air filters and capture small particulate matter with a filtration efficiency of 98.99%. For this purpose, cellulose acetate (CA) and cellulose acetate + polyvinylpyrrolidone (CA + PVP) CBRN filters were developed by electro-spinning method. The air permeability and filtration efficiency of CBRN filters were investigated using a permeability tester (ProWhite AirTest II) and an automatic filter tester (8130A, TSI Inc.). The air permeability rate of CA nanofiber filters coated on melt-blown fabric was 29 m^3h^{-1}, and CA + PVP nanofiber filters were 25 m^3h^{-1}. While the filtration efficiency of CA nanofiber filters was 89.69%, the filtration efficiency of CA + PVP nanofibers increased to 93.19%. Considering that the filtration efficiency of a high-efficiency filter should be between 90%-100%, the melt-blown fabric + CA + PVP nanofiber filter can be considered in a standard filter category because it has a high filtration efficiency.

Keywords – CBRN, Chemical warfare agents, Nanofiber filters, Filtration efficiency, Air permeability.

I. INTRODUCTION

Chemical, biological, radiological, and nuclear (CBRN) hazards refer to events that can result in death in living things. CBRN hazards include chemical warfare agents with high poisoning potential, such as nerve agents, choking agents, blister agents, and blood-poisoning gases. Although chemical warfare agents are taken into the body through respiration, digestion, or skin, one of the highest exposures occurs through respiration [1]. Therefore, in such cases, civilians, military personnel, and healthcare workers need superior filtration technologies. The filtration process is used in many different areas and one of the most important of these areas is air filtration. For the filtration process to be successful, one of the most important factors affecting the structural properties of the filters is the properties of the fiber used. Fibers are the basic element of the filter, and as the diameter of the fibers decreases, the amount of fiber increases and the pore size decreases, so the particles are captured more successfully [2]. Nanofibrous materials are developed by the electro-spinning method [3]. The greatest advantages of nanofibrous materials produced by this method compared to other materials are that they can provide a high filtration efficiency thanks to their large surface area, tiny diameter fibers, and tiny pores [4]. For this purpose, cellulose acetate (CA) and cellulose acetate + polyvinylpyrrolidone (CA + PVP) CBRN filters have been developed by electro-spinning.

II. Materials and Method

A. Production of CBRN Filter

Nanofibrous filters were separately developed by electrospinning method [5]. The main factor in the collection of polymer on the collector in the form of fibers is the process conditions. Process conditions were controlled by the concentration of the polymer solution (5%-15%), the distance between the syringe and the collector (7-20 cm), and the applied voltage (5-25 kV) [6]. Cellulose acetate (50 kDa) was used for the production of the Cellulose Acetate nanofiber filter. The polymer solution was prepared by adding 10%, 15%, 17% and 20% cellulose acetate into the 2:1 Acetone / DMac solution [7]. The polymer mixture was taken into a 5 mL syringe and placed on the syringe pump in the electrospinning apparatus. The distance between the syringe tip and the collector was adjusted and the high voltage power supply was turned on. The experiment was continued for a certain period to ensure sufficient fiber formation. At the end of the experiment, the cellulose acetate nanofiber filter was taken from the collector and dried at room temperature to remove the solvent. To increase the filtration efficiency in the production of Cellulose Acetate + PVP nanofiber filter, the cellulose air filter is combined with PVP. The polymer solution was prepared by adding 5%, 7% and 10% PVP (40 kDa) to the optimum cellulose acetate concentration. The polymer mixture was taken into a syringe. The distance between the syringe tip and the collector was adjusted and the high voltage power supply was turned on. The experiment was continued for a certain period to ensure sufficient fiber formation.

B. Air Permeability

The determination of the air permeability properties of the developed CBRN filters was carried out in accordance with TS 391 EN ISO 9237 standards. In this context, the air permeability of CBRN filters was tested according to ASTM D737 with the ProWhite AirTest II permeability tester [8]. The test area was set at 38 cm^2, the test pressure drop was 125 Pa, and the ambient temperature was set at 22 ± 2°C.

C. Particulate Filtration Efficiency

The particle filtration capacity of CBRN filters was determined using an automatic filter tester (8130A, TSI Inc.) [9]. Solid sodium chloride (NaCl) particles are produced from a solution of NaCl with a mass concentration of 2%. Filter samples with an effective area of 100 cm^2 were tested against aerosols in the range of 0.26 ± 0.07 μm at a surface velocity of 15.83 cms^{-1}. The pressure drop and filtration efficiency of the filter samples, which are the two main parameters that determine the quality of the air filter, were measured.

III. Results

To produce cellulose acetate (CA) nanofiber filter, the polymer solution was prepared at 10%, 15%, 17% and 20%. The optimum concentration for a successful electrospinning process was determined to be 15%. Electrospinning parameters for 15% CA nanofiber; The distance between the syringe tip and the collector was found to be 10 cm, the applied voltage was 22 kV, the flow rate was 1 ml/h, and the rotation speed of the collector was 300 rpm. To produce the nanofiber filter, different polymer solutions were prepared by separately adding 5%, 7% and 10% PVP onto cellulose acetate (15%). The optimum concentration for the CA + PVP nanofiber filter was determined as 15% CA and 10% PVP. Electrospinning parameters for 15% CA + 10% PVP nanofiber are; The distance between the syringe tip and the collector was found to be 10 cm, the applied voltage was 20 kV, the flow rate was 2 ml/h and the rotation speed of the collector was 300 rpm. While the air permeability rate of CA nanofiber filters coated on melt-blown fabric was 29 m^3h^{-1}, the air permeability rate decreased to 25 m^3h^{-1} when melt-blown fabric was coated with CA + PVP nanofibers (**Figure 1**). While the particle filtration efficiency of CA nanofiber filters coated on melt-blown fabric was found to be 89.69%, the particle filtration efficiency increased to 93.19% when melt-blown fabric was coated with CA + PVP nanofibers (**Figure 2**). Considering that the filtration efficiency of a high-efficiency filter should be between 90%-100%, the melt-blown fabric + CA + PVP nanofiber filter can be considered in a standard filter category because it has a high filtration efficiency.

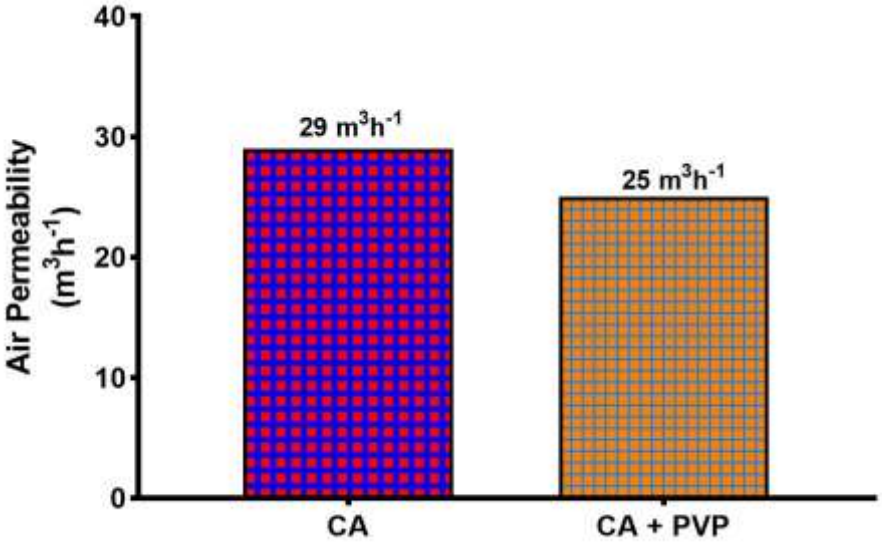

Figure 1 Air permeability rate of CA and CA + PVP nanofiber filters

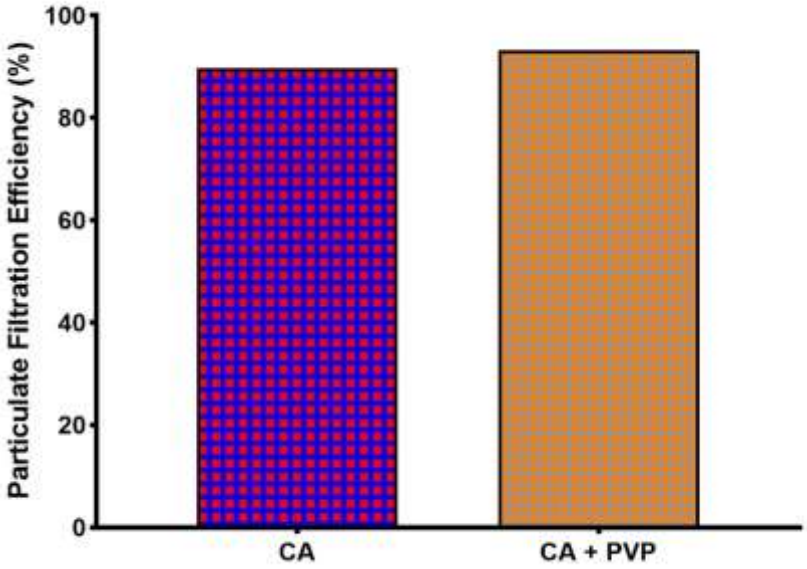

Figure 2 Particulate Filtration Efficiency of CA and CA + PVP nanofiber filters

IV. DISCUSSION

Filtration is generally the process of cleaning the air by keeping particles, microorganisms, and viruses in the environment using a porous structure. Environmental pollution and its effects on living things, which have been made worldwide in recent years, are a very important issue for filtration research. With the COVID-19 pandemic encountered in the recent past, the importance of air filtration has increased. High-performance air filters are important for healthcare professionals, patient relatives, and all living things at risk of disease. Nanofibrous materials developed for this purpose are promising for air filtration due to their specific surface area and porous structure [10]. In nanofibrous filters, ultra-low particulate air filters show a filtration efficiency of 98.99%, while high-efficiency particulate air filters capture small particulate matter with a filtration efficiency of 98.98% [11]. In this study, biodegradable nanofiber filters were manufactured using different raw materials, and cellulose nanofibers and PVP were combined. By choosing biodegradable polymers for filtration, it is aimed to reduce plastic waste and increase sustainability. It has been determined that the filters, which will be produced quite frequently and with a large amount of fiber, can hold some viruses and bacteria as well as chemical materials thanks to their

small size. The resulting nanofibrous CBRN air filters will be very valuable for next-generation force protection, as they can be used for both ambient filtration and masks.

V. CONCLUSION

To improve the filtration capabilities of CBRN filters, materials that will provide respiratory comfort and thermal comfort with antibacterial/antiviral properties should be selected. In this regard, new, cost-effective, effective, and convenient ways are being sought. With the production of nano-sized filters, filtration efficiency can be improved as a result of multiplying the layers of these filters and integrating them. In this study, cellulose nanofibers were used for biodegradable green nanofiber filter application. Cellulose acetate nanofibers are combined with polyvinylpyrrolidone (PVP). PVP has a high potential to be used for nanofiber filters due to its low cost and low toxicity. After this preliminary study, when the filtering feature of CBRN filters against toxic chemical gases or biological agents is investigated, it is expected to show a selective filtration feature. If the filtration is successful, national filters with commercialization potential can be developed in the field of CBRN.

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Adli Ebelik

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Özet – Ebeler çeşitli alanlarda çalışmakta olup, doğumhane, , aile sağlığı merkezleri, kadın hastalıkları ve doğum servisleri, acil servisler, yenidoğan/yenidoğan yoğun bakım servisleri, çocuk servisleri, sağlık evleri, aile planlaması merkezleri ve toplum sağlığı merkezleri, gibi yerler bu alanlar arasında sayılabilir. Bu nedenle ebelik adli olaylarla çok sık karşılaşan meslek grubu olarak söylenebilir. Ebeler adli olaylarda bireyle ilk karşılaşan, eşyalarına veya kendisine ilk temas eden sağlık çalışanlarıdır. İlk adli delillere ulaşabilen sağlık çalışanlarından biri olan ebeler sadece durum bildirimi yükümlülüğü ile sınırlı kalmamalıdır. Ebelerin kadın, gebe ve çocukların içinde bulunduğu adli vakalarda; öykü alma, genel fizik muayene yapma, kanıtın tanımlanması, toplanması, saklanması ve korunması, kanıtın kaydedilmesi ve olayları anlık yönetebilme gibi oldukça hassas görevleri bulunmaktadır. Obstetrik aciller, kadına ve gebeye karşı şiddet, çocuk ihmal ve istismarı, tecavüz gebeliği, adölesan gebelik, rızasız genital muayene, gebelikte madde bağımlılığı, bebek karıştırma veya kaçırma örnek adli vakalardır. Ebeler bu adli vakalarla karşılaştıklarında çok dikkatli olmalı ve mutlaka bildirim yapmalıdırlar. Aksi durumda özensizlik veya mesleğin yükümlülüklerini yapmamaktan ortaya çıkabilecek olumsuz durumalar nedeni ile hukuki süreç ve cezai işleme tabi tutulabilmektedirler.

Anahtar Kelimeler – adli bilimler, adli ebelik, adli tıp, adli vaka, ebelik

I. GİRİŞ

Ebelik Dünya Sağlık Örgütü (DSÖ) tarafından, “Gebelik sırasında, doğumda ve doğumdan sonra gerekli bakım ve danışmanlığı sağlamak, normal sorumluluğunda doğumları yaptırmak, kendi yenidoğanın bakımını, aile planlaması danışmanlığını yapmak üzere eğitilmiş kişi” olarak tanımlanmaktadır [1]. Sağlık Bakanlığı’nın tanımında ise “ebe; ana-çocuk sağlığı hizmetlerini yürüten, doğum öncesi, doğum ve doğum sonrası hizmetleri veren, doğum yaptıran, 0-6 yaş grubu çocuk beslenme ve aşıları yapan, aile planlaması, kişisel temizlik kuralları, ilk yardım, bulaşıcı ve sosyal hastalıklardan korunma ve savaşla ilgili konularda bireye, aileye, topluma sağlık eğitimi veren, doğum ve ölüm istatistik verilerini toplayan, değerlendiren, kamu kuruluşları ile gerekli işbirliğini sağlayan insani ve ahlaki davranışları ile örnek, sağlık bakanlığınca tescil edilmiş bir okuldan mezun olan meslek mensubudur.” [2].

Ebeler çeşitli alanlarda çalışmakta olup, doğumhane, , aile sağlığı merkezleri, kadın hastalıkları ve doğum servisleri, acil servisler, yenidoğan/yenidoğan yoğun bakım servisleri, çocuk servisleri, sağlık evleri, aile planlaması merkezleri ve toplum sağlığı merkezleri, gibi yerler bu alanlar arasında sayılabilir. Bu nedenle ebelik adli olaylarla çok sık karşılaşan meslek grubu olarak söylenebilir. Ebeler adli olaylarda bireyle ilk karşılaşan, eşyalarına veya kendisine ilk temas eden sağlık çalışanlarıdır [3]. Adli vakaların çoğunluğunda kişiyi ilk gören ona ilk dokunan, ailesiyle ilk temasa geçen, muayene sırasında kişinin özel eşyalarını gören ve kişiden alınacak olan laboratuvar örnekleriyle herkesten önce temas eden meslek grubudur. İlk adli delillere ulaşabilen sağlık çalışanlarından biri olan ebeler sadece durum bildirimi yükümlülüğü ile sınırlı kalmamalıdır. Bu nedenle kadın ve çocuk savunuculuğu rolüde olan ebelerin adli vakaları tanıması, bildirmesi, tedavi yapabilmesi ve bakım sağlaması oldukça önemlidir [4]. Adli

olaylarda sorumluluk açısından doktor, ebe ve hemşirelerin cezai sorumlulukları birbirinden ayrılmamıştır. Doktorların mesleki yükümlülüklerini ve sınırlarını çizen her yönetmelik, diğer sağlık çalışanları için de belirleyici kapsamdadır. Bu yüzden ebelerinde TCK (2004)'ya göre bildirim yapması zorunludur [5].

A. Adli Ebelik Kavramı

Adli bilimler multidisipliner bir biçimde ilerleme sağlar. Adalet ve cezai işlemler için öncelikli yol gösterici bir disiplindir. Bu disiplin hukuksal çıkmazlarda bilimsel olarak çözüm üretmeyi hedeflemektedir. Adli vakanın tanımı "başka bir birey ya da kurumun tedbirsiz, dikkatsiz ihmalkar veya kasıtlı eylemi sonucu bireyin hastalanması ya da ölümüdür." Adli vakalarda sağlık çalışanlarının kanıtların değerlendirilmesindeki yeri oldukça önemlidir. Kanıtlara uygulanan (tanımlama, saklama vb.) prosedür ve tekniklere hakim olan sağlık çalışanlarının tedavi ve bakım esnasında adli incelemenin hızlanmasına ve vakaların daha kolay bir şekilde sonuçlanmasına yardımcı olacaklardır [6]. Sağlık hizmeti veren tüm kurum ve kuruluşlarda sağlık çalışanlarının tamamı adli vakalarla karşılaşmaktadırlar [7].

ICM Adli Ebelik'te dört tema belirlemiştir bu temalar aşağıdaki tabloda belirtilmiştir [8].

Tablo 1. Uygulama Alanlarına Yönelik Adli Ebelik Temaları

Uygulama Alanlarına Yönelik Adli Ebelik Temaları
❖ Gebelik sorunlarıyla ilgili uygulamalar
❖ Kadınlara ve çocuklara yönelik şiddet
❖ Ebelikte malpraktis
❖ Adli ebelikte profesyonelliğin geliştirilmesi

Adli ebelik; ebelik, tıp, hukuk ve kriminolojinin ebelik alanında eşit olarak harmanlanmasıdır. Öncelikli olarak sağlık hizmeti veren yerlerde çalışan ebeler; kadına, gebeye veya çocuğa yönelik şiddet, tecavüzü saptayarak ve madde kullanımının önlenmesi ile psikolojik ve fizyolojik çözümler sunarak gerekli bakım ve danışmanlığı yapmaktadırlar. Ebelerin; birinci basamakta aile sağlığı merkezleri, aile planlaması ve toplum sağlığı merkezleri, ana-çocuk sağlığı merkezleri; ikinci basamakta devlet hastaneleri, şehir hastaneleri, doğumevleri, doğumhaneler ve kadın sağlığı servislerinde; üçüncü basamakta tıp fakültesi hastaneleri, eğitim ve araştırma hastaneleri, yoğun bakımlar, acil servislerde çalışma alanı bulmaktalar. Ebeler kadın, gebe ve çocuklara yönelik şiddet, ihmal ve istismar şüphesi, cinsel saldırıya uğrayan kişilerle birebir karşılaşılan yerlerde istihdam edilmektedirler [9]. Yasal sorumlulukları göz önüne alındığında adli olaylarla karşılaşmaları oldukça sık olmaktadır.

Adli vakaların çoğunluğunda kişiyi ilk gören ona ilk dokunan, ailesiyle ilk temasa geçen, muayene sırasında kişinin özel eşyalarını gören ve kişiden alınacak olan laboratuvar örnekleriyle herkesten önce temas eden meslek grubudur. İlk adli delillere ulaşabilen sağlık çalışanlarından biri olan ebeler sadece durum bildirimi yükümlülüğü ile sınırlı kalmamalıdır. Bu nedenle kadın ve çocuk savunuculuğu rolüde olan ebelerin adli vakaları tanıması, bildirmesi, tedavi yapabilmesi ve bakım sağlaması oldukça önemlidir [4]. Ebeler; doğum, hastalık ve ölümleri raporlamak ve bu raporları gerekli üst mercilere bildirmek zorundadır [2]. Bu hizmetler kapsamında ebelerin vaka bildirimi, kanıtların toplanması, korunması ve

bakım verme gibi görevleri vardır [7]. Ebelerin kadın ve çocuk mağdurların olduğu adli olaylarda; öykü alma, fiziksel muayene, kanıtın tanımlanması, kanıtın toplanması, kanıtın saklanması, kanıtın koruma zincirinin sağlanması, kanıtın kayıt edilmesi ve krize müdahalede oldukça hassas rolleri bulunmaktadır [9]. Obstetrik aciller, kadına ve gebeye karşı şiddet, çocuk ihmal ve istismarı, tecavüz gebeliği, adölesan gebelik, rızasız genital muayene, gebelikte madde bağımlılığı, bebek karıştırma veya kaçırma örnek adli vakalardır. Ebeler bu adli vakalarla karşılaştıklarında çok dikkatli olmalı ve mutlaka bildirim yapmalıdırlar [10].

B. Adli Ebelerin Çalışma Alanları

Adli Ebelik eğitimi almış ebeler, hastanelerde ve aile sağlığı merkezlerinde rastladıkları herhangi bir adli olay karşısında eğitimli bilirkişi olarak adli vaka yöneticisi olabilmektedirler. Ayrıca Adli Ebeler; devlet hastaneleri, tıp fakültesi hastanesi, özel hastaneler, aile sağlığı merkezleri, toplum sağlığı merkezleri ve dispanserler gibi sağlık kurumları, adli tıp kurumları, hastanelerin adli tıp polikliniki leri, çocuk izlem merkezleri, cinsel saldırı mağdur izlem merkezleri gibi birçok kurum ve kuruluşta çalışabilecek uzman sağlık profesyonelleridir [11]. Mahkemede tanıklık, klinik adli ebeliği, cinsel saldırı muayene ebeliği, pediatride adli ebelik, geriatride adli ebelik, obstetri ve jinekolojide adli ebelik, cezaevlerinde adli ebelik, bilirkişilik, kişiler arası şiddette adli ebelik, adli psikiyatri ebeliği, adli araştırma ebesi, ebelik hukuku danışmanı, olay yeri inceleme gibi birçok çalışma alanına sahiptir [10]. Ebelerin sıklıkla karşılaştıkları adli olgular; dışarıdan bir etki sonucu oluşan, kişilerin psikolojik ve fizyolojik sağlığının bozulmasına ya da ölümüne neden olan her olay adli olgu olarak değerlendirilebilmektedir. Ebeler genellikle kadına, gebeye, çocuğa yaşlıya ve engelliye yönelik herhangi bir şiddet, ihmal veya istismar, mesleğe yönelik ise; malpraktis gibi adli vakalar ile karşı karşıya kalmaktadırlar. Bu vakalar klinik adli tıp alanında değerlendirilir ve bunlar klinikte en çok görülen adli vakalardır [12].

Tüm meslekler gibi ebelikte de mesleki yükümlülükler ve cezai yükümlülükler vardır. Ebelerin adli konulardaki yasal yükümlülükleri kanunlar ile belirtilmektedir. Ebeler, mesleğine ilişkin kanun ve mevzuatları temel alarak, adli olgulardaki hukuki sorumluluklarını 5237 Sayılı Türk Ceza Kanunu (TCK) (Madde 99,135,136,137,190, 204, 205, 209, 210, 279, 280, 281) ve 5271 Sayılı Ceza Muhakemesi Kanunu (CMK) (Madde 75, 76, 80)'nun ilgili maddeleri çerçevesinde yerine getirmek zorundadırlar. Aksi durumda özensizlik veya mesleğin yükümlülüklerini yapmamaktan ortaya çıkabilecek olumsuz durumalar nedeni ile hukuki süreç ve cezai işleme tabi tutulabilmektedirler. Bu nedenle mesleki hak, yükümlülük ve görevlerin iyi bilinmesi sağlık hizmetlerinin sunulması sürecinde ebeleri önemli düzeyde koruyacaktır [11,12].

II. SONUÇ VE ÖNERİLER

- Adli ebelik hakkında yasal mevzuatın düzenlenmesi ve adli ebeliğin görev tanımının, rollerinin ve yükümlülüklerinin ortaya koyulması,
- Adli ebeliğin görev tanımının en kısa sürede ve açıkça ortaya koyulması,
- Hizmet içi eğitimlerle adli ebelik ve adli vakalara nasıl yaklaşılacağıyla ilgili bilgilere yer verilmesi ve sürekli olarak bu eğitimlerin devam ettirilmesi,
- Sağlık hizmeti sunan kurumlarda en az bir adet adli ebelik alanında uzman bir ebenin istihdam edilmesi,
- Obstetri ve jinekoloji bilim dalı, adli vakalarla karşılaşılma ihtimalinin en yüksek olduğu sağlık alanlarından biri olduğu için ebelerin bu konuda yeterli bilgi, eğitim ve donanıma sahip olmaları gerekmektedir. Bu nedenle lisans ve lisansüstü müfredatlarına tıbbi hukuk ve adli tıp, adli ebelik vb. derslerin eklenmesi ve yaygınlaştırılması önerilmektedir.

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Düşük Oranlarda Yumurta Kabuğu Tozunun Epoksi Kompozitlerin Mekanik Özelliklerine Etkisi

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Özet **–** Bu çalışmada, yumurta kabuğu tozunun epoksi reçine matrisli kompozit malzemeler üzerindeki etkisi detaylı bir şekilde incelenmiştir. Yumurta kabuğu tozu, %1, %3 ve %5 oranlarında epoksi reçineye eklenmiş ve ASTM standartlarına göre eğilme ve çekme testlerine tabi tutulmuştur. Eğilme testleri sonuçlarına göre, %1 yumurta kabuğu tozu ilavesi eğilme dayanımını %0.89 artırırken, %3 ilavesinde bu artış %2.27'ye, %5 ilavesinde ise %4.25'e kadar yükselmiştir. Çekme testleri ise belirli konsantrasyonlardan sonra çekme mukavemetinde azalmalar göstermiştir; %1 yumurta kabuğu tozu ile %0.39 artış kaydedilirken, %3 ve %5 ilavelerinde sırasıyla %-0.88 ve %-2.1 azalmalar gözlenmiştir. Bu sonuçlar, yumurta kabuğu tozunun kompozit malzemelerdeki potansiyelini göstermektedir ancak konsantrasyonun dikkatlice seçilmesi gerektiğini ortaya koymaktadır. Ayrıca, malzeme üretim sürecinde oluşabilecek boşluklu yapıların mekanik özellikler üzerindeki etkisi de dikkate alınmalıdır. Bu çalışma, sürdürülebilir biyo-katkı maddelerinin kompozit malzemelerde kullanımının mekanik performans üzerindeki etkilerini anlamak için önemli bir adım sağlamaktadır. Ancak, konsantrasyon ve üretim süreci gibi faktörlerin optimize edilmesi gerektiği ve çalışmanın bazı kısıtlamaları olduğu unutulmamalıdır. Bu çalışma için boşluklu yapıların etkisi doğrudan değerlendirilmediği için mekanik test sonuçları hasar analizleri ile beraber yorumlanamamıştır.

Anahtar Kelimeler – Yumurta Kabuğu Tozu, Epoksi, Çekme Testi, Eğilme Testi, Biyo Kompozit

I. GİRİŞ

Atık malzemelerin geri dönüştürülmesi ve bunların kompozitlere biyo katkı maddeleri olarak dahil edilmesi, sürdürülebilir malzeme biliminin ilerlemesi açısından oldukça önemlidir [1]. Tarımsal atıklar, endüstriyel yan ürünler ve tüketim sonrası atıklar gibi malzemelerin kullanılması çevresel etkiyi azaltır ve geleneksel, yenilenemeyen kaynaklara sürdürülebilir bir alternatif sağlar [2]. Kompozit malzemelerde, bu geri dönüştürülmüş biyo katkı maddeleri genel maliyeti düşürürken dayanıklılık, mukavemet ve termal stabilite gibi özellikleri geliştirebilir. Örneğin, atık tekstillerden veya plastiklerden geri dönüştürülmüş elyafların kompozitlere dahil edilmesi, polimer kompozitlerin mekanik özelliklerini geliştirebilir [3, 4]. Pirinç kabuğu, hindistancevizi kabuğu ve jüt gibi tarımsal kalıntılar, kompozitin yapısal bütünlüğünü artıran ve yoğunluğunu azaltan, malzemeyi daha hafif ve daha verimli hale getiren dolgu maddeleri olarak kullanılabilir [5]. Bu biyo katkı maddelerinin kullanımı aynı zamanda atıkların çöplüklerden uzaklaştırılması ve işlenmemiş ham maddelere olan talebin azaltılması yoluyla döngüsel ekonomiye de katkıda bulunmaktadır. Ayrıca, bu tür uygulamalar, küresel sürdürülebilirlik hedeflerine uygun olarak, geleneksel malzemelerin üretimi ve imhasıyla ilişkili sera gazı emisyonlarını azaltabilir [6]. Bu nedenle, atık malzemelerin kompozitlerde kullanılarak geri dönüştürülmesi, yalnızca atık yönetimi zorluklarını gidermekle kalmaz, aynı zamanda gelişmiş performansa ve çevresel faydalara sahip gelişmiş malzemeler de ortaya çıkarır [7].

Gıda endüstrisinin yaygın bir yan ürünü olan yumurta kabukları (YK), benzersiz özelliklerinden dolayı kompozit malzemeler için sürdürülebilir bir biyo katkı maddesi olarak dikkat çekmektedir [8]. Esas olarak kalsiyum karbonattan ($CaCO_3$) oluşan yumurta kabukları, yüksek sertliğe ve dayanıklılığa sahiptir, bu da onları polimer matrisleri güçlendirmek için ideal kılar [9]. Teknik olarak yumurta kabuğu parçacıkları, polimer matris ile takviye fazı arasındaki arayüzey bağlanmasını geliştirebilen bir dolgu malzemesi görevi görür [10]. İnce öğütülmüş yumurta kabuğu parçacıklarının yüksek yüzey alanı/hacim oranı, kompozit içinde daha iyi gerilim aktarımı ve dağılımına olanak tanıyarak malzeme performansının artmasını sağlar. Ek olarak yumurta kabukları, kompozitin termal bozulmaya karşı direncini artırabilen ve değişen sıcaklık koşulları altında boyutsal stabilitesini geliştirebilen mükemmel termal stabiliteye sahiptir [11]. Yumurta kabuklarının kompozitlerde kullanılması, bunların ince parçacıklar halinde öğütülmesini içerir; bu parçacıklar daha sonra çekme mukavemeti, darbe direnci ve sertlik gibi mekanik özellikleri geliştirmek için bir polimer matris içinde eşit şekilde dağıtılabilir.

Deniz ve Güneş [12] çalışmalarında yumurta kabuğu tozu ile takviye edilmiş epoksi kompozitlerin mekanik özelliklerini incelenmişlerdir. Saf epoksi ve %5, %10, %20, %30, %40 gibi yüksek oranlarda yumurta kabuğu tozu içeren kompozit numuneler hazırlamış ve çekme ve üç nokta eğilme testlerine tabi tutmuşlardır. %5 yumurta kabuğu tozu ile en iyi çekme mukavemeti elde edilmiş, bu oran arttıkça mukavemet azalmıştır. Eğilme testlerinde ise en yüksek mukavemet %20 oranında yumurta kabuğu tozu ile elde edilmiş ve bu oranın üstünde mukavemet düşmüştür. Sonuçlar, takviye oranının kompozitlerin çekme ve eğilme mukavemetini önemli ölçüde etkilediğini göstermektedir. Sarmin ve ark. [13] ağırlıkça %40 hurma lifi ve ağırlıkça %5, 10, 15 ve 20 yumurta kabuğu kullanarak biyo-kompozitler üretmişlerdir. Ağırlıkça %15 yumurta kabuğu katkılı olan kompozitin optimum çekme ve eğilme özelliklerine sahip olduğunu, ağırlıkça %5'in ise darbe mukavemetini iyileştirdiğini gözlemlemişlerdir. SEM analizi, yumurta kabuğu dolgu maddelerinin biyo-epoksi yapısını değiştirdiğini ortaya çıkarmıştır. Ayrıca yapısal uygulamalara uygun, polimer kompozitlerin güçlendirilmesi için etkili yeşil malzemeler olduğu sonucuna varmışlardır. Hiremath ve ark. [14] yumurta kabuğu tozunun cam elyaf takviyeli reçine matrisli kompozitlerde dolgu maddesi olarak kullanımını inceleyerek çevresel ve ekonomik kaygıları ele almışlardır. Ağırlıkça %5 ve ağırlıkça %10 yumurta kabuğu tozu ile ağırlıkça %50 fiber kullanarak elle yatırma işlemiyle kompozit üretmişler ve bunları ASTM standartlarına göre test etmişlerdir. %5 katkı oranının rijitliği arttırdığı fakat %10'da düştüğünü tespit etmişlerdir.

Yapılan literatür çalışmalarında genellikle yumurta kabuğu tozu yüksek oranda kullanılmıştır. Düşük miktarların etkisi de ayrıca incelenmesi gereken önemli bir konudur. Bu çalışmada %1, %3, %5 oranında düşük miktarlarda yumurta kabuğu tozu epoksi reçinesine ilave edilmiş ve çekme ve eğilme deneyleri gerçekleştirilmiştir.

II. MATERYAL VE YÖNTEM

Yumurta kabuğu tozunu hazırlamak için yumurta kabukları (YK) 80 °C sıcaklıktaki fırında 24 saat boyunca kurutuldu. Kurutulduktan sonra laboratuvar öğütme makinesi kullanılarak ince toz haline getirildi. Ortaya çıkan toz, tekdüze parçacık boyutları elde etmek için sırasıyla 150 um ve 75 um'lik eleklerden elendi.

Daha sonra tozlar belirtilen boyutlardaki ahşap kalıp içerisine 330 gram MGS L 285 epoksi reçine ve 110 gram H287 sertleştirici ilave edilerek kompozit bir karışım hazırlandı. Yumurta kabuğu tozları reçine karışımına %1, %3 ve %5'lik kütle oranlarında dahil edildi. Yumurta kabuğu tozları başlangıçta manuel olarak epoksi reçine ile 5 dakika karıştırıldı, ardından homojenliği sağlamak için 250 rpm'de 30 dakika manyetik olarak karıştırıldı. Karışım daha sonra kalıplara döküldü ve 80°C'de 4 saat kürlendi. Sertleştirme sonrası kompozit numuneler bir CNC yönlendirici kullanılarak ASTM standartlarına göre kesildi. Üretim aşamaları Şekil 1.'de gösterilmiştir.

Numunelerin titizlikle hazırlanmasından sonra, malzeme mekanik özelliklerinin kapsamlı bir şekilde değerlendirilmesi için ASTM D790 standartlarına göre 3 nokta eğilme testlerine maruz bırakılmıştır [15]. Standart boyutlara göre hazırlanmış her numune, numunenin tam orta noktası boyunca stratejik olarak yerleştirilmiş iki destek noktasına yerleştirilmiştir. Her numunenin ortasına hassas bir şekilde kontrol edilen bir yük uygulanmıştır. Bu metodoloji, orta noktada belirgin bir kiriş yapısının oluşumunu etkili bir

şekilde kolaylaştırarak eğilme özelliklerinin hassas bir şekilde ölçülmesini sağlamıştır. Yüksek hassasiyetli 100 kN yük hücresi ile donatılmış bir Shimadzu Üniversal Çekme Makinesinin kullanılması, test prosedürü boyunca doğruluk ve güvenilirliği sağlamıştır. Eğilme testleri, tutarlı ve tekrarlanabilir sonuçlar elde etmek için 5 mm/dk kontrollü hızda gerçekleştirilmiştir. Eğilme gerilmeleri, Denklem 1 kullanılarak hesaplanmıştır.

$$\sigma_f = \frac{3PL}{2bd^2} \quad (1)$$

Çekme testleri, malzeme çekme özelliklerinin değerlendirilmesinde bir ölçüt olan ASTM D638-14 standartlarına uygun olarak yapılmıştır. Bu testler, aynı Shimadzu Üniversal Çekme Makinesi kullanılarak, gerinim hızı (1 mm/dk) ve numune boyutları gibi parametreler belirtilen standartlara uyarak kontrollü koşullar altında gerçekleştirilmiştir [16]. Hem eğilme hem de çekme testlerinden elde edilen veriler, malzemenin farklı yükleme senaryolarındaki mekanik tepkisinin kapsamlı bir şekilde değerlendirilmesine toplu olarak katkıda bulunmaktadır.

Şekil 1. Üretim aşamaları

III. BULGULAR

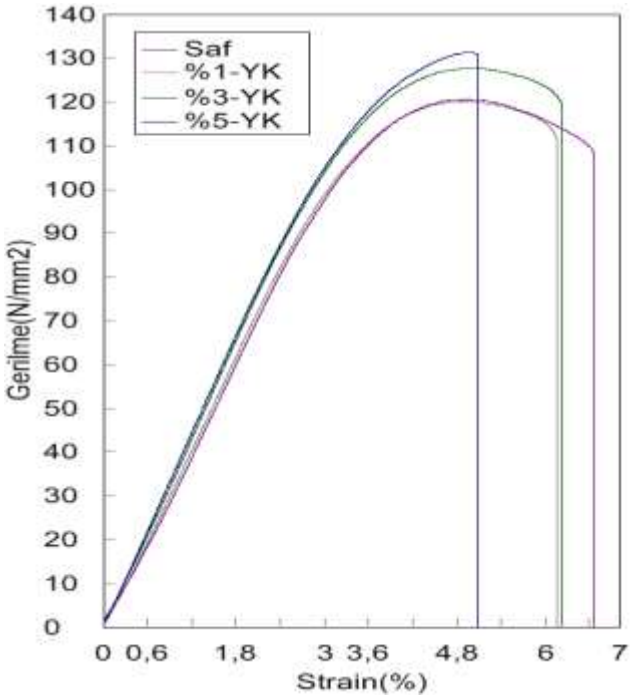
Eğilme ve çekme testleri her bir parametreden 5 er adet olacak şekilde gerçekleştirilmiş ve maksimum gerilme değerleri ortalamalar alınarak hesaplanmıştır. Şekil 2'de eğilme testi için gerilme-strain (birim şekil değiştirme) grafiği, Şekil 3'te çekme testi için gerilme-strain (birim şekil değiştirme) grafiği verilmiştir. Çekme ve eğilme testi sonucunda elde edilen maksimum gerilme değerleri Tablo 1'de verilmiştir.

Tablo 1. Çekme ve eğilme testi mekanik özellikler

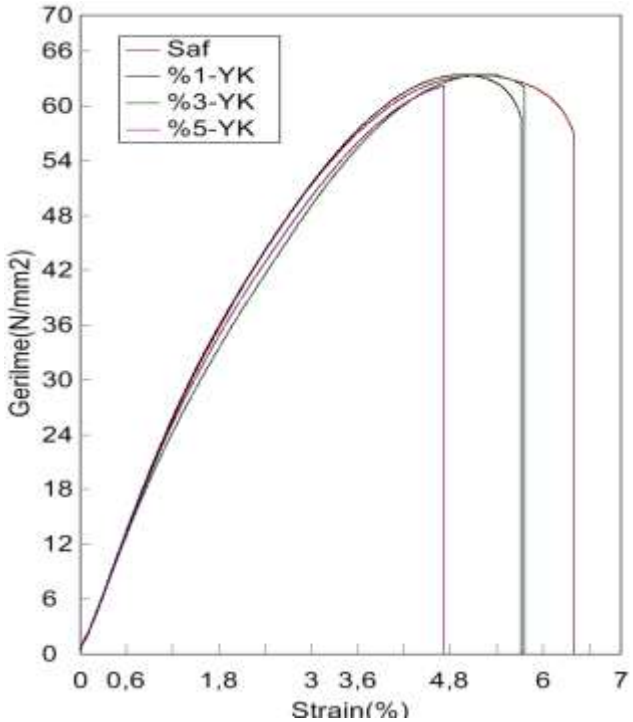
Test	Saf	%1YK	%3YK	%5YK
Eğilme Testi Maksimum Gerilme (MPa)	122.48	123.58	125.26	127.69
Çekme Testi Maksimum Gerilme (MPa)	63.19	63.44	62.63	61.86

Eğilme testi sonuçları incelendiğinde yumurta kabuğu tozu arttıkça eğilme dayanım değerlerinin arttığı görülmektedir. %1 YK tozu olan numunede bu artış %0.89, %3 YK tozu olan numunede bu artış %2.27 ve %5 YK tozu olan numunede bu artış %4.25 olarak gerçekleşmiştir.

Çekme testi sonuçları incelendiğinde yumurta kabuğu tozu arttıkça çekme dayanım değerlerinin %1 YK tozu olan numunede artarken %3 ve %5 YK tozu olan numunede azaldığı görülmektedir. %1 YK tozu olan numunede artış %0.39, %3 YK tozu olan numunede azalma %-0.88 ve %5 YK tozu olan numunede azalma %2.1 olarak gerçekleşmiştir.



Şekil 2. Eğilme testi gerilme-strain (birim şekil değiştirme) grafiği



Şekil 3. Çekme testi gerilme-strain (birim şekil değiştirme) grafiği

YK tozu yüzdesi arttıkça (% 1'den% 5'e), çekme mukavemetinin artmasına çeşitli faktörler katkıda bulunmaktadır. Partikül dolgu maddesi olan yumurta kabuğu tozu, epoksi matrisini etkili bir şekilde güçlendirerek gerilme mukavemetini artırabilir. Parçacıklar, uygulanan gerilme kuvvetlerinin kompozit boyunca daha düzgün bir şekilde dağılmasına yardımcı olur, böylece erken hasara uğramaya yol açabilecek lokalize gerilme konsantrasyonlarını azaltır. Bu takviye mekanizması tipik olarak, % 0.39'luk bir artışın kaydedildiği% 1 YK tozlu numunede gözlemlendiği gibi çekme mukavemetinde bir artışa yol açar.

Bununla birlikte, YK tozu konsantrasyonu daha da arttıkça (% 3 ve% 5 YK tozu), kompozitin yapısal bütünlüğü etkilenebilir. Daha yüksek partikül dolgu konsantrasyonları, potansiyel olarak reçine matrisi içindeki parçacıkların topaklanmasına veya kümelenmesine neden olabilir. Bu kümelenme, mikroyapısal kusurlar veya zayıf noktalar oluşturabilir. Sonuç olarak, çekme mukavemeti, sırasıyla %-0.88 ve%-2.1'lik düşüşlerin gözlendiği% 3 ve% 5YK tozlu numunelerde görüldüğü gibi azalmaya başlayabilir.

Malzemenin eğilme mukavemetinin değerlendirildiği 3 noktalı eğilme testlerinde ise sonuçları etkileyen baskın faktör, kompozitin eğilme gerilimi altında deformasyona ve kırılmaya direnme kabiliyetidir. Burada yumurta kabuğu tozu ilavesi, epoksi reçine ile parçacıklar arasındaki arayüzey bağını iyileştirme eğilimindedir. Bu geliştirilmiş yapıştırma, malzemenin eğilme kuvvetlerine karşı direncini artırarak yumurta kabuğu tozu konsantrasyonu arttıkça eğilme mukavemetinin artmasına neden olur. Değişen YK toz yüzdelerinde eğilme mukavemetinde gözlenen pozitif korelasyon (% 1 YK için% 0,89 artış, % 3 YK için% 2,27 artış ve% 5 YK için% 4,25 artış) bu güçlendirme etkisini yansıtmaktadır.

IV. TARTIŞMA

Deniz ve Güneş [12] yaptıkları çalışmada yumurta kabuğu tozunun %5 katkı oranında eposki kompozitin çekme ve eğilme dayanımlarını arttırdığını tespit etmişlerdir. Shin ve ark. [17] cam elyaf katkılı kompozitlere kütlece %10 oranında kattıkları yumurta kabuğu tozları ile çekme gerilmesinde artış gözlemlemişlerdir. Souza ve ark., [18] kütlece %10 oranında yumurta kabuğu tozu kattıkları epoksi kompozitlerin çekme gerilmesi değerlerinde artış gözlemlemişlerdir. Bu çalışmada literatür ile benzer şekilde eğilme gerilmelerinde artış gözlemlenirken çekme gerilmelerinde ise literatüre ters bir şekilde %1 katkı oranından sonra %5 katkı oranına kadar azalma gözlemlenmiştir. Bunun sebebi üretim sırasında oluşan boşluksu yapılar olabilir. Boşluksu yapılar eğilme dayanımın maksimum oluştuğu bölgede oluşmamış be böylece eğilme dayanım değerlerini olumsuz etkilememiş olabilir. Öte yandan çekme testinde boşluksu yapılar doğrudan bütün kesit alanını etkilediği için çekme gerilme değerlerini azaltmış olabilir. Sonuç olarak bu çalışmada boşluksu yapıya bakılmadığı için net bir şey söylemek mümkün değildir. Ancak bu tür toz katkılı kompozitlerde boşluksu yapıların da incelenmesi oldukça önemlidir.

V. SONUÇLAR

Bu çalışma, yumurta kabuğu tozunun epoksi reçine matrisli kompozit malzemeler üzerindeki etkilerini sistemli bir şekilde değerlendirmiştir. Yapılan eğilme testleri sonuçlarına göre, yumurta kabuğu tozunun %1, %3 ve %5 oranlarında eklenmesiyle eğilme dayanımında belirgin artışlar gözlemlenmiştir. %1 yumurta kabuğu tozu ile %0.89, %3 tozu ile %2.27, %5 tozu ile ise %4.25 artış sağlanmıştır. Bu artışlar, yumurta kabuğu tozunun kompozit malzemelerdeki takviye potansiyelini göstermektedir. Ancak, çekme testleri sonuçlarına göre, belirli konsantrasyonlardan sonra çekme mukavemetinde azalmalar gözlenmiştir. %1 yumurta kabuğu tozu ilavesi ile %0.39 artış kaydedilirken, %3 ve %5 ilavelerinde sırasıyla %-0.88 ve %-2.1 azalmalar gözlenmiştir. Bu azalmalar, yüksek konsantrasyonlardaki tozun reçine matrisi içindeki homojen dağılımını olumsuz etkileyebileceğini göstermektedir.

Çalışmanın bulguları, yumurta kabuğu tozunun kompozit malzemelerin mekanik özelliklerini önemli ölçüde etkileyebileceğini ve sürdürülebilir biyo-katkı maddelerinin kullanımının malzeme mukavemeti ve dayanıklılığı üzerinde potansiyelini ortaya koymaktadır. Ancak, malzeme üretim sürecinde oluşabilecek boşluklu yapıların mekanik performans üzerindeki etkisi dikkate alınmalıdır. Bu çalışma, sürdürülebilir malzeme biliminin ilerlemesi açısından önemli bir adım olmuştur. Gelecekteki araştırmalar, yumurta

kabuğu tozu konsantrasyonunun yanı sıra üretim sürecindeki diğer faktörlerin optimize edilmesini içermeli ve malzeme yapısal bütünlüğünün daha derinlemesine incelenmesi gerekmektedir.

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Equivalent Circuit Model of Two Symmetrical Split Ring Resonators based Microwave Sensor Design

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Abstract **–** In this study, an equivalent circuit model of a microwave sensor design based on two symmetrical split ring resonators is presented. The design process involves leveraging the unique electromagnetic properties of split ring resonators to achieve high sensitivity and selectivity in material characterization. The equivalent circuit model is meticulously developed to represent the sensor's behavior accurately. Detailed 3D simulations are conducted to validate the model and analyze the sensor's performance. The integration of advanced modeling techniques and simulation tools provides a comprehensive understanding of the sensor's operational principles. The sensor operates by inducing resonant frequencies that are highly sensitive to the dielectric properties of the material. By monitoring shifts in these resonant frequencies, precise material characterization is achieved. This study also explores the potential applications of the proposed sensor in various fields, including material science, engineering, and industrial quality control. The versatility and effectiveness of the sensor are highlighted through its ability to detect subtle changes in material properties, making it a valuable tool for non-destructive testing and real-time monitoring. The robustness of the design ensures consistent performance across different operating conditions. Overall, the integration of split ring resonators in microwave sensor design opens new avenues for advanced material characterization techniques, offering significant improvements in accuracy and reliability over traditional methods. This work lays the groundwork for future advancements and practical implementations of split ring resonator based sensors in diverse applications.

Keywords – microwave sensor, dielectric characterization, equivalent circuit model, split ring resonators, frequency variation sensor

I. INTRODUCTION

Microwave sensors have emerged as a vital tool in the realm of material characterization, offering a unique blend of precision, versatility, and non-invasiveness. These sensors operate in the microwave frequency range, typically from 300 MHz to 300 GHz, utilizing electromagnetic waves to probe the intrinsic properties of various materials [1]. The interaction of microwaves with materials provides valuable insights into their dielectric properties, moisture content, density, and other critical parameters. The growing interest in microwave sensors is driven by their broad application potential across multiple industries [2], including aerospace [3], automotive [4], healthcare [5], and environmental monitoring [6]. Advancements in microwave technology, such as the integration of machine learning algorithms, have significantly enhanced the accuracy, sensitivity, and speed of material characterization processes. Machine learning, a subset of artificial intelligence, has revolutionized data analysis by enabling the extraction of complex patterns and relationships from large datasets. When applied to microwave sensing, machine learning algorithms can optimize sensor performance, improve measurement accuracy, and

enable real-time monitoring of material properties [7]. This synergy between microwave technology and machine learning not only elevates the capabilities of traditional sensors but also opens new avenues for innovative applications and research.

The RLC equivalent circuit model is a fundamental concept in the design and analysis of microwave sensors, playing a pivotal role in understanding their electrical behavior. The RLC circuit model provides a simplified yet effective representation of the complex impedance characteristics of microwave sensors. This model enables the translation of physical phenomena into electrical parameters, facilitating the analysis and optimization of sensor performance. By mapping the sensor's frequency response to the corresponding RLC components, engineers and researchers can gain valuable insights into the sensor's functionality and identify ways to enhance its accuracy, sensitivity, and stability. Understanding the RLC equivalent circuit model is particularly important for the development of advanced microwave sensors used in material characterization. The non-invasive nature of these sensors makes them ideal for applications in various industries, including healthcare, aerospace, and environmental monitoring. However, accurately modeling their behavior requires a deep comprehension of how the sensor's components interact with the target material at microwave frequencies. Recent advancements in computational techniques and simulation tools have furthered the development of more precise RLC models, incorporating factors such as parasitic effects and material heterogeneity. Moreover, the integration of machine learning algorithms with RLC modeling has opened new avenues for enhancing sensor performance through data-driven optimization and real-time analysis.

II. Materials and Method

Microwave sensor design for liquid material dielectric characterization is proposed. The proposed sensor is planar and designed and fabricated with double sided 1.6 mm thick Rogers RO4003C substrate. The total sensor dimensions are 20 mm x 35 mm with a sensing area of 4 mm x 4 mm. The proposed sensor design is presented in Fig. 1 with top and ground layers.

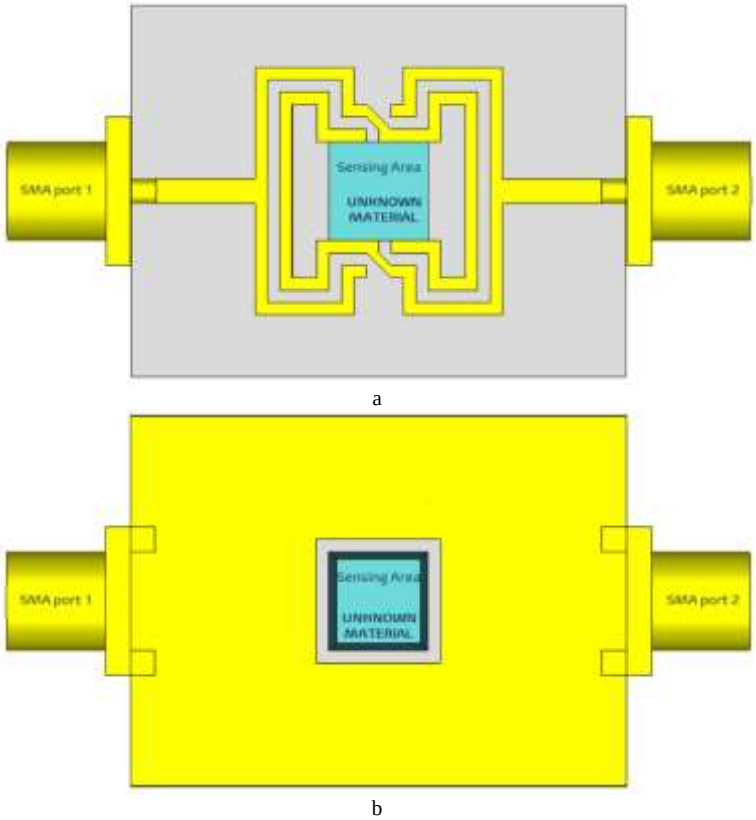


Fig. 1 Two symmetrical split ring resonators-based microwave sensor design.

The proposed sensor operates based on frequency variation, when liquid is added to the sensing area, a shift in the transmission parameter resonant frequency occurs. Thanks to this shift, the dielectric properties of the unknown material are obtained.

The transmission line, substrate, sensing area, and ground layer, which are the components of the proposed sensor design, are modelled as resistors, capacitors, and inductors in the equivalent circuit model. Parallel RLC elements are used in this model, the resonant frequencies of each RLC element are equivalent to the elements in the sensor model. The equivalent circuit model is shown in Fig. 2 and the values of the elements are presented in Tab. 1.

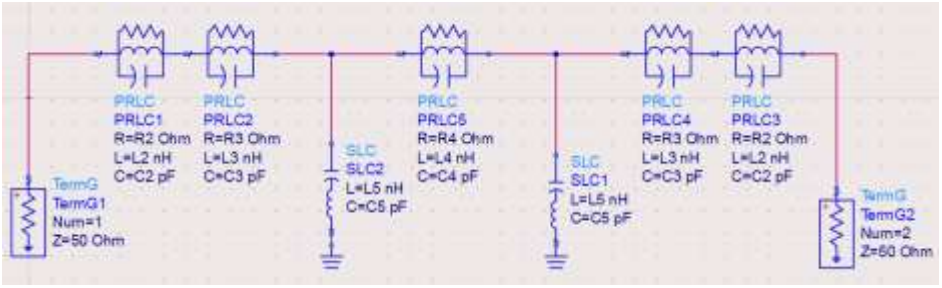


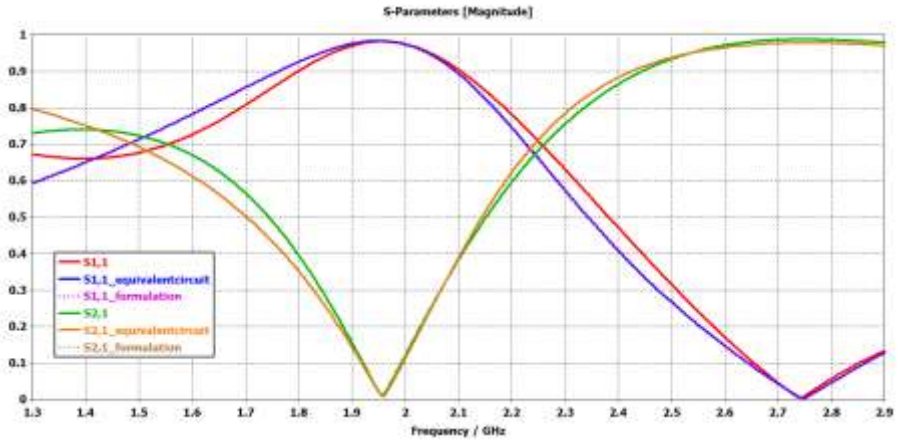
Fig. 2 Equivalent circuit model of the proposed microwave sensor.

Table 1. Equivalent circuit model design parameters.

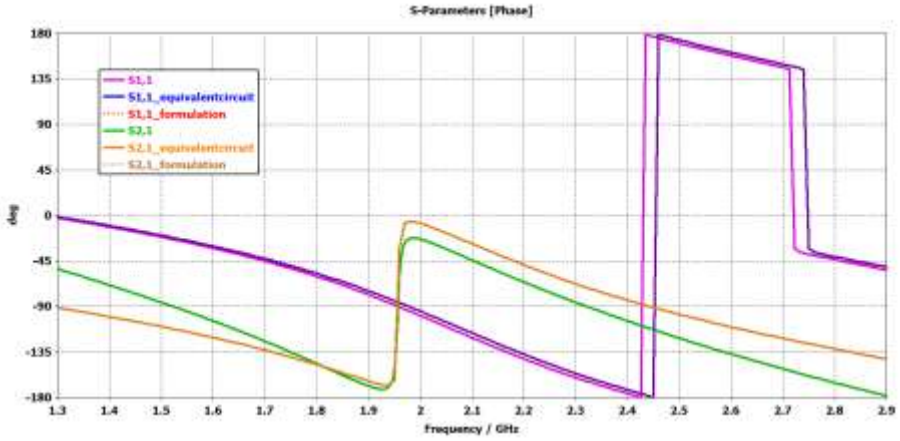
R2	**R3**	**R4**	**L2**	**L3**	**L4**
208	1000	753.4	9.7	0.6	2457
L5	**C2**	**C3**	**C4**	**C5**	
4.1	4.1	6.8	0.5	300	

III. Results and Discussion

The unique properties of SRRs are leveraged to achieve high sensitivity and selectivity in detecting material properties. The equivalent circuit model and 3D simulation results are discussed in detail to illustrate the sensor's performance and efficacy. Since the proposed sensor design is symmetrical between the two ports, the equivalent circuit model is also designed with symmetrical elements between the two ports. As a result, S_{11} and S_{22} values are equal and S_{12} and S_{21} values are equal. The magnitude and phase of the S-parameters from 3D physical model simulation, equivalent circuit simulation, and calculated using the equation are presented comparatively in the Fig. 3.



a



b

Figure **Hata! Belgede belirtilen stilde metne rastlanmadı.**.1: S-parameters of proposed MWS 3D model, equivalent circuit, and formulation results; (a) magnitude and (b) phase.

The graphs in the figure belong to the 3D model simulation, the equivalent circuit model, and the result calculated by integrating the elements in the equivalent circuit model into the formulation. All the results obtained are quite consistent with each other.

IV. CONCLUSION

The proposed microwave sensor design, based on two symmetrical split ring resonators, has demonstrated significant potential in material characterization applications. The equivalent circuit model developed for this sensor accurately represents its behaviour and performance, as validated by detailed 3D simulation results. The high sensitivity and selectivity achieved by leveraging the unique properties of SRRs underscore the efficacy of this design. The integration of advanced modelling and simulation techniques has been instrumental in providing a thorough understanding of the sensor's operational principles. This study highlights the potential of SRR-based microwave sensors in various fields, suggesting a wide range of applications in material science and engineering. Future work will focus on further refining the sensor design and exploring its capabilities in different material characterization scenarios.

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Cytotoxic Effects of Macrovipera Lebetinus Venom and Protein Fractions on Colorectal Cancer Cells

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Abstract – Colorectal cancer is a significant disease, ranking second among women and third among men worldwide. Due to the low sensitivity and toxicity of traditional treatment methods, new and alternative therapeutic approaches are being investigated. This study aims to develop natural therapeutic methods using protein-rich compounds from the venom of *Macrovipera lebetinus* (*M. lebetinus*), commonly known as the Levant viper, found in the Southeastern Anatolia region of Turkey. The characterization of the venom, rich in cytotoxic enzymes, non-enzymatic proteins, and peptides affecting various receptors on the DLD-1 colon cancer cell line, was performed. Venom samples obtained from the Levant viper were lyophilized and then characterized using HPLC, SDS-PAGE, and spectroscopic methods. Within the venom, 15 different protein fractions, including metalloproteinases, serine proteases, L-amino acid oxidase, C-type lectin, and dimeric 5' nucleotidase/phosphodiesterase, were identified based on their molecular weights. The cytotoxic properties of the venom were evaluated using the Alamar blue assay. The IC_{50} value for the DLD-1 colon cancer cell line was calculated to be 6.12 µg/mL, while the IC_{50} value for the healthy CCD-18Co cell line was 15 µg/mL. The higher cytotoxic effect of the Levant viper venom on colon cancer cells compared to healthy colon cells suggests its potential use in combating cancer cells. In conclusion, the high cytotoxic effect of *Macrovipera lebetinus* venom on colon cancer cells indicates that this natural compound could be considered a potential alternative in colorectal cancer treatment.

Keywords – Macrovipera lebetinus, DLD-1, Cytotoxicity, Colorectal Cancer, Characterization

I. INTRODUCTION

Colorectal cancer has been shown to cause the death of 935,000 people, according to International Agency for Research on Cancer (IARC) statistics announced in 2020. It is the third most common disease in men and the second most common in women worldwide, and it is an important disease that is difficult to treat [1]. Patients receiving cancer treatment often do not respond to traditional treatment methods. There are many reasons for this. One of the first reasons is that cancer cells behave like stem cells and transform into different cancer cells. These tumors initiate the process of angiogenesis to obtain oxygen and nutrients. After the disintegration of the basement membrane, migration and proliferation of the endodel cells, lumen formation, new blood vessels connect to the existing circulation and transform into different tumor cells by reshaping the extracellular matrix. Tumor cells that differentiate after such a process often do not respond to traditional treatments [2]. The second reason is that cancer patients being treated have a low immune system, causing damage to healthy cells during treatment, and the process showing non-specific cytotoxic properties is insufficient for treatment [3]. For this reason, the need for natural methods that can be used in cancer treatment and have fewer side effects is increasing. From past to present, many researchers have focused on natural poisons, especially snake venom and venom peptides [4]. These poisons are known for

their potent biological effects and can bind with high affinities to various molecular targets, making them pharmacologically important [5]. *M. lebetinus* snakes, first described by Linnaeus, live in a wide geography from Western and Central Asia to North Africa. They are found in Turkey, especially in the Southeastern and Eastern Anatolia regions [6, 7]. They are popularly known as "big vipers". The species has many subspecies accepted in its taxonomy. *M. l. lebetinus*, *M. l. obtusa*, *M. l. transmediterranea*, *M. l. turanica* and *M. l. chernovi* is among the known subspecies. These snakes usually exceed 2 meters in size and weigh around 3 kg. They are reptiles whose upper parts are generally gray or dusky brown, while their middle parts are reddish in color. Their tails are short and suddenly pointed [6, 8]. These protein/peptide poisons consist of toxic proteins such as neurotoxins and cardiotoxins, non-poisonous proteins, enzymes, enzyme inhibitors, biological amines and ions [9, 10]. When previous studies were examined, Viperidae family member snake venoms contained; phospholipase A2 (PLA2), LAAO enzymes, phosphodiesterases (PDE), C-type lectin, Kunitz-type protease inhibitor and dimeric degradants showed cytotoxic properties in different cancer cell lines [11-13]. However, in previous studies, the cytotoxic effects of all protein-containing compounds found in *M. lebetinus* venom, affecting the receptors on cancer cells without purification, were not investigated. In this study, the cytotoxic effects of snake venom, popularly known as big viper, obtained from Şanlıurfa Province in the Southeastern Anatolia Region of Turkey, on healthy human colon cells and colon cancer cells were examined. Through characterization studies, the protein contents that constitute these mechanisms of action have been identified.

II. MATERIALS AND METHOD

II.I. Collection of *Macrovipera lebetinus* Snake Species and Milking Its Venom

M. lebetinus species snakes were collected from Soğmatar Village of Şanlıurfa. The *M. lebetinus* species venom sample used in this study was obtained from Aydın Adnan Menderes University, Department of Biology. *M. lebetinus* venom was collected according to the method specified for vipers by Mirtschin et al. (2006). First, the snake was bitten into a sterile collection container covered with parafilm, and the venom glands were squeezed and the milking process was performed. Then, the expressed venom was taken with a micropipette and transferred to a sterile Eppendorf tube. This process was done twice a month to obtain a sufficient amount of poison. Expressed venom was stored at −80 °C.

II.II. Lyophilization Studies of *Macrovipera lebetinus* Snake Venom

In this study, lyophilization was carried out to ensure that snake venom did not lose its potency and stability and to obtain more accurate findings. First, the poison was filtered and transferred into vials. Then, the poison was lyophilized below -55°C and turned from liquid to solid. Lyophilized venom was stored at -80°C.

II. III. Characterization Studies of *Macrovipera lebetinus* Snake Venom

II. III. I. HPLC Analysis Studies

Protein fractions in *M. lebetinus* venom were determined by HPLC method. Analyzes were performed on a C18 reverse phase column (Inert Sustain AQ-C18 Analytical Columns, 5 µm, 4.6 mm I.D. x 250 mm) with the Shimadzu Prominence-i LC2030 3D Plus system. The venom sample was analyzed with Solvent A (0.12% trifluoroacetic acid - TFA in water) and Solvent B (TFA in 0.10% acetonitrile) on a 0-60% low gradient program at a concentration of 1ppm at a flow rate of 1 mg/mL. The PDA detector scanned the samples at a wavelength of 280 nm.

II. III. II. Spectrum Analysis Studies

For spectrum analysis of snake venom, a Shimadzu UV-1900i model spectrophotometer was used and wavelengths between 190 nm and 400 nm were scanned. Additionally, a Bruker brand spectrometer with Fourier transform infrared (FT-IR) vibration spectroscopy was used to identify various chemical groups and the analysis was carried out in the range of 3500-500 cm-1.

II. III. III. SDS-PAGE Analysis Studies

Proteins in *M. lebetinus* venom were separated according to their molecular weight using sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) [14, 15]. The proteins in the venom were separated with the help of ERB solution in 4% stacking and 12% separating gels. Then, after staining with Coomassie Brilliant Blue dye, protein images were visualized using the Syngene Imaging System.

II. IV. Cell Culture Studies

Colon cancer cell line DLD-1 and human healthy colon cell line CCD-18Co (American Type Culture Collection, Rockville, MD) were obtained from the company for cytotoxicity studies. The cells were incubated in an incubator containing 10% FBS, 2 mM L-glutamine and 1% penicillin streptomycin (Pen/Strep) added to RPMI-1640 and Eagle's Minimum Essential Medium (EMEM), which are nutrient media, respectively, at 37°C and 5% CO_2. has been enlarged. Cells that reached sufficient size were planted in a 96-well plate at 1 x 104 cells and treated with *M. lebetinus* snake venom in different concentration ranges of 1-20 µg/mL. It was determined using the Alamar blue method to calculate the poison concentration that inhibited cell viability by 50% (IC_{50} value) after 48 hours. Then, fluorescence measurements were taken with a BioTek Synergy HTX microplate reader at an excitation wavelength between 530-560 nm and an emission wavelength of 590 nm. Sigmoidal curves were drawn to determine cell death rates.

III. RESULTS

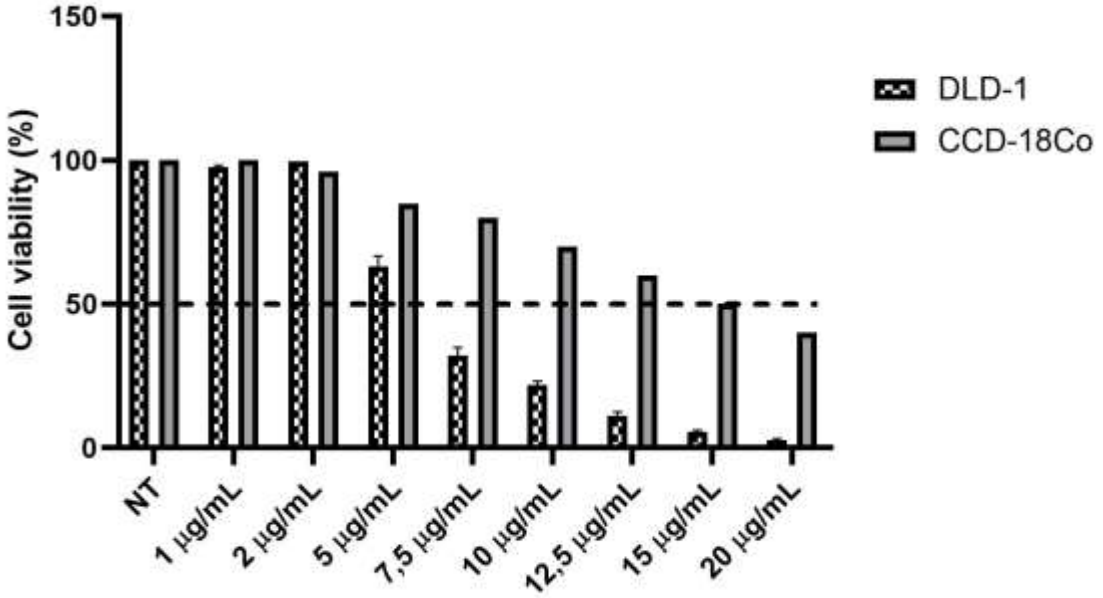

Fig.1. Cytotoxicity analysis studies of *M. lebetinus* venom. Bar graph of dose-dependent inhibition of DLD-1 and CCD-18Co cells measured by the Alamar Blue method after treatment with venom

Characterization studies were carried out on the snake venom of the *M. lebetinus* species, which is a member of the Viperidae family, and its bioactive content was determined. Protein fractions of the crude venom were made visible by SDS-PAGE method, 15 different protein fractions in the range of 11-245 kDa according to their molecular weight. In order to separate, identify and measure the active components in the venom in more detail, 29 protein fractions were used with High Performance Liquid Chromatography (HPLC). Different protein fractions were detected. The wavelength that became visible by UV-VIS Spectrum measurement gave maximum absorption at 280 nm. Fourier transform infrared (FT-IR) spectra identified 11 important peaks representing the chemical groups found as a result of the measurement between 3500-500 cm-1 wavelengths. The majority of the characteristic region lies between 1800 and 500 cm-1. Cell culture studies were performed to determine the cytotoxicity of snake venom on cells. The cytotoxic effects of *M. lebetinus* venom on colon cancer cell line DLD-1 cells and healthy human colon cell line CCD-18Co cells treated at different concentrations were determined by the Alamar Blue method. IC50 values of DLD-1 and CCD-18Co cells were found to be 6.12 µg/mL and 15 µg/mL. *M. lebetinus* venom treated in a dose-dependent manner caused a decrease in the viability of DLD-1 and CCD-18Co cells. A significantly higher cytotoxic effect was observed in the DLD-1 colon cancer cell line than in healthy human colon cells.

IV. DISCUSSION

In this study, the cytotoxic properties of DLD-1, a colon cancer cell line, and CCD-18Co, a healthy colon cancer cell line, treated with *M. lebetinus* snake venom, were investigated. Venom-treated DLD-1 and CCD-18Co cells reduced the number of viable cells in a dose-dependent manner. IC50 values (Fig.1) were calculated as 6.12 µg/mL in DLD-1 and 15 µg/mL in CCD-18Co. In line with the results obtained from the research, it was found that healthy human colon cells had a very low cytotoxic effect compared to the colon cancer cell line. Characterization studies of the poison were carried out to further investigate the bioactive protein-containing substances that are effective in its cytotoxic effect on colon cancer cells. Protein-containing substances in the venom were separated by SDS-PAGE analysis according to their molecular weight. In the acrylamide gel, 15 different protein fractions were determined to be in the range of 11-245 kDa. When our band images are compared with the literature; Metalloproteases and serine proteases

weighing 60 kDa and 50 kDa, serine proteases 30 kDa, metalloprotease types and vascular endothelial growth factor weighing 25 kDa, C-type lectin weighing around 18 kDa, dimeric L-amino acid oxidase weighing about 125 kDa and Various peptide-containing protein substances have been found, such as dimeric 5' nucleotidase/phosphodiesterase [16, 17]. t is thought that these bioactive proteins have cytotoxic properties by affecting different specific receptors on cell surfaces. [18, 19]. In order to determine the protein compounds in the venom in more detail, 29 different peaks were detected with High Performance Liquid Chromatography (HPLC). UV-VIS Spectrum measurement of snake venom showed compatibility with literature studies and gave the maximum absorption wavelength at 280 nm [20, 21]. The analysis of the chemical groups in the poison was carried out by FT-IR spectroscopic characterization study. In our study, Amide A, N–H stretching of proteins and amines (mainly), with contribution from O–H stretching of carbohydrates, CH_3 asymmetric stretching, Asymmetric CH_2 stretching, Symmetric CH_3 stretching, Amide I; 80% C=O stretching, 10% N–H bending, 10% C–N stretching, N-O stretching, CH_3 asymmetric bending, CH_3 symmetric bending, PO_2^- antisymmetric stretching (non H-bonded), PO_2^- symmetric stretching (fully H -bonded) contents found [22-28]. Since the results of FT-IR analysis of *M. lebetinus* snake venom compared with the Viperidae species are compatible with the literature; It consists of peptide structures, amines, nucleosides, carbohydrates and inorganic substances [29]. C-O and C-C stretching bonds may originate from the carbohydrate parts of nucleosides, nucleotides and venom glycoproteins present in the venom [29-32]. PO_2^- stretching bonds confirm the presence of ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) substances found in the venom gland of snake venom [33, 34].

V. CONCLUSION

In this study, we aimed to find substances that affect the receptors on cancer cells and lead them to death, since snake venom has a cytotoxic effect on the colon cancer cell line DLD-1 compared to the healthy colon cell. These protein-containing substances were identified by performing various characterization analyzes such as SDS-PAGE, HPLC, UV-VIS spectroscopy and FT-IR spectroscopy. It is thought that it will contribute to future research on the effects of *M. lebetinus* species snake venom in cancer treatment.

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YALIN TASARIM YAKLAŞIMI İLE ÜRETİM HATTI ORGANİZASYONU

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Özet – Gelişen teknolojinin kullanımı ile birlikte yüksek katma değerli ürün ve hizmetlere odaklanılmıştır. Artan nüfus, azalan kaynaklar ve rekabet, maliyet kontrolünü ve israfı azaltmayı önceliklendirmektedir. Bu noktada, Yalın üretim, maliyet, işçilik ve israfı minimize ederek kârı artırmayı hedefleyen bir çözüm olarak ortaya çıkmıştır. Yalın üretim müşteri için değer yaratmayan her şeyi ortadan kaldırmayı ve en uygun maliyet seviyesini yakalamayı amaçlamaktadır. Teknolojinin gücüyle birlikte, güçlü tasarımlar ortaya çıkmış olsa da günümüzde rekabet arttığı için, teknoloji, ergonomi ve estetiği bir araya getiren yeni ve yaratıcı tasarımlar yapmak artık tek başına yeterli değildir. Bu tasarımların en uygun maliyetle üretimi de sağlanmalıdır. Yapılan çalışma, tasarım faaliyetlerinin Yalın üretim teknikleri kullanılarak fazladan maliyet yaratmadan mevcut üretime nasıl adapte edileceğini ve katma değer yaratacağını ele almaktadır. Çalışmada, yalın üretimin tarihi, felsefesi ve teknikleri ayrıntılı olarak açıklanmış; kavramsal tasarım süreçleri işletilerek gerçek bir tasarım değişikliği, gerçek bir üretim hattına en düşük maliyetle uyarlanmıştır.

Anahtar Kelimeler – Yalın Üretim, Tasarım, Yalın Tasarım

I. GİRİŞ

Günümüzde artan rekabet ve azalan kaynaklar, üreticiler için maliyet kontrolünü hayati önem taşıyan bir faktör haline getirmiştir. Bir ürünün piyasa fiyatının üzerinde satılması, organizasyonun başarısını olumsuz etkileyebilir. Bu nedenle, ürünün tasarımından üretimine kadar geçen süreçte prototipleme, malzeme, işçilik, hata ve benzeri maliyetleri azaltmak için yalın üretim teknikleri kullanılmaktadır. Yalın üretim, tek bir unsura odaklanabileceği gibi birden fazla unsura da odaklanabilir. Bu unsurların en başta geleni ise tasarımdır. Ürünün tasarımında meydana gelebilecek değişimler, üretim maliyetini doğrudan etkilemektedir. Tedarik edilen hammadde, insan kaynağı, üretim yöntemi ve üretim hatları doğrudan etkilenmekte, bu da maliyet performansını olumsuz etkilemektedir. Üretici firmalar, tasarımda değişiklik gerektiğini fark etseler bile, zaman ve maliyet kaygılarından dolayı bu değişikliklerde tutucu davranabilirler. Özellikle ülkemizde yalın üretimin yaygın olmaması, bu problemleri üreticiler için daha da can sıkıcı hale getirebilmektedir. Bu çalışma, ürün tasarımında yaşanacak değişikliklerin yalın üretim tekniklerinden herhangi biri/birileri kullanılarak en az maliyetle üretim hattı durmadan nasıl bütünleşmiş edilebileceğinin cevabını aramaktadır. Çalışmada, yalın üretim tekniklerinden biri kullanılarak hali hazırda üretilen ve üretim hattındaki bir ürünün bir parçasında tasarım değişikliği yapılmıştır. Daha önce yalın üretim ve tasarım ilişkisi adına hiç çalışma yapılmamış bir ortamda oldukça faydalı sonuçlar elde edilmiştir.

II. MATERYAL VE YÖNTEM

A. Yalın Üretim

Yalın üretim, israfı minimize ederek değer yaratmayı amaçlayan bir üretim felsefesidir. İlk olarak Toyota tarafından geliştirilen bu sistem, üretim süreçlerinde verimliliği artırmayı, maliyetleri düşürmeyi ve müşteri memnuniyetini artırmayı hedefler. Yalın üretim, gereksiz adımları ortadan kaldırarak sadece değer katan faaliyetlere odaklanır [1] [2]. Maliyet azaltma, verimlilik artışı, kalite iyileştirme, stok azaltma, çalışan memnuniyeti, müşteri memnuniyeti arttırma gibi faydaları vardır [3] [4]. Yalın üretim, birçok sektörde ve alanda kullanılmaktadır. Özellikle kullanıldığı alanlar otomotiv, elektronik, sağlık, gıda ve içecek, hizmet sektöründe kullanılmaktadır [5] [6]. Yalın üretimde en çok Kaizen, 5S, Kanban, Değer Akış Haritalama (VSM), Tam Zamanında Üretim (JIT) gibi yöntemler kullanılmaktadır [7] [8]. Yalın üretimde en çok başlangıç maliyetleri, kültürel direnç, uygulama zorlukları ve risk yönetimi gibi riskler ile karşılaşılmaktadır [9] [10]. Gelecekte yalın üretim, yapay zekâ, dijitalleşme ve Endüstri 4.0 ile daha da bütünleşmiş hale gelecektir. Akıllı fabrikalar, IoT (Nesnelerin İnterneti) ve büyük veri analitiği gibi teknolojiler, yalın üretim süreçlerini daha verimli ve esnek hale getirecektir. Ayrıca, sürdürülebilirlik ve çevreye duyarlılık konuları da yalın üretimin gelecekteki uygulamalarında önemli bir rol oynayacaktır. Yalın üretim, sürekli iyileştirme ve verimlilik odaklı yapısı sayesinde, gelecekte de rekabet avantajı sağlamak isteyen organizasyonlar için vazgeçilmez bir strateji olmaya devam edecektir [11] [12].

B. Yalın Tasarım

Yalın üretim ve tasarım, modern endüstriyel faaliyetlerin temel taşlarından kabul edilir. Her ikisi de üretim süreçlerini iyileştirmeyi, verimliliği artırmayı ve son kullanıcıya daha iyi ürünler sunmayı hedefler. Örneğin, bir araba tasarımında, kullanıcıların gereksinimlerini karşılayacak şekilde iç mekân düzenlemesi yapılması, yalın üretim sürecinde parça ve malzeme israfını önler. Bununla birlikte, yalın üretimin tasarıma etkisi sadece ürünlerin fiziksel tasarımıyla sınırlı değildir. Yalın düşünce tarzı, süreçlerin optimize edilmesi ve verimliliğin artırılmasıyla ilgilidir. Bu nedenle, yalın prensipleri endüstriyel tasarım sürecinin her aşamasında uygulanabilir. Örneğin, ürün tasarımı aşamasında, yalın düşünce ürünün optimize edilmesine yardımcı olabilir ve üretim sürecindeki gereksiz adımların ve israfın azaltılmasını sağlayabilir. Aynı şekilde, üretim sürecinde, yalın prensipler, malzeme akışını iyileştirerek ve atıkları azaltarak endüstriyel tasarımı desteklemektedir. Endüstriyel tasarımın yalın üretim üzerindeki etkisi, ürünlerin pazara daha hızlı bir şekilde sunulmasını sağlar. İyi tasarlanmış ürünler, üretim sürecindeki gereksiz adımları ve gecikmeleri azaltarak üretim süresini kısaltabilir. Ayrıca, kullanıcıların ihtiyaçlarına daha iyi uyum sağlayan ürünler, rekabet avantajı sağlayarak pazar payını artırabilir. Yalın üretim ve endüstriyel tasarım arasındaki bu görevdeşlik, şirketlerin daha hızlı ve daha esnek bir şekilde piyasaya sürmelerine olanak tanımaktadır. Sonuç olarak, yalın üretim ve tasarım arasındaki bağlantı, etki ve ilişki oldukça derindir. Her ikisi de ürünlerin daha iyi tasarlanmasını, üretim süreçlerinin optimize edilmesini ve sürdürülebilirlik açısından daha iyi sonuçlar elde edilmesini sağlar [13] [14] [15] [16].

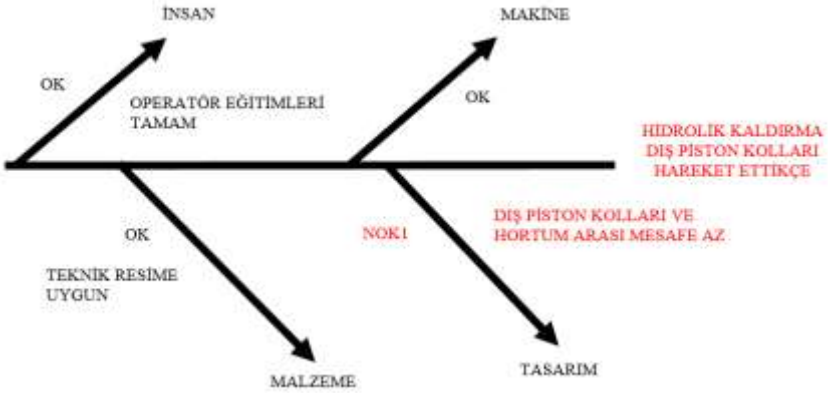
C. Kaizen Yalın Tasarım Bakış Açısıyla Üretim Hattı Adaptasyonu

Hidrolik kaldırma makineleri üzerine üretim yapan bir fabrikada uygulama gerçekleştirilmiştir. Hidrolik kaldırıcı hortumlarının sürtünmesi ile aşınması sonucunda tasarım olarak belirlenen bir hata önce kavramsal tasarım ve sonra sistematik tasarım yaklaşımı ile ele alınarak tasarımsal bir geliştirme uygulanmış olup üretim hattı durmadan minimum maliyet ile çözüme kavuşturulmuştur. Metot olarak yalın üretim tekniklerinden Kaizen seçilmiştir.

D. Bir Hidrolik Kaldırıcı Hortumunun Yeniden Tasarımı

Tablo 1 5N+1K Soruları

5N+1K	Mevcut Durum
Ne?	Hidrolik kaldırıcı hortumlarının sürtünmesi sonucu aşınması
Nerede?	Bimal Tezgâhı Hidrolik Kaldırıcı Testi
Ne Zaman?	FMEA sürecinde yapılan değerlendirme esnasında
Ne kadar?	PFMEA sürecinde tüm gövdelerde
Nasıl?	Hidrolik kaldırıcı kolları her kalktığında hortumlar dış pistona sürterek aşınmaktadır
Kim?	Burada uygulanabilir değildir.



Şekil 1 Hidrolik Kaldırma Kolları Tasarımı Kök Neden Analizi

E. Kavramsal Tasarım

Tablo 2 İhtiyaç Listesi - Tasarım Şartnamesi

Sıra No	**İstenilen özellikler / İhtiyaçlar (İstek/Arzu)**
1.	Sürtünme olmaması **(İ)**
2.	Aşınma olmaması **(İ)**
3.	Eğimli/engebeli ortama uyum göstermeli **(A)**
4.	Hortumların ideal uzunluğa sahip olması **(A)**
5.	Maliyeti düşük olmalı **(İ)**
6.	Tasarımı basit olması **(A)**
7.	Montajı kolay olmalı **(İ)**
8.	Ekstradan malzeme kullanılmaması **(A)**
9.	Üretim hattını aksatmamalı **(İ)**
10.	Güvenli olması **(İ)**

Hidrolik Kaldırma Kolları Hortum Tasarımı kavramsal tasarımı için hazırlanmış ihtiyaç listesi Tablo 2'de görülmektedir. Bu ihtiyaç listesinde tasarlanacak ürünün; maliyetinin düşük olması, aşınmaması tasarımın basit olması gibi özellikler yer almaktadır. Bu aşamada kavramsal tasarım için gerekli olan ve ihtiyaç durumunda esnetilebilecek özellikler belirtilmiştir. İhtiyaç listesinde yer alan özellikler, İstekler (İ) ve Arzular (A) şeklinde gösterilmiştir. İstekler tasarım için gerekli olan ve zorunlu özellikleri belirtirken, arzular ise şartlar el verdiği ölçüde karşılanmalıdır.

Tablo 3 Morfolojik Kart

Çözüm İlkeleri / Alt Fonksiyonlar		1	2	3
1	**Malzeme Türü**	Çelik Tel Destekli Kauçuk	Termoplastik	Çelik Tel Örgülü
2	**Malzeme Tipi**	Silindirik	Helezonik	Spiral
3	**Bağlantı Tipi**	Paslanmaz Çelik Rakor	Düz Rakor	
4	**Renk**	Siyah		

Tablo 4 Kavramsal Tasarım Seçenekleri ve İlişkili Alt Çözümler

Seçenek 1	1.1 – 2.1 – 3.1 – 4.1	Seçenek 6	1.2 – 2.2 – 3.1 – 4.1
Seçenek 2	1.1 – 2.1 – 3.2 – 4.1	Seçenek 7	1.2 – 2.2 – 3.2 – 4.1
Seçenek 3	1.1 – 2.2 – 3.1 – 4.1	Seçenek 8	1.3 – 2.1 – 3.1 – 4.1
Seçenek 4	1.1 – 2.2 – 3.2 – 4.1	Seçenek 9	1.3 – 2.2 – 3.1 – 4.1
Seçenek 5	1.2 – 2.1 – 3.1 – 4.1	Seçenek 10	1.3 – 2.2 – 3.2 – 4.1

F. Kavramsal Tasarım Ön Değerlendirilmesi (Seçim Kartı)

Tablo 3 ve 4'teki morfolojik kart ile oluşturulan on farklı seçenek arasından daha iyi olanları belirlemek amacıyla; tüm işlevlerle uyumlu olma, şartname isteklerini karşılama, üretile bilirlik, müsaade edilebilir maliyet, emniyet şartlarını doğrudan karşılama, kolay tasarım ve yeterli bilgi ölçütleri temel alınarak bir ön eleme işlemi yapılmıştır. Bu işlem için seçim kartı kullanılır (Tablo 6). Her bir tasarım seçeneği için belirlenen ölçütlere göre son sütunda bir karar verilmektedir. Bu işlem sonucu Tablo 5'de olumlu (+) işaretli olan Ç1, Ç3 ve Ç5 seçenekleri daha iyi tasarımlar olarak belirlenmiş ve diğer yedi seçenek ise elenmiştir. Ç1 tasarımı, çelik örgü destekli kauçuk yüksek basınca dayanıklı silindirik boru şeklinde ve suya, ısıya ve çamura dayanıklı paslanmaz çelik rakorlar ile bağlanmış bir tasarımdır. Ç3 tasarımı ise Ç1 tasarımının silindirik boru yerine helezonik bir boru ile bağlanmış hali olarak ortaya çıkmıştır. Ç5 tasarımı ise Ç1 tasarımının çelik örgü destekli kauçuk yerine termoplastik malzeme ile düşünülmüş hali olarak ortaya çıkmıştır.

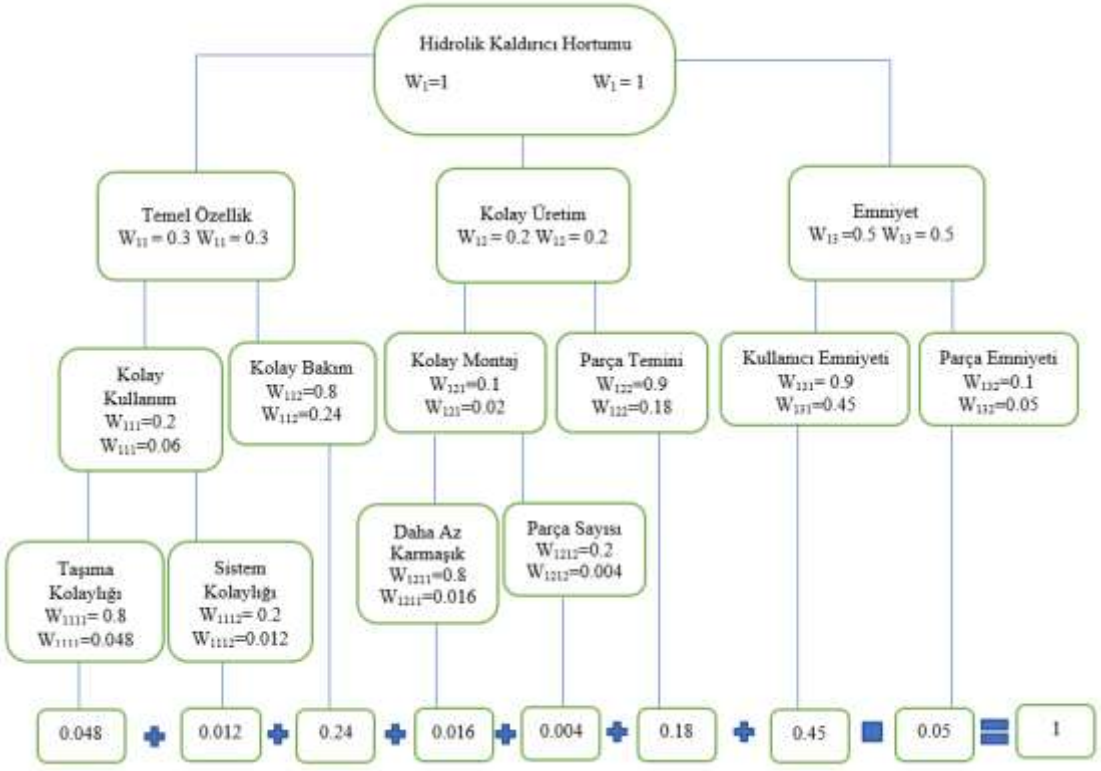
Tablo 5 Kavramsal Tasarım Ön Değerlendirilmesi (Seçim Kartı)

		SEÇİM KARTI								
Çözüm Varyasyonlarını Gir		Çözüm Seçeneklerini Değerlendir (+) Evet (-) Hayır (?) Bilgi Yetersiz (!) Tanımı Kontrol Et							KARAR Çözüm Seçeneklerini İşaretle (+) Çözümü Sürdür (-) Çözümü Elimine Et (?) Bilgi Topla Çözümü Tekrar Değerlendir	
		Tüm İşlevlere Uyumlu								
		Şartname İsteklerini Karşılar								
		Üretilebilir								
		Müsaade Edilebilir Maliyet								
		Emniyet Şartlarını Doğrudan Karşılar								
		Kolay Tasarım								
		Yeterli Bilgi								
Çözümler		A	B	C	D	E	F	G	İşaretler (Niyetler, Sebepler)	KARAR
Ç.1	1	+	+	+	+	+	+	+		+
Ç.2	2	+	+	?	+	?	+	+		?
Ç.3	3	+	+	+	+	?	+	+		+
Ç.4	4	+	+	?	-	?	?	+		?
Ç.5	4	+	+	?	+	?	+	+		+

Ç.6	6	+	+	?	?	?	+	+		?
Ç.7	7	+	+	?	+	?	?	+		?
Ç.8	8	?	-	+	+	-	+	?		-
Ç.9	9	?	-	+	+	-	+	?		-
Ç.10	10	?	-	+	+	-	+	?		-

G. Amaçlar Ağacı ve Değerlendirme Tablosu

Bu aşamada üç tasarım seçeneği daha detaylı bir şekilde incelenerek ek seçim işlemleriyle önce ikiye düşürülecek ve sonra da en ideal çözüme ulaşılacaktır. Bu ek seçim işlemlerinde önce Şekil 7'de görünen amaçlar ağacı oluşturulmuştur. Önem durumuna göre kriterlere yüzde değeri verilip bir alt basamakta bu tüm değer kriterlere paylaştırılmaktadır. Bu işlem en alt basamağa kadar devam etmektedir. En alt düzeyde kriter değerlerinin toplamı 1'e (veya 100'e) eşit olmalıdır [18]. Ek seçim işlemlerinin ikinci aşamasında ise Tablo 6'da gösterilen değerlendirmede; ilk olarak kriterler parametrelere dönüştürülmektedir. Kalan son iki tasarım seçeneğine bu parametrelere uygunluk durumuna göre puanlar verilmektedir. Seçenek puanları toplandığında ise birinci ve ikinci seçeneğin beşinci seçenekten daha yüksek toplam puana sahip olduğu görülmektedir. Bu işlem sonucu seçenek sayısı ikiye inmektedir. Buradaki son işlem bu iki seçeneğe ait Şekil 8'deki değer profil diyagramı hazırlanmasıdır. Bu grafikte kriterlerin önem durumuna (yüzdelik orana) göre dikdörtgen kalınlıkları belirlenmektedir. Kalan son iki seçeneğin kriterlerden aldıkları puanlar,

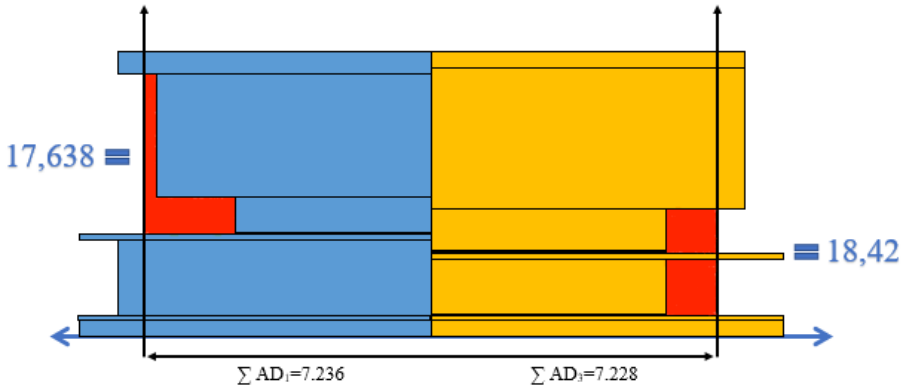


Şekil 2 Ek Seçim İşlemi: (a) Amaçlar Ağacı

dikdörtgenler ile şematik gösterilmektedir. Grafikte taralı olarak gösterilen alanlar seçeneklerin zayıf noktalarını belirtmektedir. Taralı alanı daha fazla olan $Ç_3$ seçeneği elenerek en ideal tasarım $Ç_1$ olarak seçilmiştir [18].

Tablo 6 Seçim İşlemi: (b) Değerlendirme Tablosu

Değerlendirme Tablosu				Seçenek 5			Seçenek 1			Seçenek 3		
Kriter		W	Parametreler	Oran	Değer	Ağırlık Değeri	Oran	Değer	Ağırlık Değeri	Oran	Değer	Ağırlık Değeri
1.	Taşıma Kolaylığı	0.048	Ergonomi	Fazla	8	0,384	Fazla	9	0.432	Fazla	9	0.432
2.	Sistem Kolaylığı	0.012	Kolay Kullanım	Fazla	8	0.096	Fazla	9	0.108	Fazla	9	0.108
3.	Kolay Bakım	0.24	Bakım Kolaylığı	Orta	6	1.44	Fazla	8	1.92	Orta	6	1.44
4.	Daha Az Karmaşık	0.016	Basit Kullanım	Fazla	8	0,128	Fazla	9	0.144	Fazla	9	0.144
5.	Parça Sayısı	0.004	Parça Sayısı	Orta	6	0,024	Orta	5	0.02	Orta	6	0.024
6.	Parça Temini	0.18	Parça Temini	Orta	4	0,72	Orta	5	0.9	Orta	6	1.08
7.	Kullanıcı Emniyeti	0.45	Emniyet	Orta	7	3,15	Orta	7	3.15	Fazla	8	3.6
8.	Parça Emniyeti	0.05	Güvenirlik	Fazla	8	0,4	Fazla	8	0.4	Fazla	8	0.4
∑ W=1				∑ D_5=55 ∑ AD_5=6,342			∑ D_1=62 ∑ AD_1=7.236			∑ D_3=61 ∑ AD_3=7.228		



Şekil 3 Ek seçim işlemi: (c) Değer profil diyagramı

Şekil 4 Ç1 Tasarımının Çizimi

G. Pahl ve W. Beitz Mühendislik Tasarımında Sistematik Yaklaşımına göre yapılan kavramsal tasarım sonucu oluşan çözüm uygulanması aşamasında Kaizen ekibi Tablo – 7'deki gibi bir yol izlemişlerdir [18].

Tablo 7 Kaizen Faaliyet Planı

Kök Neden #	Çözüm	Planlanan Faaliyet	Uygulama Maliyeti
1	Hortum Tasarımlarının Değiştirilmesi	Tasarım Ekiplerine Bildirimde Bulunması	-
1	Hortum Tasarımlarının Değiştirilmesi	Teknik Resme Detayların İşlenmesi	-
1	Tasarım Ekiplerine Konunun Aktarılması	Teknik Resme Detayların İşlenmesi	-
1	Hortum Sürtünmesinin Test Edilmesi	Sahada, Tezgâhta Sürtünmenin Görülmesi	-

III. BULGULAR

Hidrolik kaldırma makineleri üreten bir fabrikada gerçekleştirilen bu çalışmanın bulguları, Kaizen yaklaşımı ve yalın tasarım prensiplerinin üretim hattına adaptasyonunun etkinliğini göstermektedir. Hidrolik kaldırıcı hortumlarının sürtünme nedeniyle aşınması sorunu, yalın tasarım prensipleri kullanılarak tespit edilmiştir. Kavramsal tasarım ve sistematik tasarım yaklaşımlarıyla bu sorun ele alınmış ve tasarımsal bir geliştirme uygulanmıştır. Sorunun çözümünde Kaizen metodu kullanılmıştır. Bu metodun seçilmesi, sürekli iyileştirme ve küçük adımlarla büyük sonuçlar elde etme felsefesine dayanır. Kaizen uygulaması sayesinde, üretim hattı durdurulmadan, minimum maliyetle sorun çözülmüştür. Sorunun çözülmesiyle birlikte, üretim sürecindeki gereksiz duraklamalar ve aksaklıklar minimize edilmiştir. Bu durum, üretim hattının verimliliğinde belirgin bir artışa yol açmıştır. Üretim hattının durdurulmadan yapılan iyileştirme çalışmaları, işletmenin maliyetlerini önemli ölçüde düşürmüştür. Minimum maliyetle yapılan bu iyileştirme, işletme için ekonomik bir avantaj sağlamıştır. Hidrolik hortumların aşınma sorununun giderilmesi, nihai ürün kalitesinde bir iyileşme sağlamıştır. Daha dayanıklı ve güvenilir ürünler üretilerek müşteri memnuniyetinin artırılması hedeflenmiştir. Kaizen yaklaşımı, çalışanların sürece aktif katılımını teşvik etmiş ve onların önerileri doğrultusunda iyileştirmeler yapılmıştır. Bu katılım, çalışan memnuniyeti ve motivasyonunu artırmıştır. Üretim hattının durdurulmadan iyileştirme yapılması, üretim sürekliliğini sağlamış ve üretim kayıplarını önlemiştir. Bu süreklilik, siparişlerin zamanında teslim edilmesine ve müşteri memnuniyetinin korunmasına katkı sağlamıştır.

IV. TARTIŞMA

Yalın tasarım ve Kaizen metodolojilerinin birlikte kullanılması, üretim süreçlerinde verimlilik ve kaliteyi artırma konusundaki etkinliğini daha da pekiştirmektedir. Örneğin Otomotiv sektöründeki yalın üretim ve tasarım uygulamalarının tarihçesi ve gelişimi üzerine yapılan çalışmalar, bu metodolojilerin uzun vadeli sürdürülebilir rekabet avantajı sağladığını ortaya koymaktadır [19]. Bir başka örnek olarak elektronik sektöründe yalın tasarım ve Kaizen uygulamaları, ürün geliştirme süreçlerini hızlandırarak pazara sunma süresini kısaltmış ve üretim maliyetlerini düşürmüştür [20].

Bu çalışmanın bilime katkıları, yalın tasarım ve Kaizen metodolojilerinin entegre kullanımıyla çeşitli yönlerden derinlemesine incelenmesiyle ortaya çıkmaktadır. Çalışma, yalın tasarım ve Kaizen prensiplerinin farklı sektörlerde ve üretim süreçlerinde uygulanabilirliğini ve etkinliğini teyit eder. Bu, teorik bilgi birikimine pratik uygulama örnekleri ekleyerek literatürü zenginleştirir. Yalın tasarım ve Kaizen'in süreç iyileştirme ve verimlilik artırma konularındaki etkinliğini gösteren örnekler, diğer araştırmalara ve uygulamalara ilham verir. Bu, işletmelerin operasyonel süreçlerde yenilikçi çözümler geliştirmesine katkı sağlar. Yalın tasarımın ürün geliştirme süreçlerine entegrasyonu, pazara sunma süresini kısaltır ve ürün kalitesini artırır. Bu, işletmelerin pazar rekabetinde avantaj sağlamasına yardımcı olur ve literatürde ürün geliştirme süreçlerine yönelik yeni bakış açıları sunar. Yalın tasarım ve Kaizen uygulamalarının çevresel sürdürülebilirlik üzerindeki etkileri, çevre dostu üretim süreçleri ve sürdürülebilir endüstriyel çevre sunar.

V. SONUÇLAR

Bu çalışma ile üretim hatlarında tasarımdan meydana gelen değişikliklerde, üretim hattının durdurulmadan veya herhangi bir maliyet gerektirecek değişikliğe uğratmadan devamı sağlamanın çözümü

aranmıştır. Bir üretim hattındaki bir parça tasarımının değişikliği göz önüne alınarak yapılan çalışmada herhangi bir maliyet yaratmadan tasarım değişikliği sisteme monte edilebilmiş ve somut kazanç sağlanmıştır. Bu sonuç önemlidir çünkü günümüz ekonomik koşullarında maliyetlerin her kalemde her türlü arttığı (hammadde, enerji, iş gücü ve benzeri) ortamda her bir parçadan kazanç sağlamak toplam ürün yönetiminde çok avantaj sağlamaktadır. Bu araştırma hali hazırda mükemmele yakın bir tesiste yapıldığı için daha fazla kazanımların olup olmadığı hususu başka tesislerde de yapılarak bir başka çalışmanın konusu olabilir. Bu sonuç daha ileri düzeylerde ve farklı ortamlarda araştırma yapma açısından önemlidir. Bu araştırma sonuçları istenildiğinde veya talebe göre parasal değer olarak belirtilebileceği gibi zaman, hammadde, iş gücü, enerji gibi diğer faktörler açısından da ifade edilebilir. Bu çalışma, yalın üretim konusunda daha önce yapılan daha önceki çalışmalarla da paralellik gösterecek şekilde sonuçlanmıştır. Yalın üretim, son kullanıcının ilgilenmediği alanlardaki kazançları ile bu araştırmada da olumlu sonuçlar vermiştir. Bu araştırma, endüstriyel tasarım uygulamalarının gerçek hayatta maliyet kaynaklı karşılaşabileceği sorunların üstesinden gelme noktasında bilimsel bir yol açmıştır. Daha inovatif daha faydalı tasarımların maddi kaygılardan dolayı önünün kesilmesi veya tasarım değişikliklerinden kaçınılması gibi durumlarda yalın üretim tekniklerini bir çözüm olarak ortaya koymuştur. Gelişen teknoloji ve endüstri 4.0 yaklaşımları endüstriyel tasarımı her ne kadar daha da önemli hale getirse de günümüz ekonomik koşulları tasarımcıları maliyet konusunda gittikçe daha da zorlayacaktır. Bu noktada bu çalışma tasarımcılara bir fikir verecektir.

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Classification of Android Malware Using Random Forest Approaches

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Abstract – Mobile and IoT devices have become very common and affordable with the development of technology in recent years. Naturally, many software programs have been developed and are being developed in this field. With the increase in devices with Android operating system, software that opens the application data of devices with this operating system to the public without permission and removes device permissions is also being developed. These data and permissions may contain information and data that are inconvenient for individuals and organizations to be known by others. In order to prevent these situations, there is an urgent need for software that detects and identifies malicious software. In this paper, we focus on the classification of malware targeting applications running on the Android operating system. In this context, the performance of different approaches of the Random Forest algorithm on the TUNADROMD (Android Malware) database, which is a recent dataset, is analyzed. In the classification process, different estimator numbers of the Random Forest classification algorithm, one of the machine learning algorithms, were taken into account. The results of the experimental study by changing the number of estimators of the Random Forest algorithm are given. As a result of the tests, Accuracy and Mean Squared Error values of Goodware and Malware values were analyzed according to Precision, Recall, F1 score and Estimator number. The F1 score and accuracy value exceeding 0.99 were achieved while presenting negligible false positive and false negative rates in the results. According to these values, the interpretability of the overall system is improved.

Keywords – Android, Random Forest, Classification, Algorithm, Mobile, IoT

I. INTRODUCTION

The Android operating system plays an important role not only for personal use, but also in many industrial controls such as smart homes, healthcare, automotive industry and many more. Due to different reasons such as price and ease of use, mobile applications with android operating system are expanding and their operability in IoT devices is increasing [1]. Android offers user-friendly applications that facilitate button control with a unified interface. These applications include software that can be used for different purposes such as IoT. There is a security and privacy attack on portable devices with the Android operating system, as the usage area is expanding day by day [2], [3], [4].

The security problem caused by malware has led to significant security risks in mobile devices used in different areas, especially IoT. These malware are at a level that can cause data breaches, unauthorized use and privacy issues on mobile devices. Devices with inadequate security levels are at great risk. Malware poses a great risk by making the application data of the mobile device public [5]. Damaged mobile devices are also highly likely to be used in DDoS attacks by non-user malicious actors [1]. The risk is even greater when the device under such attack is a portable device using an android operating system that manages a smart home system. Malware is impacting many areas, from excessive data consumption to data breaches, from unauthorized remote control to financial fraud [6], [7].

It is recommended that all portable devices with Android operating system install mobile applications from the google play store area [8], [9]. Installing apps from different sources on mobile devices increases the impact of malware [10]. Different mechanisms and methods, such as encryption, are applied to reduce the impact of malware [10], [11].

Many antivirus companies have entered into studies to detect and eliminate malware developed for the android operating system. However, they state that downloads outside the google play store increase the number of malicious software [12]. 13% of Android apps are downloaded from sources outside the google play store environment [1]. Cyber attackers who attack mobile devices often use software that appears to be legitimate. Android users should carefully review the permission requests before installing the application.

The following sections of the article consist of four parts. The second section summarizes the related work. The third section introduces the dataset samples and the algorithm used in the paper. Section four presents the results of the random forest algorithm at different estimator values. The fifth section concludes the paper.

II. Related Works

Çetiner classified the data damaging the Android operating system with different kernel types of SVM algorithm [13]. Aug et al. classified web pages with random forest algorithm [14]. They tried to categorize internet data into different categories by classifying web pages. Azar et al. tried to classify the most distinctive attributes in lymph diseases with random forest. They achieved a good performance with the integrated use of genetic algorithm and random forest algorithm by removing unnecessary elements. Song et al. performed classification using random forest algorithm on a fingerprint dataset consisting of nine different classes. Pal successfully classified data consisting of images of a field near Littleport in Cambridgeshire, England using random forest [15]. Garcia et al. conducted experimental studies on information obtained on 4616 patients being treated at the University Hospital of Salamanca [16]. Among different machine learning algorithms, the random forest algorithm is reported to give the best results.

Belgiu and Dragut investigate the existence of random forest algorithm in remote sensing systems [17]. They recommend that methods such as proximity analysis should be used to detect outliers in the training samples of the data they use during research. Galiano et al. used the random forest algorithm for effective classification of a complex landscape in terms of natural cover. [18]. In their research, they use 14 different terrain data, Landsa- 5 thematic mapping data from the south of Spain.

Wajahat et al. want to distinguish between malicious and benign android operating system software [1]. In their work, they are not only concerned with identifying benign and malignant software written for the Android operating system, but also investigating the spread of such software in the Interest of Things (IoT) space.

III. Materials and Method

A. Material

The dataset, known as the TUNADROMD dataset in the literature, contains 4665 pieces of sample information. Studies using the related dataset [13], [19], [20], [21], [22], [23], [24] . This article focuses on the classification of good and malicious software targeting software running on the Android operating system [19], [25]. In the classification process, different estimator numbers of the Random Forest classification algorithm, one of the machine learning algorithms, were taken into account. The classification results of the Random Forest algorithm with the default number of estimators were found to be effective.

B. Random Forest

Proposed in 2001 by Leo Breiman, the Random forest algorithm was developed at the University of California [26]. Many decision classifiers come together to form the Random Forest algorithm. In the Random Forest algorithm, after the training is completed, a data that is not used in the training in the dataset is given as input to the model, and it is an algorithm that decides according to the result voting from many independent decision makers.

Parmar et al. summarized the working principles of the Random Forest algorithm in their study [27]. First, it assigns a number of elements to each attribute subset. Second, it randomly selects one of the attribute subsets. Third, it performs training for different training groups using the attribute subsets of each training group. Finally, a test data, which is not used in training, is used to determine the class with the data outputs from each sub-decision tree.

IV. Experimental Results and Discussion

In this section of the paper, we analyze the performance of different approaches of the Random Forest algorithm on a recent Android Malware dataset. The results of the experimental study by changing the number of estimators of the Random Forest algorithm are presented in the tables between Table 1 and Table 8. At the same time, the graphs of the obtained results are presented in this section.

Looking at the results in Table 1, the performance values obtained in the Random Forest algorithm when the number of estimators is 0 are quite high.

Table 1. Performance values obtained with Random Forest when the number of estimators is 0

Class	Precision	Recall	F1 score	Estimator number
Goodware	0.99	0.99	0.99	0
Malware	1.00	1.00	1.00	0
Accuracy		0.9955		
Mean Squared Error		0.00448		

Looking at the results in Table 2, although the number of estimators increases, the results decrease slightly. Mean Square Error (MSE) value increases. The accuracy value is reduced from 0.9955 to 0.9928.

Table 2. Performance values obtained with Random Forest when the number of estimators is 10

Class	Precision	Recall	F1 score	Estimator number
Goodware	0.99	0.97	0.98	10
Malware	1.00	1.00	1.00	10
Accuracy		0.9928		
Mean Squared Error		0.00717		

When we look at the results in Table 3, the number of estimators increases and values close to the results of estimator 0 are obtained. The MSE value increases according to the results of estimator 0. The accuracy value is reduced from 0.9955 to 0.9946. It can be said that when the number of estimators is 0, it gives better results than 10 and 15 estimator values.

Table 3. Performance values obtained with Random Forest when the number of estimators is 15

Class	Precision	Recall	F1 score	Estimator number
Goodware	0.99	0.99	0.99	15
Malware	1.00	1.00	1.00	15
Accuracy		0.9946		
Mean Squared Error		0.00538		

When we look at the results in Table 4, the results at estimator 0 were obtained by increasing the number of estimators. It can be said that when the number of estimators is 0, it gives better results than 10 and 15 estimator values.

Table 4. Performance values obtained with Random Forest when the number of estimators is 20

Class	Precision	Recall	F1 score	Estimator number
Goodware	0.99	0.99	0.99	20
Malware	1.00	1.00	1.00	20
Accuracy		0.9946		
Mean Squared Error		0.00538		

When we look at the results in Table 5, the number of estimators increases and values close to the results of estimator 0 are obtained. The MSE value increases according to the results of estimator 0. The accuracy value is reduced from 0.9955 to 0.9937. It can be said that when the number of estimators is 0, it gives better results than 10, 15 and 20 estimator values.

Table 5. Performance values obtained with Random Forest when the number of estimators is 25

Class	Precision	Recall	F1 score	Estimator number
Goodware	0.98	0.99	0.98	25
Malware	1.00	1.00	1.00	25
Accuracy		0.9937		
Mean Squared Error		0.00627		

When we look at the results in Table 6, the results at estimator 0 were obtained by increasing the number of estimators. When the number of estimators is 30, it can be said that it gives better results than estimator values of 10, 15, 20 and 25.

Table 6. Performance values obtained with Random Forest when the number of estimators is 30

Class	Precision	Recall	F1 score	Estimator number
Goodware	0.98	0.99	0.98	30
Malware	1.00	1.00	1.00	30
Accuracy		0.9946		
Mean Squared Error		0.00538		

When we look at the results in Table 7, the number of estimators increases and values close to the results of estimator 0 are obtained. The MSE value increases according to the results of estimator 0. When the number of estimators is 100, it can be said that it gives better results than estimator values of 10, 15, 25 and 30.

Table 7. Performance values obtained with Random Forest when the number of estimators is 100

Class	Precision	Recall	F1 score	Estimator number
Goodware	0.99	0.99	0.99	100
Malware	1.00	1.00	1.00	100
Accuracy		0.9955		
Mean Squared Error		0.00448		

When we look at the results in Table 8, the number of estimators increases and values close to the results of estimator 0 are obtained. The MSE value increases according to the results of estimator 0. When the number of estimators is 200, it can be said that it gives better results than 10, 15, 25 and 30 estimator value.

Table 8. Performance values obtained with Random Forest when the number of estimators is 200

Class	Precision	Recall	F1 score	Estimator number
Goodware	0.99	0.99	0.99	200
Malware	1.00	1.00	1.00	200
Accuracy		0.9955		
Mean Squared Error		0.00448		

In general, when the values between Table 1 and Table 8 are examined, even if the number of estimators is the same in precision, recall, F1 score values, there may be a difference in MSE value.

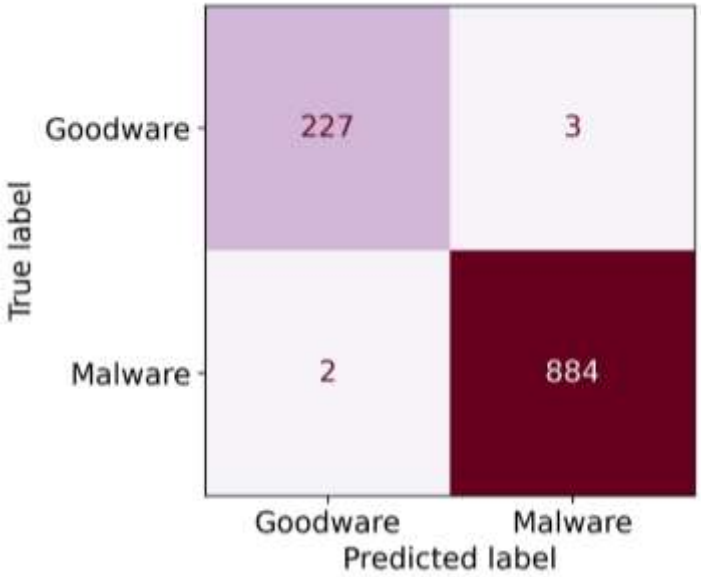

Fig. 1. 0 confusion matrix result of Random Forest algorithm with estimator number

The reflection of the results in Table 1 in the confusion matrix table is given in Fig. 1. As a result, there are differences in the reflection of the number of estimators on the confusion matrix.

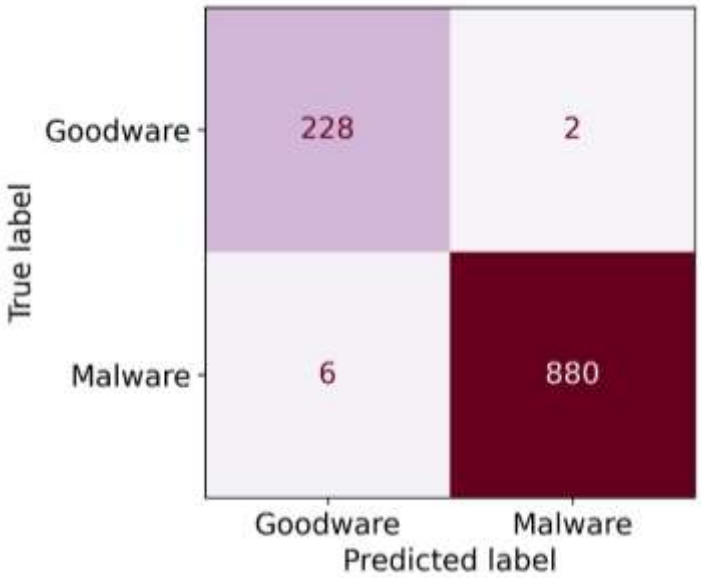

Fig. 2. Confusion matrix result of Random Forest algorithm with 10 estimators

The reflection of the results in Table 2 in the confusion matrix table is given in Fig. 2. As a result, there are differences in the reflection of the number of estimators on the confusion matrix.

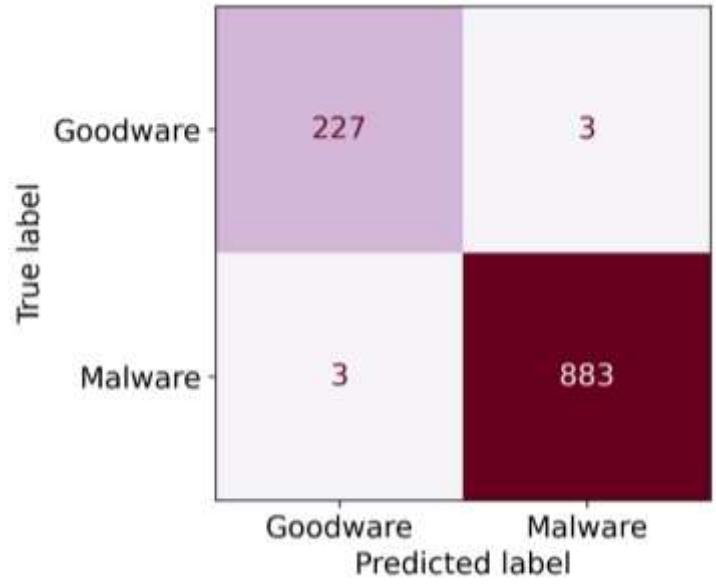

Fig. 3. 15 confusion matrix results of the Random Forest algorithm with estimator number

The reflection of the results in Table 3 in the confusion matrix table is given in Fig. 3. As a result, there are differences in the reflection of the number of estimators on the confusion matrix.

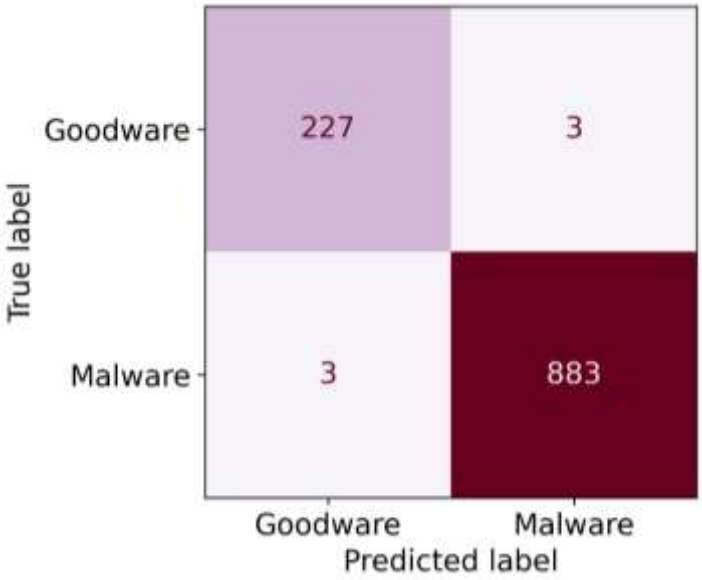

Fig. 4. 20 confusion matrix result of Random Forest algorithm with estimator number

The reflection of the results in Table 4 in the confusion matrix table is given in Fig. 4. As a result, there are differences in the reflection of the number of estimators on the confusion matrix.

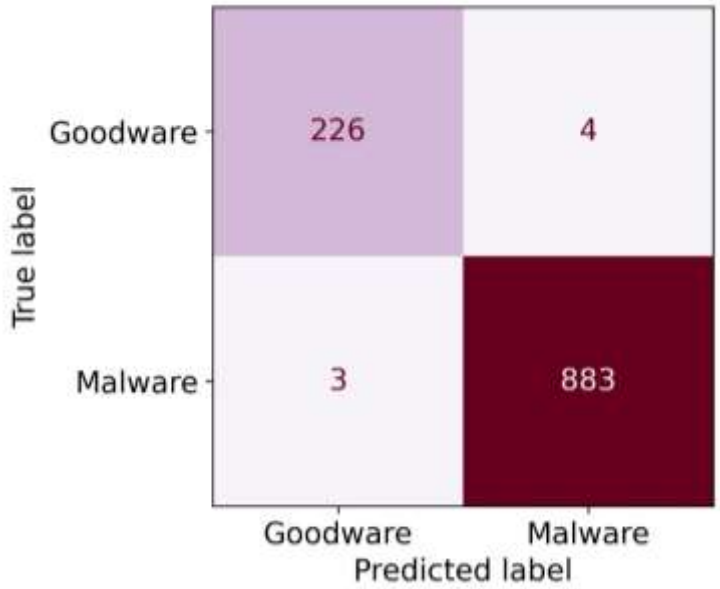

Fig. 5. 25 confusion matrix results of the Random Forest algorithm with estimator number

The reflection of the results in Table 5 in the confusion matrix table is given in Fig. 5. As a result, there are differences in the reflection of the number of estimators on the confusion matrix.

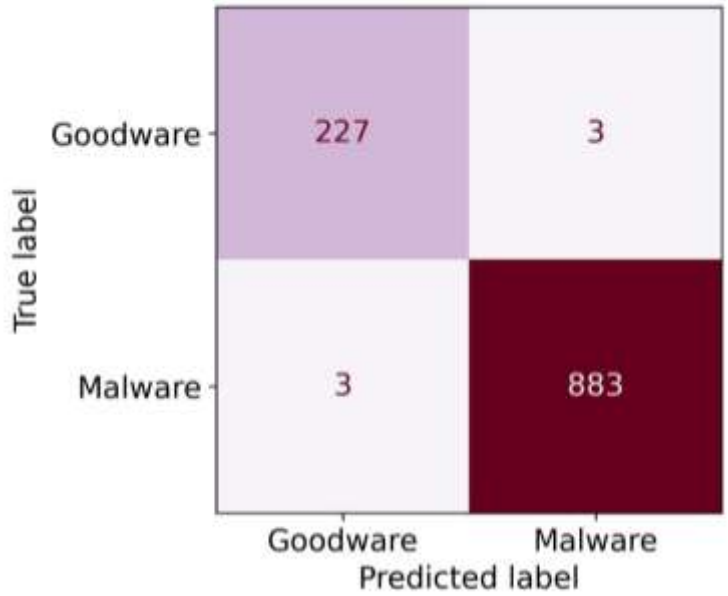

Fig. 6. 30 confusion matrix result of Random Forest algorithm with number of estimators

The reflection of the results in Table 6 in the confusion matrix table is given in Fig. 6. As a result, there are differences in the reflection of the number of estimators on the confusion matrix.

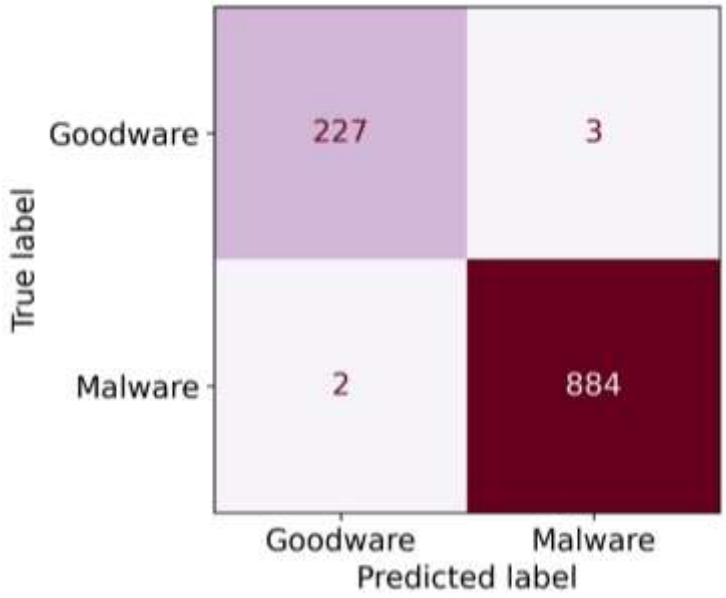

Fig. 7. Confusion matrix result of Random Forest algorithm with 100 estimators

The reflection of the results in Table 7 in the confusion matrix table is given in Fig. 7. As a result, there are differences in the reflection of the number of estimators on the confusion matrix.

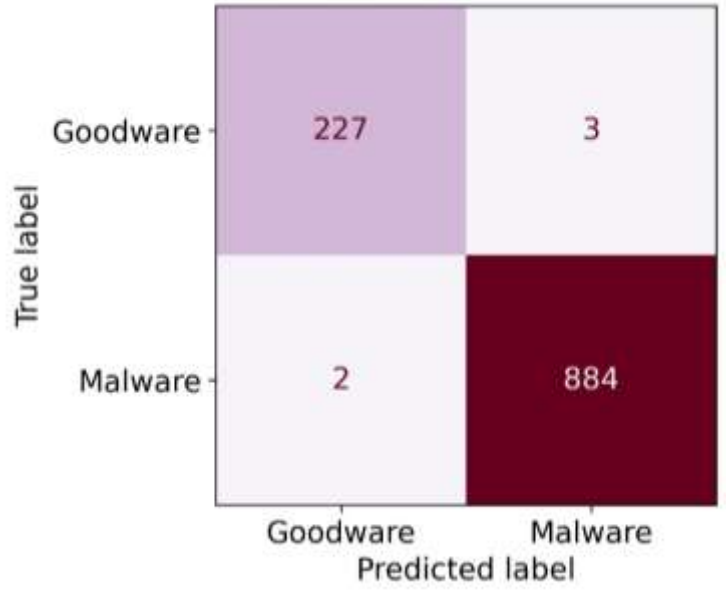

Fig. 8. Confusion matrix result of the Random Forest algorithm with 200 estimators

The reflection of the results in Table 8 in the confusion matrix table is given in Fig. 8. As a result, there are differences in the reflection of the number of estimators on the confusion matrix.

V. CONCLUSION

The use of IoT and mobile devices running on the Android operating system is increasing day by day around the world. In addition to this, malware known as cyber-attacks on these devices and malware that disrupts the current functioning and causes material and moral damages are increasing. In this article, we share the classification results obtained with different estimator values of the Random Forest method to be applied on the TUNADROMD database on the Kaggle platform. In general, when the values between Table 1 and Table 8 are analyzed, even if the precision, recall, F1 score values are the same, there may be a difference in the MSE value according to the number of estimators. Estimator values of 0, 100 and 200 give

the best results, while the others are close to these values. When the performance results in these parameters are examined in detail, even if all other performance results are the same, there are differences in MSE values. It can be stated that malware written for the Android operating system can be classified according to the results obtained.

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The Mediating Role of Corporate Image and Job Satisfaction in the Effect of Internal Marketing on Employee Performance

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Abstract – The aim of this study is to examine the effect of internal marketing on employee performance and the mediating roles of both corporate image and job satisfaction in this effect. A face-to-face survey was used to collect the research data. Data were collected from 278 employees of a national cargo company. Jamovi software was used to perform statistical analyses of the data collected. The results of the statistical analysis show that internal marketing has a direct positive effect on employee performance and also that internal marketing has an indirect effect on employee performance through the mediating roles of both corporate image and job satisfaction. In addition, internal marketing has a direct positive significant effect on corporate image and job satisfaction, while corporate image and job satisfaction have a direct positive effect on employee performance. The results obtained are discussed.

Keywords – Internal Marketing, Corporate Image, Job Satisfaction, Employee Performance

INTRODUCTION

Internal marketing is based on the view of ensuring the satisfaction of employees, who are also referred to as internal customers and interact one-to-one with external customers, and constitutes the intersection point of the marketing and human resources functions of the enterprise [1]. In this context, businesses' orientation towards the satisfaction of internal customers with various tools and techniques that will increase the motivation of employees will facilitate the formation of employees who adopt corporate values and internalise organisational goals [2].

The purpose of this study is to determine the effect of the mediating role of corporate image and job satisfaction on the effect of internal marketing practices on employee performance. Internal marketing and strategies applied to increase employee performance are important for businesses. Employees, who are the most important resource of enterprises, are considered to be the most important determinants of the success of enterprises. In order to reveal the situation of the subject in practice, an application was carried out for a cargo company. It is thought that this study will be a guide for business managers in terms of positively affecting the corporate image perception of their employees by applying internal marketing and increasing employee performance by positively affecting their job satisfaction.

LITERATURE REVIEW AND HYPOTHESES

Internal marketing strategy, which has its origins in marketing research in the service sector [3-4], emerged from the idea that businesses in the service sector should value, respect and see their employees as "internal customers" and that customer satisfaction depends on employee satisfaction [5].

Internal marketing is defined as working to attract, develop, motivate and maintain high quality staff by providing employees with the work products they need [6]. Accordingly, internal marketing consists of an

organisation's efforts to train and motivate its employees to provide better service [7-8]. Previous studies have shown that internal marketing activities have a positive relationship with employee performance [8-9-10-11]. Therefore, we propose the following hypothesis:

H_1: Internal marketing has a significant and positive effect on employee performance.

Corporate image refers to the sum of the images that customers, investors, employees, supporters and society in general have of a company [12]. Positive impressions of well-managed and participatory businesses that do things for the benefit of the society in which they are located, produce projects, are sensitive to culture, art and environmental issues, turn into a good corporate image for them over time [13]. Studies in the literature show that internal marketing represents an important component in creating corporate image and affects the perception and satisfaction of customers [14-15-16]. In the light of this information, the following hypothesis is formed:

H_2: Internal marketing has a significant and positive effect on corporate image.

Job satisfaction is defined as the satisfaction seen as a result of the compatibility between work life or workplace conditions and the positive attitude that people have towards their jobs [17]. In many studies in the literature, there are findings that internal marketing has a significant effect on job satisfaction [18-19-20-21-22-23]. Therefore, we consider that:

H_3: Internal marketing has a significant and positive effect on job satisfaction.

Employees' perception of a positive image of their organisation will lead to an increase in their effort and performance [24]. According to management scientists, a good corporate image perception can give employees a positive perspective, enable employees to develop positive attitudes towards the business and managers, and thus a meaningful bond between the person and the business can be formed through positive image [25-26]. Studies show that corporate image is perceived as a status indicator and as a result, it increases the performance of employees [2-27-28-29-30]. Therefore, we propose the hypothesis:

H_4: Corporate image has a significant and positive effect on employee performance.

In general terms, job satisfaction refers to "the general attitude that individuals have towards their jobs" [31]. Ensuring job satisfaction in businesses has a significant effect on the quality of the activities to be performed by employees [32]. Previous studies report that job satisfaction has positive effects on employee performance [33-34-35-36]. The following hypothesis was formed based on this information.

H_5: Job satisfaction has a significant and positive effect on employee performance.

As in the previous sections, it has been argued that internal marketing, corporate image and job satisfaction have an impact on employee performance and that corporate image and job satisfaction are important outcomes of internal marketing practices. Therefore, it is important to check whether there is a mediating role of corporate image and job satisfaction on employee performance. Therefore, the following hypotheses can be put forward:

H_6: Corporate image has a mediating role in the effect of internal marketing on employee performance.

H_7: Job satisfaction has a mediating role in the effect of internal marketing on employee performance.

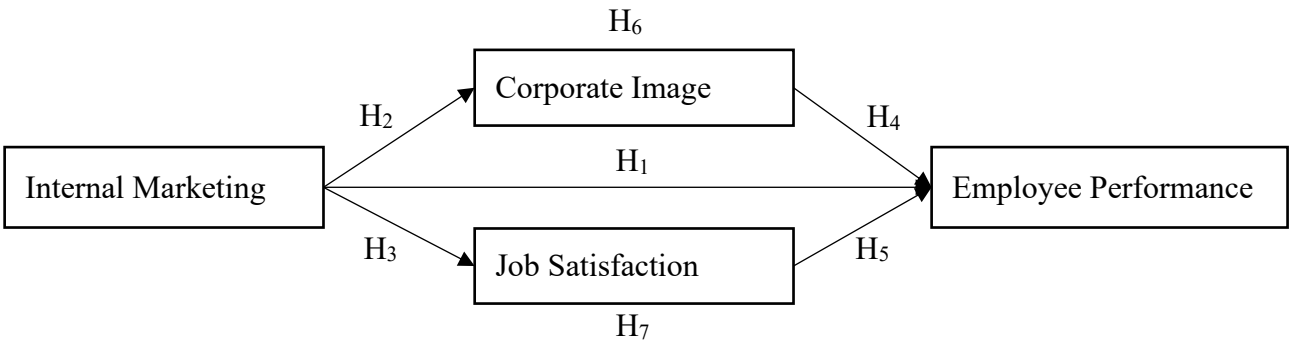

Figure 1. Research Model

MATERIALS AND METHOD

Items from the scales on internal marketing [37], corporate image [38], job satisfaction [39] and employee performance [40] have been adapted from previous studies for use in this study.

Data were collected through a face-to-face survey from 278 employees of a national cargo company. The sample size of 278 people is more than 10 times larger than the total of 23 scale items used in this study [41]. The sample size therefore meets the criteria for a minimum sample size.

The result of Harman's one-factor test is 48.42%, which is <50% [42]. In addition, Table 5 shows that the correlation coefficient between the two factors is <.90 [43]. According to these results, there is no problem of common method variance bias in the data set obtained.

Data analysis was performed using Jamovi software [44-45]. The results of the statistical analyses are reported on the following pages.

RESULTS

Table 1 shows that the number of employees who are male (Counts=240; 86.33 %), married (Counts=251; 90.29 %), aged 30-39 (Counts=133; 47.84 %), have a bachelor's degree (Counts=120; 43.17 %) and have 6-10 years' service (Counts=89; 32.01 %) is higher.

Table 1. Results of Frequency Analysis

Gender	**Counts**	**% of Total**	**Cumulative %**
Female	38	13.67 %	13.67 %
Male	240	86.33 %	100.00 %
Marital Status	**Counts**	**% of Total**	**Cumulative %**
Married	251	90.29 %	90.29 %
Single	26	9.35 %	99.64 %
Divorced	1	0.36 %	100.00 %
Age	**Counts**	**% of Total**	**Cumulative %**
18-29 years old	13	4.68 %	4.68 %
30-39 years old	133	47.84 %	52.52 %
40-49 years old	66	23.74 %	76.26 %
50-59 years old	57	20.50 %	96.76 %
≥60 years old	9	3.24 %	100.00 %
Education Level	**Counts**	**% of Total**	**Cumulative %**
High school graduate	83	29.86 %	29.86 %
Associate degree	66	23.74 %	53.60 %
Bachelor's degree	120	43.17 %	96.76 %
Postgraduate	9	3.24 %	100.00 %
Service Time	**Counts**	**% of Total**	**Cumulative %**
<1 year	7	2.52 %	2.52 %
1-5 years	17	6.12 %	8.63 %
6-10 years	89	32.01 %	40.65 %
11-15 years	62	22.30 %	62.95 %
16-20 years	33	11.87 %	74.82 %
>20 years	70	25.18 %	100.00 %

As a result of the exploratory factor analysis in Table 2, it can be seen that the KMO of each of the four factor dimensions is >0.70, the p-value is <0.05 [46] and the explained variance is >.52.03 [47], while the factor loadings of the items of the four factor dimensions are >0.50 [41].

Table 2. Results of Exploratory Factor Analysis

Internal Marketing	**Factor Loading**	**% of Variance**	**Bartlett's Test of Sphericity**			**KMO Measure of Sampling Adequacy**
			χ^2	**df**	**p**	
IM1	0.638	54.5	2082	45	0.00	0.898
IM2	0.703					
IM3	0.749					
IM4	0.737					
IM5	0.691					
IM6	0.736					
IM7	0.834					
IM8	0.800					
IM9	0.732					
IM10	0.745					
Corporate Image	**Factor Loading**	**% of Variance**	**Bartlett's Test of Sphericity**			**KMO Measure of Sampling Adequacy**
			χ^2	**df**	**p**	
CI1	0.782	68.0	689	6	0.00	0.798
CI2	0.861					
CI3	0.916					
CI4	0.727					
Job Satisfaction	**Factor Loading**	**% of Variance**	**Bartlett's Test of Sphericity**			**KMO Measure of Sampling Adequacy**
			χ^2	**df**	**p**	
JS1	0.739	73.2	1170	10	0.00	0.882
JS2	0.890					
JS3	0.917					
JS4	0.921					
JS5	0.794					
Employee Performance	**Factor Loading**	**% of Variance**	**Bartlett's Test of Sphericity**			**KMO Measure of Sampling Adequacy**
			χ^2	**df**	**p**	
EP1	0.780	68.0	690	6	0.00	0.803
EP2	0.926					
EP3	0.878					
EP4	0.696					

The reliability analysis results in Table 3 show that both Cronbach's α and McDonald's ω values of the internal marketing, corporate image, job satisfaction and employee performance scales are >0.70 [48].

Table 3. Results of Reliability Analysis

Scale	**Mean**	**Standard Deviation**	**Cronbach's α**	**McDonald's ω**
Internal Marketing	4.28	0.540	0.922	0.923
Corporate Image	4.21	0.655	0.891	0.894
Job Satisfaction	4.16	0.724	0.930	0.931
Employee Performance	4.29	0.625	0.889	0.894

The results of the normality test in Table 4 show that the skewness and kurtosis values of the four factor dimensions are between ±2 and therefore the data have a normal distribution [49].

Table 4. Results of Normality Test

Descriptives	**Internal Marketing**	**Corporate Image**	**Job Satisfaction**	**Employee Performance**
Mean	4.28	4.21	4.16	4.29
Standard error mean	0.0324	0.0393	0.0434	0.0375
Median	4.20	4.00	4.00	4.13
Standard deviation	0.540	0.655	0.724	0.625
Variance	0.291	0.429	0.525	0.391
Minimum	2.40	2.00	1.20	1.25
Maximum	5.00	5.00	5.00	5.00
Skewness	-0.503	-0.605	-1.01	-0.927
Standard error skewness	0.146	0.146	0.146	0.146
Kurtosis	0.387	0.270	1.87	1.95
Standard error kurtosis	0.291	0.291	0.291	0.291

The results of the correlation analysis in Table 5 show that there is a significant and positive relationship between all four factors, while the Pearson's r between the two factors is < 0.90.

Table 5. Results of Correlation Analysis

Correlations		Internal Marketing	Corporate Image	Job Satisfaction	Employee Performance
Internal Marketing	Pearson's r	—			
	df	—			
	p-value	—			
Corporate Image	Pearson's r	0.707***	—		
	df	276	—		
	p-value	0.000	—		
Job Satisfaction	Pearson's r	0.625***	0.682***	—	
	df	276	276	—	
	p-value	0.000	0.000	—	
Employee Performance	Pearson's r	0.558***	0.562***	0.617***	—
	df	276	276	276	—
	p-value	0.000	0.000	0.000	—
Note: * p < 0.05, ** p < 0.01, *** p < 0.001					

To test the research model, the results of the GLM mediation model are presented in Table 6. The results show that internal marketing-IM has a significant and positive effect on corporate image-CI (β=0.707; p<0.05), job satisfaction-JS (β=0.625; p<0.05) and employee performance-EP (β=0.212; p<0.05), while the positive effect of corporate image-CI (β=0.154; p<0.05) and job satisfaction-JS (β=0.379; p<0.05) on employee performance-EP is also significant. In addition, both corporate image-CI (β=0.109; p<0.05) and job satisfaction-JS (β=0.237; p<0.05) play a mediating role in the positive effect of internal marketing-IM on employee performance-EP. These results show that all hypotheses are supported.

Table 6. GLM Mediation Model Results for Testing the Research Model

Type	**Hypothesis**	**Effect**	**Estimate**	**Standard Error**	**95% Confidence Intervals**		**β**	**z**	**p**
					Lower	**Upper**			
Direct	H_1	IM⇒EP	0.246	0.0767	0.0953	0.396	0.212	3.20	0.001
Component	H_2	IM⇒CI	0.859	0.0515	0.7582	0.960	0.707	16.69	0.000
	H_3	IM⇒JS	0.840	0.0628	0.7165	0.963	0.625	13.37	0.000
	H_4	CI⇒EP	0.147	0.0674	0.0147	0.279	0.154	2.18	0.030
	H_5	JS⇒EP	0.327	0.0552	0.2191	0.435	0.379	5.93	0.000
Indirect	H_6	IM⇒CI⇒EP	0.126	0.0584	0.0117	0.240	0.109	2.16	0.031
	H_7	IM⇒JS⇒EP	0.275	0.0507	0.1755	0.374	0.237	5.42	0.000
Total	H_{Total}	IM⇒EP	0.646	0.0578	0.5332	0.760	0.558	11.19	0.000
Note: IM= Internal Marketing, CI= Corporate Image, JS= Job Satisfaction, EP= Employee Performance									

DISCUSSION AND CONCLUSION

The positive effects of internal marketing practices on businesses have been revealed by various studies. According to the research results that are in parallel with our study, internal marketing has a positive effect on corporate image [50-51-52], employee performance [53-54-55] and job satisfaction [2-56-57-58], while corporate image has a positive effect on employee performance [59-60-61] and job satisfaction has a significant and positive effect on employee performance [62-63-64].

In this study conducted for a cargo company, as mentioned above, findings that are in parallel with the literature have been reached. Accordingly, it is seen that internal marketing has a direct positive effect on employee performance, corporate image and job satisfaction, while internal marketing has an indirect effect on employee performance through the mediating roles of both corporate image and job satisfaction. According to these results, it can be said that effective internal marketing activities can increase corporate image and job satisfaction in cargo companies.

These results show that businesses operating in a competitive environment should attach importance to internal marketing practices. In this context, marketers should develop and adopt various marketing practices within the company. In particular, increasing the number of satisfied customers through internal marketing practices will contribute positively to increasing the share of the business in the market and will contribute to increasing profit rates. Internal marketing requires investment in human resources and envisages that this investment will be returned as high performance and high customer satisfaction. As a matter of fact, Papasolomou (2003) argues that unless awareness and understanding of internal marketing practices increase, it will be impossible to cope with rival organisations that have adapted internal marketing to the entire management and marketing process [65].

In summary, the results of this research are considered to be important in terms of contributing to the marketing and management literature and filling a gap in the service sector. There are also some limitations that should be considered while evaluating the findings of the research. The findings obtained are for a cargo company in the service sector. Therefore, it cannot be said that these findings can be generalised for other cargo companies or other enterprises operating in the service sector.

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Diminishing Linguistic Taboos in Pakistani Society: A Descriptive Analysis

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Abstract **–** Language, according to Halliday (1978), is a social semiotic phenomenon, and is thus, inseparable from society. Rapid societal transformations are being observed in the contemporary world owing to globalization and technological advancements. Due to this evolution of societal norms and practices, notable changes are also occurring in language and its structures including the perception and usage of linguistic taboos. The current research examines the variation in the perception and usage of linguistic taboos across different generations and genders in Pakistani society. Additionally, it also explores how Pakistani bilinguals perceive and use linguistic taboos differently in their first versus their second language. The data for the present study was collected through a web-based questionnaire that was filled by one hundred Urdu-English bilinguals who were equally divided into four groups based on their age and gender. The data was analyzed using quantitative methods of research. The study revealed that gender did not significantly influence perspectives on linguistic taboos, whereas the age of participants showed a notable difference in perceptions. This indicates that the diminishing of linguistic taboos is not gender-dependent but is associated with age. Although there is an overall decline in linguistic taboos, certain taboos still maintain their offensive nature. The data analysis highlights the significant role of social media, parents, and peers in exposing children to abusive and taboo language. Additionally, how taboo words and swear words are expressed can influence the perception that bilingual learners develop regarding them.

Keywords – Linguistic taboos, bilingualism, emotional force, perception and usage of linguistic taboos, abusive language

I. INTRODUCTION

Language, according to Halliday (1978), is a social semiotic phenomenon, meaning that it cannot exist in isolation from society. In the present era, the forces of globalization and technological progress are driving rapid transformations in society. Consequently, language and its structures are also undergoing significant changes. As societal norms and practices evolve in response to these shifts, linguistic taboos are likewise subject to alteration.

Linguistic Taboos

Linguistic taboos are possessed by each language owing to the norms, values, and traditions of the culture and society to which that language belongs. They can denote various concepts and ideas such as bodily functions, concepts that are held sacred or prohibited to discuss openly in certain cultures, etc (De Klerk, 1992). These concepts may also include the metaphysical, religion, death, etc (Bușu, 2023). According to Jay (2009), taboo language is a phenomenon that is socially, culturally, psychologically, and emotionally rich and its usage is prohibited on individual and institutional levels to prevent the harm that

will occur in case it is spoken. Linguistic taboos usually attain their status due to societal norms and institutions (Jay, 2009). According to Pinker (2008), a form of this harm are the strongly negative emotions that we go through upon encountering a word that has been declared taboo owing to societal or cultural conventions. Pinker (2008) further asserts that this experience is the exact reason why people often tend to use taboo or swear words because they wish to hurt a certain person or to convey how deeply they have been disturbed or offended due to something.

Linguistic taboos' are made to keep their quality of being taboo and forbidden whilst being transmitted from one generation to the next as parents emphasize this quality in front of their children and make them realize their perceived offensiveness. No one is born with the knowledge of taboo words and their offensive nature. Children gradually learn about taboos and how their use is prohibited through caregivers and family members as well as through other social interactions (Jay, 2009).

There are several kinds of linguistic taboos based on their degree of offensiveness and being forbidden or the concepts that are denoted by them. They encompass a range of topics and serve different purposes, including religious, social, and emotional triggers. Finn (2017) categorizes taboo words into five groups based on the kind of negative emotion they elicit. These include disgust related to bodily secretions and organs, including fear related to religion (supernatural), dread associated with disease and death, revulsion related to sexuality, and hatred toward disfavored people or ethnicities,

A huge proportion of the linguistic taboos of many cultures is covered by linguistic taboos that stemmed due to religion, which is the main source of swearing for several languages including English (Pinker, 2008). Other than religion, bodily excretions, orifices, diseases, and plagues are also sources of linguistic taboos such as "*Bring out your dead*" (from Monty Python) and *'Bloody' etc* (Pinker, 2008).

Research Objectives

The objectives of this research study are as follows:

1. Investigate variation in the perception and usage of linguistic taboos across different age groups in Pakistani society.
2. Investigate variation in the perception and usage of linguistic taboos between genders in Pakistani society.
3. Find out if linguistic taboos are diminishing in Pakistani society.
4. Investigate the variation in the perception of taboo words in bilingual learners based on the language in which taboo words are uttered i.e. their first versus their second language.

Research Questions

The current study aims to answer the following research questions:

1. To what extent is there a variation in the perception and usage of linguistic taboos across different age groups in Pakistani society?
2. To what extent is there a variation in the perception and usage of linguistic taboos between genders in Pakistani society?
3. Whether or not linguistic taboos are diminishing in Pakistani society?
4. To what extent do bilingual individuals perceive taboo words differently depending on whether they are using their first language or second language?

Significance of the Study

The rapid transformations of our society that are mainly being caused due to globalization and technological advancements add to the significance and requirement of this study. Due to these changes, modifications are also occurring in cultural inclinations and values as well as compliance towards these values. These cultural and behavioral changes are also reflected in the linguistic habits of our habits. The current study sheds light on the variation in the perception and utilization of linguistic taboos by different genders and age groups in Pakistani society. It also adds to the current body of relevant research by

exploring the variation in perception and understanding of linguistic taboos based on the language in which bilingual individuals hear these taboos i.e. their first versus their second language.

Literature Review

Linguistic Taboos and Gender

The perception and usage of linguistic taboos have been observed to vary across genders. Males and females differ in their attitudes and utilization of linguistic taboos based on factors such as the category to which a particular linguistic taboo belongs and the concept denoted by it etc.

Women are usually considered to use linguistic words less in their day-to-day communication as compared to men. The main reason behind this is the widely accepted belief that to adopt behavior and mode of living that is typically more "ladylike," women have to avoid using vulgar and taboo language (De Klerk, 1992). Various studies prove this view as correct while others refute this view. Risch (1987) and De Klerk (1992) oppose this view and state that women are familiar with and use slang and abusive terms nearly as much as their male counterparts. From her study on the understanding and usage of offensive words by college-age females, Uhlman (2015) also concludes that women use offensive words as much as men irrespective of the nature of the gathering that they are present in i.e. mixed or all-female. Mohammadi et al. (2014) also opine that the language of both women and men is characterized by the usage of taboo words with the exception of certain situations. These views are opposed by the results of the study conducted by Ghounane (2014) who states that men and women avoid discussing certain taboos in mixed gatherings and prefer mentioning them in single-sex groups. Pervaiz et al. (2021) also oppose Risch (1987) and De Klerk (1992) by concluding that in Pakistani society, women tend to use less abusive and vulgar language as compared to men.

There are certain categories of linguistic taboos that individuals of each gender feel comfortable discussing with other members of their gender but they avoid mentioning them in front of the members of other genders. In many cultures, the concepts of pregnancy, virginity, menstruation, and menopause are viewed as sensitive topics. In these cultures, women frequently refrain from discussing these topics in the presence of men, even though they typically feel at ease discussing them when among individuals of the same gender.

While there are linguistic taboos that women can openly discuss or mention among themselves, regardless of age, variations in the interpretation and application of these taboos still exist among women from different age groups, influenced by their respective cultural backgrounds. Based on the difference in their age, women belonging to the same culture may differ in their perception and usage of the same linguistic taboos.

Diminishing Linguistic Taboos

Language is an ever-changing and dynamic phenomenon. It continues to undergo changes and modifications as the society to which it belongs constantly transforms itself Halliday (1978). Due to changes in societies, the structures and forms of their languages continue to change as well. These linguistic changes range from adopting new structures, modifying previous structures, and even discarding the usage of older and previous structures. Since linguistic taboos, swear words and abusive words are also among the structures of language, they are subject to change as well.

Due to technological and scientific advancements around the globe and due to globalization, linguistic taboos in languages belonging to various cultures have been observed as being gradually diminished. There used to be a time when religious oaths, cursing, or swearing were considered very offensive and disrespectful acts. This might still be the case in several cultures in the world, however, in the English-speaking community, such swearing is no longer considered offensive (Pinker, 2008).

Another variety of linguistic taboos that are no longer considered offensive generally includes linguistic taboos that denote plagues and diseases as well as the linguistic taboos related to death, which are also gradually diminishing in several cultures and societies (Pinker, 2008). However, in Pakistani

society or Muslim communities in general, the concept of death is brought into discussion by using euphemisms such as "*Wo fout hogaye"* (Urdu for 'He passed away).

Although in Pakistani society, euphemisms such as the ones mentioned above still hold the same importance in both the younger and older age groups, there are a few linguistic taboos that are diminishing in Pakistani society similar to how linguistic taboos are diminishing in other societies around the globe. Pervaiz et al. (2021) state that several linguistic taboos such as using '*yaar*' to refer to people, and talking to one's fiancé/fiancée before marriage, etc are gradually diminishing.

Influence of First vs. Second Language on the Perception of Linguistic Taboos

Bilingual speakers have reported that they experience greater emotional resonance whilst listening to their first language. This emotional resonance is decreased when their first language is replaced by their second language. The second language of an individual generates comparatively lesser emotional responses as compared to his native language (e.g., Dewaele, 2004; Caldwell-Harris & Ayçiçeği-Dinn, 2009; Pavlenko, 2006). Using one's second language induces more controlled processes and decreases emotional responses. Due to this, the degree of emotional force and resonance of words is decreased and the speakers and listeners feel more emotionally detached whilst using their second language. This very emotional resonance and force is increased while bilinguals are being exposed to their native language.

Languages learned earlier in life seem to have a stronger emotional hold on individuals than the languages that they learn later in life (Amati-Mehleret al., 1993; Javier, 1989; Santiago-Rivera & Altarriba, 2002). The reason behind this is the experiences that are attached to one's native language. Since it is learned during one's early years, hence speakers are less emotionally detached while perceiving or speaking words in their first language.

Bilinguals find it easier to utter emotionally charged words or expressions in a language that is not their native language due to a decrease in the degree of emotional resonance (Caldwell-Harris, 2014). Words that denote concepts that are considered taboo as well as swear words are perceived by bilinguals as being more emotionally stunted when uttered in their second language (Caldwell-Harris, 2014).

Due to the variation in emotional resonance on shifting between the first and the second language, bilinguals may switch from their first to their second language due to an increase in the emotional distance (Bond and Lai, 1986; Javier and Marcos, 1989). Bond and Lai (1986) state that due to the stunted emotional arousal linked to conversing in second and foreign languages, individuals find it easier to discuss topics in their second or foreign language that they would find hard to talk about in their first language. Dewaele (2004) conducted a study on 1039 multilinguals after which he reported that the emotional force associated with swear and taboo words decreased when they were heard in languages that individuals had learned later in their lives. Gonzalez-Reigosa (1976) and Javier (1989) also state that because it was learned in early childhood, an individual's first language elicits comparatively more emotional responses from him. Any factor belonging to the context in which an utterance takes place can influence the way that utterance is perceived. This includes the language in which the particular expression is uttered (Caldwell-Harris, 2014).

II. MATERIALS AND METHOD

Participants

A total of one hundred individuals participated in the study. They were equally divided into four groups based on their age and gender. In the first group, young females were placed, and young males were placed in the second group. In the third group, elder females and lastly, in the fourth group, elder males were placed. The participants in the first two groups were within the age range of fifteen to thirty. On the other hand, the participants of the last two groups were within the age range of forty-five to sixty.

Data Collection

The data for the current research was collected by making the participants fill out a web-based questionnaire comprising a total of twenty-four questions. The items in the questionnaire were based on the four research questions of this study and they address the ideas of the usage and perception of linguistic taboos held by different age groups and genders in Pakistani society. The items related to the first two research questions were designed to collect data regarding the general perceptions of individuals about abusive words, vulgar language, and using euphemisms to discuss uncomfortable topics. Through the items of the questionnaire, the perceptions of the members of the four groups about a total of six linguistic taboos of our society were also collected. These six linguistic taboos are as follows:

1. Referring to your spouse using his/her name.
2. Talking to fiancé/fiancée before marriage.
3. Referring to your elders using '*yaar*.'
4. Referring to the opposite gender using '*yaar*.'
5. A newly married couple to talk to each other, in the presence of elders.
6. Discussing matrimonial plans with one's father.

The items in the questionnaire also address the question that whether or not linguistic taboos are diminishing in our society and whether or not bilingual learners perceive taboos and swear words differently based on the language in which these words are uttered. Participants were asked if they felt any variation in the perceived offensiveness of taboo, swear, and abusive words when those words were heard and uttered in Urdu (their first language) compared to when those words were heard and uttered in English (their second language).

Data Analysis

To analyze the data, chi-square tests were conducted to assess whether or not an association exists between the categorical variables being studied. After conducting the chi-square tests, the data collected through the web-based questionnaire was analyzed by comparing the descriptive values of the responses of the groups with each other. This was done by assigning a point to each of the five answer options in the Likert scale used in the questionnaire as follows:

Strongly Agree=1 Agree=2 Neutral=3 Disagree=4 Strongly Disagree=5

The means of the responses were calculated and based on the above division of points, the results were given regarding the extent to which participants agreed or disagreed with an item in the questionnaire. If the mean value of the response of a group fell somewhere around two, then it was concluded that the majority of the participants agreed with the statement of the item in question.

RQ#1: Variation in Perception and Usage of Linguistic Taboos across different age groups in Pakistani Society

To assess whether or not there is a significant relationship between the perception and usage of linguistic taboos and the age of individuals in Pakistani society, a chi-square test was conducted. A null hypothesis was proposed that assumed that no such association existed between the two categorical variables in question. This null hypothesis is as follows:

H_0: No association exists between the perception and usage of linguistic taboos and the age of individuals in Pakistani society.

Table 1: Chi-Square Tests for RQ#1

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	43.330[a]	21	.003
Likelihood Ratio	54.682	21	.000
N of Valid Cases	100		

The results of the chi-square show that $p<0.05$ which means that there is an association between the two categorical variables. In other words, the null hypothesis will be rejected. Since the null hypothesis was rejected, an alternative hypothesis was proposed as follows:

H_A: The two categorical variables perception and usage of linguistic taboos and the age of individuals in Pakistani society are not independent of each other and an association exists between them.

In other words, there is variation in the perception and usage of linguistic taboos based on the age of bilingual individuals in Pakistani society. After conducting the chi-square test and establishing that the two categorical variables in question were related, a comparison was drawn between the means of the responses given by the two groups belonging to the age range of 15-30 and the members of the two groups falling in the age range of 45-60.

Use of Swearwords and Abusive Language

Out of 25, 32% of the elder females answered 'Yes' when asked whether they use vulgar or abusive language. 68% of the elder females answered 'No' to the question regarding the usage of vulgar and abusive language. Only 2% of the younger females answered 'Yes' and 92% answered 'No' to this question. On the other hand, 40% of the younger males answered 'Yes' and 60% answered 'No' when asked about using vulgar and abusive language in their daily lives. Out of 25, 36% of elder males answered 'Yes' while 64% answered 'No' in response to this question. Thus, the elder age group uses vulgar and abusive language more as compared to the younger age group.

Table 2: Use of Swearwords and Abusive Language by EM and EF

Statement	N	Mean	Std. Deviation
I feel uncomfortable while using vulgar/slang words in front of the opposite gender.	50	1.82	.661
I feel uncomfortable while using vulgar/slang words in front of my peers.	50	1.90	.789
I feel uneasy while using vulgar/slang words in front of my siblings.	50	2.44	.993
I feel uneasy while using vulgar/slang words in front of my elders.	50	1.56	.733
It is okay for me to use vulgar/slang words in public.	50	3.32	1.347

People should not shy away from using vulgar/abusive language to express their true feelings and emotions.	50	3.40	1.125

Table 3: Use of Swearwords and Abusive Language by YM and YF

Statement	N	Mean	Std. Deviation
I feel uncomfortable while using vulgar/slang words in front of the opposite gender.	50	1.72	.991
I feel uncomfortable while using vulgar/slang words in front of my peers.	50	2.54	1.154
I feel uneasy while using vulgar/slang words in front of my siblings.	50	2.26	1.139
I feel uneasy while using vulgar/slang words in front of my elders.	50	1.50	.931
It is okay for me to use vulgar/slang words in public.	50	4.10	1.035
People should not shy away from using vulgar/abusive language to express their true feelings and emotions.	50	4.00	1.030

By comparing the means of the responses given by the two age groups, it was seen that the elder age group used swear words more as compared to the younger age group. However, the responses of the younger age groups also showed that they were comfortable using abusive language in front of their peers. The mean value of the responses of YF and YM to the question regarding 'using abusive language in front of one's peers' was 2.34, while the mean of the responses of the elder age groups was 1.90. In other words, the members of the younger age group did use abusive language but only in the presence of their peers i.e. other young individuals. This shows that the taboo of using vulgar and abusive language is diminishing slightly because the members of the younger age group usually consider it a taboo in the presence of the members of the elder age group.

Viewpoint on the Use of Euphemisms

By comparing the means of the responses given by the two age groups, it was seen that both the elder and younger age groups were aware and conscious of the importance of using euphemisms in everyday speech, especially for topics such as death and assault, etc.

Referring to one's spouse using his/her name

By comparing the means of the responses given by the two age groups, it was seen that the younger age agreed more as compared to the elder age group with the idea that it was acceptable to refer to one's

spouse by his/her name. The mean of the response of YM and YF to this item was 2.04 while that of EM and EF was 2.92. Thus, this linguistic taboo is gradually diminishing.

Talking to fiancé/fiancée before marriage

Engaging in conversation with one's fiancé/fiancée is a linguistic taboo that is seen to be gradually diminishing in our society and the findings based on the collected data further confirm it. The mean of the response of YM and YF to this item in the questionnaire was 2.74 while that of EM and EF was 4.02. This stark difference in the values of means shows that this linguistic taboo is gradually diminishing.

Referring to others using '*yaar*'

The word '*yaar'* was once considered extremely offensive in our society and had negative connotations attached to it. However, it is now an example of the many linguistic taboos that are gradually diminishing, and the findings from the collected data act as evidence of the diminishing of this taboo. The mean of the response of the younger age group to this item in the questionnaire was 3.14 while that of EM and EF was 4.36 and 3.94. Thus, this linguistic taboo is gradually diminishing.

A newly married couple to talk to each other, in the presence of elders

By comparing the means of the responses given by the two age groups, it was seen that this linguistic taboo is diminishing to some extent. The mean of responses of YM and YF was 2.34 which means that most of these participants agreed that it was acceptable for a newly married couple to converse in the presence of elders. The mean of responses of EM and EF was 2.98 which means that they agreed less with this particular idea as compared to the younger age group.

Discussing matrimonial plans with one's father

The means of responses to this linguistic taboo also showed that the younger age group agreed more as compared to the elder age group with the idea that it is acceptable to discuss matrimonial plans with one's father. The mean of the responses of the former group to this item in the questionnaire was 2.78 while that of the latter was 3.14.

Table 4: Comparison of the responses of YM and YF and EM and EF regarding use of Euphemisms and Linguistic taboos

Statement	**Mean of responses of YM and YF**	**Mean of responses of EM and EF**
People should be more straightforward and avoid using euphemisms.	3.12	3.72
It is necessary to use euphemisms while discussing sensitive topics like death, assault, etc.	2.14	1.56
It is acceptable to refer to your spouse using his/her name.	2.04	2.92
It is acceptable to talk to fiancé/fiancée before marriage.	2.74	4.02

It is acceptable to refer to your elders using '*yaar*.'	3.14	4.36
It is acceptable to refer to the opposite gender using '*yaar*.'	3.14	3.94
It is acceptable for a newly married couple to talk to each other spouse, in the presence of elders.	2.34	2.98
It is acceptable to discuss matrimonial plans with your father.	2.78	3.14

RQ#2: Variation in Perception and Usage of Linguistic Taboos between Genders in Pakistani Society

To assess whether or not there is a significant relationship between the perception and usage of linguistic taboos and the gender of individuals in Pakistani society, a chi-square test was conducted. A null hypothesis was proposed that assumed that no such association existed between the two categorical variables in question. This null hypothesis is as follows:

H_0 : No association exists between the perception and usage of linguistic taboos and the gender of individuals in Pakistani society.

Table 5: Chi-Square Test for RQ#2

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	60.374[a]	63	.570
Likelihood Ratio	33.745	63	.999
N of Valid Cases	100		

The results of the chi-square show that $p>0.05$ which means that there is no significant association between the two categorical variables. In other words, the null hypothesis will be accepted. Both males and females are quite similar in their perceptions and usage of linguistic taboos. After conducting the chi-square test and establishing that the two categorical variables in question were not related, a comparison was drawn between the means of the responses given by the elder and younger females and the responses of the elder and younger males.

Use of Swearwords and Abusive Language

Out of 25, 32% of the elder females answered 'Yes' when asked whether use vulgar or abusive language. 68% of the elder females answered 'No' to the question regarding the usage of vulgar and abusive language. Only 2% of the younger females answered 'Yes' and 92% answered 'No' to this question. On the other hand, 40% of the younger males answered 'Yes' and 60% answered 'No' when asked about using vulgar and abusive language in their daily lives. Out of 25, 36% of elder males answered 'Yes' while 64% answered 'No' in response to this question. Thus, men use more vulgar and abusive language as compared to women. In both the female and male groups, the elder participants were seen to use

abusive language more as compared to their younger counterparts. Although the two genders differed in their responses about using abusive language, they did not differ to a large extent.

Table 6: Use of Swearwords and Abusive Language by YF and EF

Statement	N	Mean	Std. Deviation
I feel uncomfortable while using vulgar/slang words in front of the opposite gender.	50	1.90	.886
I feel uncomfortable while using vulgar/slang words in front of my peers.	50	2.04	.989
I feel uneasy while using vulgar/slang words in front of my siblings.	50	2.46	1.110
I feel uneasy while using vulgar/slang words in front of my elders.	50	1.50	.789
It is okay for me to use vulgar/slang words in public.	50	3.80	1.245
People should not shy away from using vulgar/abusive language to express their true feelings and emotions.	50	3.80	1.069

Table 7: Use of Swearwords and Abusive Language by YM and EM

Statement	N	Mean	Std. Deviation
I feel uncomfortable while using vulgar/slang words in front of the opposite gender.	50	1.64	.776
I feel uncomfortable while using vulgar/slang words in front of my peers.	50	2.20	1.030
I feel uneasy while using vulgar/slang words in front of my siblings.	50	2.24	1.021
I feel uneasy while using vulgar/slang words in front of my elders.	50	1.56	.884
It is okay for me to use vulgar/slang words in public.	50	3.62	1.276

People should not shy away from using vulgar/abusive language to express their true feelings and emotions.	50	3.60	1.161

Viewpoint on the Use of Euphemisms

Both genders were somewhat similar in their responses regarding using euphemisms, both of the genders were aware of the importance of using euphemisms to discuss topics that are taboo or hold the potential to offend or hurt someone.

Referring to your spouse using his/her name

The values of means of the responses of both the genders to the idea of 'referring to one's spouse by their name' were the same i.e. 2.48. Thus, both genders had similar viewpoints regarding this idea.

Talking to fiancé/fiancée before marriage

The null hypothesis proposing that no association existed between the perception and usage of linguistic taboos and the gender of individuals in Pakistani society was further supported by the means of responses to this question. The mean of responses of YF and EF was 3.48 while that of YM and EM was 3.28.

Referring to others using '*yaar*'

The means of the responses of the groups showed that both genders were similar in their viewpoints on the idea of 'referring to others using the word '*yaar.'*

A newly married couple to talk to each other, in the presence of elders

The means of the responses of the groups showed that both genders were similar in their viewpoints regarding 'a newly married couple conversing in the presence of elders.'

Discussing matrimonial plans with one's father

The means of the responses of the groups showed that both genders were similar in their viewpoints regarding 'discussing matrimonial plans with one's father.'

Table 8: Comparison of the responses of YF and EF and YM and EM regarding use of Euphemisms and Linguistic taboos

Statement	**Mean of responses of YF and EF**	**Mean of responses of YM and EM**
People should be more straightforward and avoid using euphemisms.	3.48	3.36
It is necessary to use euphemisms while discussing sensitive topics like death, assault, etc.	1.70	2.00
It is acceptable to refer to your spouse using his/her name.	2.48	2.48
It is acceptable to talk to fiancé/fiancée before marriage.	3.48	3.28

It is acceptable to refer to your elders using '*yaar*.'	3.70	3.80
It is acceptable to refer to the opposite gender using '*yaar*.'	3.64	3.88
It is acceptable for a newly married couple to talk to each other spouse, in the presence of elders.	2.62	2.62
It is acceptable to discuss matrimonial plans with your father.	2.90	3.04

RQ#3: Whether or not Linguistic Taboos are diminishing?

The results of the first and second research questions show that linguistic taboos are gradually diminishing in our society. By comparing the responses of the two genders, it was seen that both genders do not differ to a large extent in their perspectives about linguistic taboos. On the other hand, by comparing the responses of the participants by dividing them into two groups based on their age, a prominent difference was observed in the perceptions of the two age groups. Thus, the diminishing of linguistic taboos does not have an association with gender but it does have a relationship with the age of the individuals.

In the current study, compared to the elder age group, participants belonging to the younger age group were observed to have less adherence to cultural norms regarding taboos such as talking to others using '*yaar*,' conversing with one's fiancé/fiancée before marriage and discussing matrimonial plans with one's father. Thus, linguistic taboos are certainly diminishing but some of them, such as not using euphemisms, still hold their quality of perceived offensiveness.

In addition to exploring whether or not linguistic taboos are diminishing, the current study also investigated the perceptions of the participants regarding the factors responsible for the gradual diminishing of these taboos. The items of the questionnaire also gathered data regarding the participants' perception of the role of social media, parents, and peers in the ever-increasing awareness of children about taboo and abusive language.

The means of responses of the participants showed that they all agreed that social media played a huge role in the usage of abusive and vulgar language by children. According to them, if there were no social media, children would have comparatively lesser knowledge about such language. Moreover, they also agreed that parents and peers play a huge role in transferring the knowledge of such language to children.

The mean of the responses to the question regarding the huge role played by social media in transmitting knowledge of taboo words to people was 1.73. In other words, majority of the participants agreed to this statement. The mean of the responses to the question regarding how children get to know more about taboo language through social media was 1.63. A unanimous agreement was also observed related to the notion that if there were no social media, children would not get to know much about such language as the mean of the responses to this question was 2.28.

Moreover, the responses of the participants regarding the role of parents and peers in transmitting knowledge of such language to children also tipped towards 'agree.' The mean value of the responses to the former question was 2.16, while that of the latter was 1.84.

Table 9: Viewpoints of participants on factors responsible for diminishing linguistic taboos

Statement	N	Mean	Std. Deviation
Social Media has a huge role in the increase in usage of taboo words.	100	1.71	.574
Through social media, children get to know more about linguistic taboos and abusive language.	100	1.63	.677
If there were no social media, children would not get to know much about linguistic taboos and abusive language.	100	2.28	1.006
Parents may play a role in their children's development of knowledge of abusive language.	100	2.16	1.051
Peer influence plays a significant role in shaping and developing children's abusive language.	100	1.84	.662
Children use abusive and vulgar language to impress their peers.	100	2.62	1.179

RQ#4: Variation in the Perception of Taboos and Swearwords based on the language they are spoken or heard in

All of the hundred participants in the study were Urdu-English bilinguals whose first language was Urdu and the second language was English. The current study also investigated whether or not these participants perceived taboo words, swear words, and other insults differently based on the language in which those words were uttered or heard.

Through the analysis of the collected data, it was discovered that the language in which taboo words and swear words are used can influence the perception that bilingual learners develop regarding them. The participants' responses revealed that taboos, reprimands, insults, and other similar words heard and spoken in Urdu, were perceived as more severe as compared to when those words were heard or uttered in English.

Table 10: Variation in the Perception of Taboos and Swearwords based on the language they are spoken or heard in

	N	Mean	Std. Deviation
Insults and reprimands heard in Urdu feel less harsh to me as compared to insults in English.	100	3.42	1.296
Swear and taboo words in different languages have different emotional weight for me.	100	2.26	.872
Taboo words heard in Urdu feel less harsh to me as compared to those in English.	100	3.62	.951
Swear words and taboo words in English feel less harsh to me as compared to the ones in Urdu.	100	2.33	.943

III. RESULTS

The results of the first and second research questions show that several linguistic taboos such as referring to others using '*yaar'* and talking to one's fiancé/fiancée before marriage are gradually diminishing in our society. In the case of using abusive words, although the younger age group uses such language less as compared to their elders, they do feel comfortable using such language in the presence of their peers, which means that the linguistic taboos of using vulgar and abusive language also carry the chances of diminishing gradually.

The study findings indicate that there is not a significant difference between genders in terms of perspectives on linguistic taboos. However, when the participants were divided into two age groups, a notable distinction in perceptions emerged. This suggests that the diminishing of linguistic taboos is not related to gender but rather associated with the age of individuals.

The study revealed that the younger age group showed less adherence to cultural norms regarding taboos compared to the older age group. Examples of these taboos included using informal terms like 'yaar' when addressing others, engaging in pre-marital conversations with one's fiancé/fiancée, and discussing matrimonial plans with one's father.

To summarize, while gender did not play a significant role in attitudes toward linguistic taboos, the study demonstrated a clear association between age groups and the diminishing adherence to cultural norms surrounding taboos. The younger generation displayed a greater inclination to challenge or disregard these norms compared to the older generation.

However, they did not show such behavior towards all of the linguistic taboos explored in the study. The younger age group had similar views regarding the use of euphemisms to discuss topics such as death and assault etc. Although linguistic taboos are experiencing a decline, it is important to note that certain taboos still retain their characteristic quality and are perceived as offensive.

Based on the participants' responses, there was a unanimous agreement that social media significantly contributes to the use of abusive and vulgar language by children. They expressed the belief that without social media, children would have limited exposure to such language. Additionally, the participants acknowledged the substantial influence of parents and peers in transmitting knowledge of this language to children.

Based on the data collected and analyzed, it was found that the language in which taboo words, swear words and similar expressions are spoken can impact the perception that bilingual learners form regarding them. The responses from 100 Urdu-English bilinguals that participated in the current study showed that the taboos, reprimands, insults, etc. heard and uttered in their first language i.e. Urdu were perceived as more harsh as compared to the ones heard and uttered in their second language i.e. English.

IV. DISCUSSION

The results of this study highlight the dynamic nature of linguistic taboos, particularly within the context of Pakistani society. As globalization and technological advancements continue to transform cultural norms and values, linguistic practices are evolving as well. This study adds to our understanding of these shifts by shedding light on the variations in the perception and utilization of linguistic taboos across different genders and age groups, as well as the influence that has bilingualism on these perceptions.

A key finding of the current study is the gradual decrease and the diminishing of adherence to certain linguistic taboos among younger individuals compared to their elders. This trend aligns with Halliday's (1978) assertion that language changes in accordance with societal changes. The study reveals that younger participants feel more comfortable using informal terms like 'yaar' and engaging in pre-marital conversations with their fiancé/fiancée, thus indicating a shift away from traditional cultural norms. This observation is consistent with Pervaiz et al. (2021), who noted similar trends in the diminishing use of specific taboos in Pakistani society.

However, the study also shows that certain taboos, such as euphemisms for discussing sensitive topics like death and assault, remain unchanged. This suggests that while some aspects of linguistic taboos are diminishing, others remain unchanged, which highlights the complex interplay between evolution of cultural norms and linguistic practices. Pinker (2008) noted a similar phenomenon in the English-speaking world, where some taboo subjects have become less offensive over time, while other maintain the status of being taboo.

Gender differences in the perception and use of linguistic taboos were not significant, which contrasts with some previous studies that found women generally use less taboo language than men (De Klerk, 1992). However, this study's findings align more closely with those of Risch (1987) and Uhlman (2015), who stated that women are just as likely as men to use taboo language in certain contexts. This discrepancy may be due to cultural and contextual differences in how taboos are perceived and used.

The influence of bilingualism on the perception of linguistic taboos presents an interesting dimension. The study supports findings by Dewaele (2004) and Caldwell-Harris (2014), which argue that bilinguals experience stronger emotional resonance with their first language. Participants reported that taboos and swear words in Urdu, their first language, felt harsher than those in English, their second language. This aligns with the idea that the languages that are learned in one’s childhood carry deeper emotional connections (Amati-Mehler et al., 1993; Javier, 1989).

The role of social media and parental influence in exposing children to abusive and taboo language emerged as a significant finding as well. Majority of the participants agreed that social media is amongst the leading factors that give rise to the use of such language among children. This finding calls for further investigation into the mechanisms of language transmission in the digital age. This insight builds on existing research into the socialization processes through which children learn taboo language (Jay, 2009).

In conclusion, this study advances our understanding of the evolving nature of linguistic taboos in Pakistani society. It highlights the decrease in the adherence to certain taboos among younger individuals,

the resilience and maintenance of specific taboos, the role of gender, and the impact of bilingualism on emotional resonance with taboo language. These findings highlight the importance of considering cultural, generational, and linguistic contexts in studying the dynamics of linguistic taboos. Future research could further explore the mechanisms behind these changes, particularly the role of digital media and cross-cultural interactions in shaping linguistic norms.

V. CONCLUSION

The study found that there was not a significant difference between genders regarding perspectives on linguistic taboos. However, a notable difference in perceptions was observed upon dividing participants into two groups based on their age. This suggests that the decrease in linguistic taboos is not associated with gender but does correlate with the age of individuals.

While linguistic taboos are indeed decreasing overall, it is important to note that certain taboos still retain their quality of being taboo and are perceived as offensive. Although there is a general trend of reduced adherence to linguistic taboos in the younger age group, some specific taboo words, phrases, or topics continue to carry a strong social stigma and are widely considered inappropriate or offensive.

Based on the data that was collected and analyzed, it is concluded that a huge role is played by social media and parents and peers of children in providing them with exposure to abusive and taboo language. Thus, these are among the several factors that contribute to diminishing linguistic taboos. Furthermore, the language in which taboo words and swear words are uttered can shape the perception that bilingual learners form regarding them.

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Green Synthesis and Characterization of Selenium Nanoparticles

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Abstract – Selenium was discovered as an essential element for mammals by Schwartz and Foltz in 1957. Selenium plays a significant role in the detoxification of reactive oxygen species (ROS). Research indicates that selenium deficiency can trigger the development of diseases such as depression, autoimmune disorders, chronic heart diseases, goiter, diabetes, and cancer. In this study, Selenium Nanoparticles (SeNPs) were synthesized using a green synthesis method to leverage selenium's ability to detoxify ROS. According to the principles of green chemistry, 5 mM sodium selenite was reacted with three different concentrations of acetic acid (AA) at 0.1 M, 0.05 M, and 0.025 M using a magnetic stirrer, resulting in brick-red solutions. The SeNPs were matured at room temperature for 24 hours, then washed and dried at 50°C. The size properties and distributions of the SeNPs were determined using scanning electron microscopy (SEM) and dynamic light scattering (DLS) methods. The results showed that the SeNPs are spherical, with size distributions ranging from 60 nm to 200 nm. The zeta potentials of the SeNPs were measured to be between -28 mV and -39 mV. The characteristic peak of the SeNPs was observed at 265 nm and confirmed using UV-VIS spectrophotometry. Considering the synthesis method, size distribution, and shape characteristics, SeNPs are believed to be easily taken up by cells and show efficacy. In conclusion, SeNPs can be used as a potential therapeutic agent for the targeted treatment of diseases arising from selenium deficiency. The findings of this study demonstrate that selenium nanoparticles (SeNPs) can be effective agents in the treatment of selenium deficiency-related diseases through ROS detoxification. The suitable bioavailability and targeting capabilities of SeNPs make them a promising therapeutic option for future clinical applications.This document presents the formatting instructions for the Proceedings of Conference on Scientific and Academic Research. This document can serve as the base template for a Microsoft Word based typesetting system. The abstract should state briefly the purpose of the research, the approach used, the principal results and major conclusions. The abstract of 200-250 words is required.

Keywords – Selenium, Nanoparticles, Green Synthesis, Chronic Diseases, Target Theraphy

INTRODUCTION

Selenium was first discovered in 1817 by Jöns Jakob Berzelius and Johan Gottlieb Gahn. This element was found to be an essential mineral required for mammals by Schwartz and Foltz in 1957. Selenium (Se) is an essential element that participates in the structure of biologically active selenoproteins. In the studies conducted by Chambers and Friends in 1986, while examining the synthesis of glutathione peroxidase and bacterial formate dehydrogenase, it was observed that it contained selenocysteine, which contains its own mRNA and tRNA code. In this way, selenocysteine was identified as the 21st amino acid. Glutathione peroxidase enzyme, which is the building block of selenocysteine, is a part of the enzyme system that protects the cell from oxidative damage of peroxidases accumulated inside the cell. Thanks to this enzyme, Se, which is necessary for the body's antioxidant defense mechanisms to function properly, is a mineral that

is essential for living life, although it is considered an essential mineral. This element is taken into our body with water as well as plant and animal foods in the forms of elemental selenium, selenite, selenide and selenate found in nature. Se deficiency may occur depending on the soil mineral characteristics of the geographical region you live in. Adults need to take an average of at least 60 µg of selenium daily. According to the World Health Organization, selenium intake of around 400 to 700µg per day has a toxic effect on human health. It has been determined that selenium plays an important role in preventing the formation of important degenerative diseases such as cardiovascular diseases, neurological problems, chronic diseases, immune diseases and cancer, with its antioxidant effect (1). It is also recommended as an alternative against the side effects associated with chemotherapy and radiotherapy (2-3). It is thought that selenium may be beneficial in breast cancer due to its effect on mechanisms such as activation of apoptosis, inhibition of cell proliferation, immune system stimulation and inhibition of angiogenesis (4). In addition, in an in vitro study conducted on breast cancer cells with selenium dioxide by combining selenium with paclitaxel (PTX), a chemotherapeutic agent, it was concluded that the application of selenium dioxide (SEL) and PTX stimulated apoptosis and reduced the expression of NF-κB in MDA-MB-231 breast cancer cells. determined. Therefore, it was concluded that there is an antagonistic effect between these two substances and SEL reduces the apoptotic effect of PTX. These studies on cancer with selenium have suggested that studies on more superior forms of selenium should be carried out to eliminate this antagonist effect (5).

The active surface area, chemical reactivity, and biological effects of nanoparticles are significantly different from the active surface area, chemical reactivity, and biological effects of micrometer-wide particles (6). Nanoparticles' surfaces can be functionalized with functional bindings, providing the opportunity for specific guidance in living tissue. Interestingly, functionalized SeNPs exhibit less cytotoxicity than their other forms, such as selenate, selenite, selenoproteins, and inorganic selenium (7-8). In addition, the synthesized SeNP can be used in many different fields in the Department of Medicine, such as cell imaging, examination of the mechanisms of action of therapeutic drugs and their therapeutic use. In addition, it is an advantage that nanoparticles can be adjusted in size and can easily penetrate the cell and nucleus. SeNP's ability to participate in reactions within the cell enables its use in targeted therapeutic systems, especially by enabling genetic stimulation through the activation and inactivation of enzymes and affecting protein expression. Therapeutics aim to increase the patient's comfort of life and reduce side effects by developing targeted therapies for effective treatment of diseases rather than systematic effects. For this purpose, selenium nanoparticle (SeNP), which is targeted to have high bioavailability in a biocompatible manner, was synthesized and characterized in accordance with the principles of green chemistry.

MATERIALS AND METHOD

Chemicals Used

Sodium selenite (Na2SeO3) and Ascorbic acid ($C_6H_8O_6$) were purchased from Sigma Aldrich.

Synthesis of Selenium Nanoparticles

Chemical reduction method was used for selenium nanoparticle synthesis. Sodium selenite was dissolved in sterile deionized distilled water to 5 mM. Ascorbic Acid (AA) was prepared in three different concentrations (0.1 M- 0.05 M- 0.025 M) as a reducing agent, and it was carried out in a mechanical mixer, using sterile pediatric dosiflor, in a device prepared to provide controlled slow flow. The reaction was carried out at room temperature, and then the nanoparticles were matured by incubating at room temperature for 24 hours. Although the solutions were colorless before the reaction, orange color formation was observed in the solution containing selenium nanoparticles after the reaction. The synthesized selenium nanoparticles were washed by centrifugation at 4000 x rpm for 15 minutes. The washing process was

repeated 3 times. The resulting supernatant was dried in the oven at 50°C. Dried selenium nanoparticles were stored at +4°C for characterization studies.

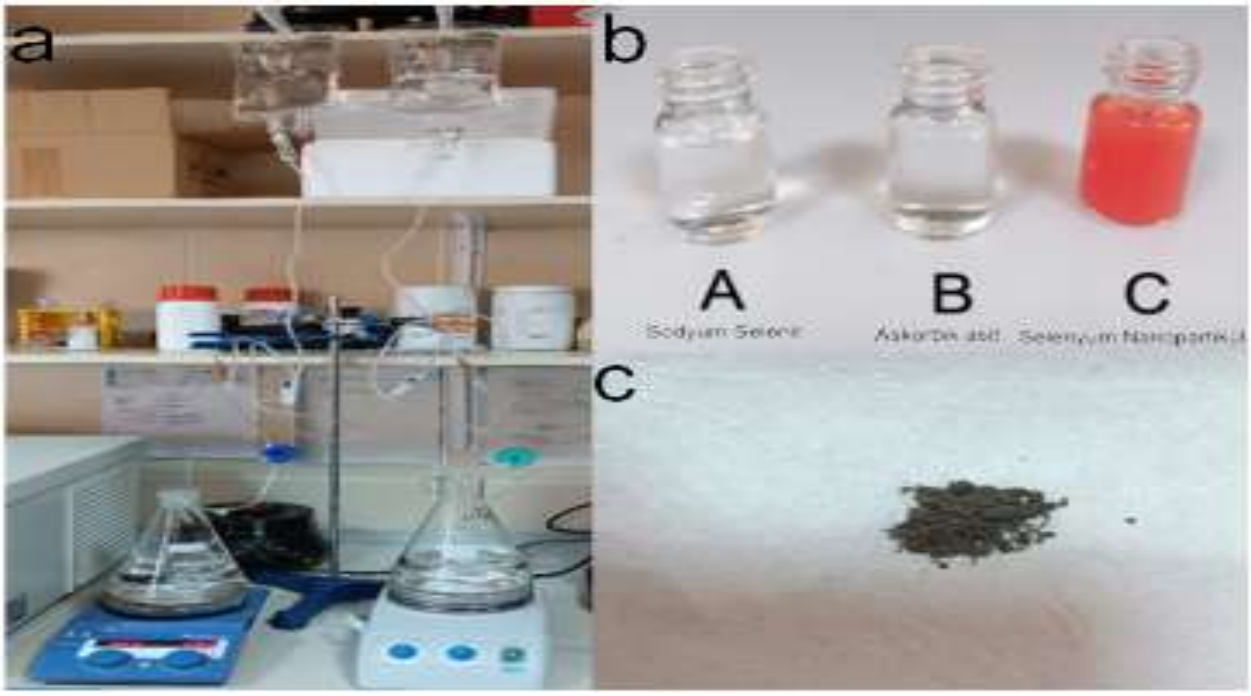

Figure 1 a-The setup set up for synthesis, b-Color change during synthesis, c-Dried state of the synthesized SeNP

Characterization of Selenium Nanoparticles

UV-vis absorbance measurement

The nanoparticles were dissolved in distilled water and measured between 200-800 nm on the UV-Vis device. The maximum peak was observed at 265 nm. Measurements were taken on a Shimadzu UV-1900i UV-VIS spectrophotometer.

DLS-Zeta Potential measurement

DLS-Zeta potential measurement of nanoparticles dissolved in distilled water was taken. Malvern Zetasizer DLS-Zeta potential measurement device was used. Particle sizes were measured between 100 and 300 nm. Surface charges were measured as negative. It is aimed to increase the effect and ensure easy entry into the cell by specifically targeting the cancer microenvironment.

SEM imaging

Size and shape data were obtained by taking SEM images of powdered nanoparticles. The synthesized nanoparticles were close to sphere-shaped, and their size was measured between 100-300nm. SEM images were taken on the ZEISS EVO LS10 SEM imaging device.

RESULTS

As a result of the measurement made in the measurement range between 200-600 nm, the solution prepared at a ratio of 1/10w/V with a UV-1900İ UV-VIS spectrophotometer (shimadzu), SeNPs gave a specific peak at 265 nm, confirming the formation of selenium nanoparticles (11).

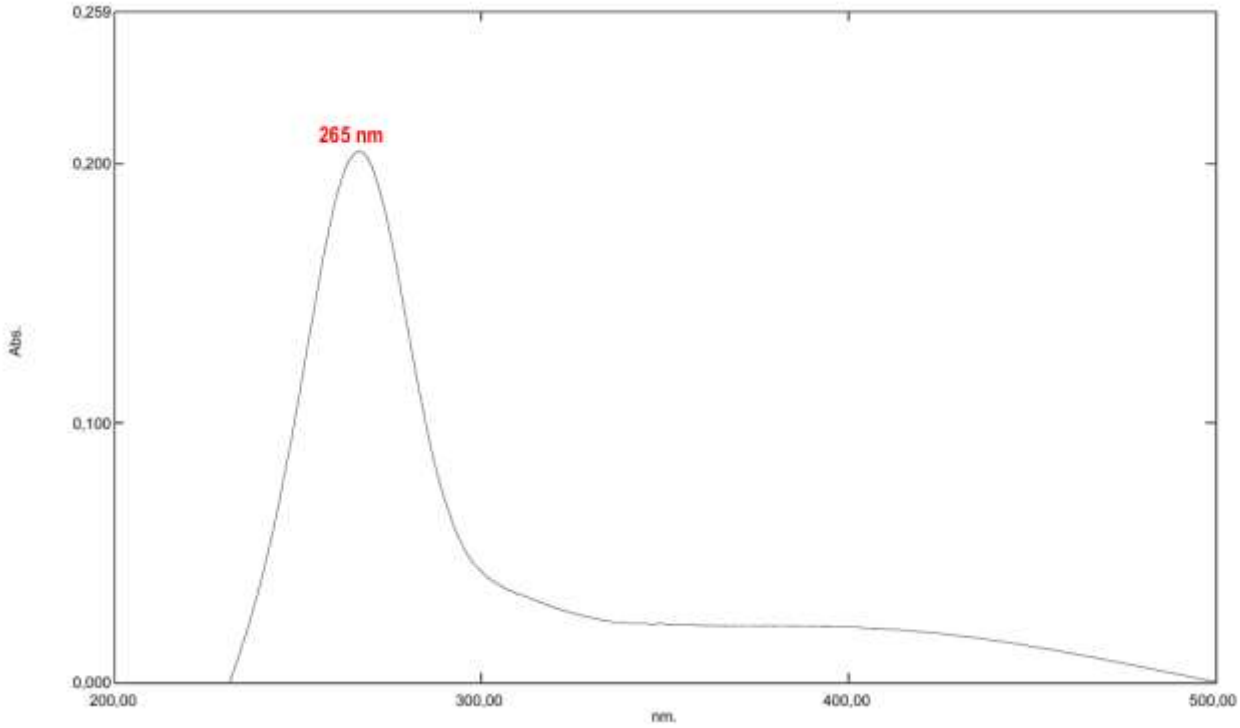

Figure 2 SeNP UV-VIS measurement

The selenium nanoparticles we synthesized were imaged without coating on the ZEISS EVO LS10 SEM imaging device. Since the selenium nanoparticle was highly aggregated in SEM imaging, it was seen to be in a sphere or near-sphere form in the images taken from the non-aggregated points.

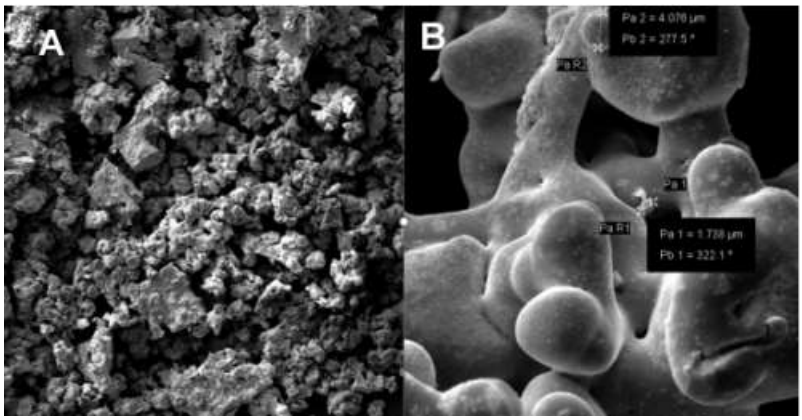

Figure 3 A- SeNP SEM image B- Measurement taken on the SeNP SEM Device

The nanoparticles we synthesized with different concentrations of AA (0.1 M – 0.05 M – 0.025 M) were dissolved in deionized sterile distilled water in a 1/10 w/V ultrasonic bath and measured on the Malvern Zetasizer DLS-Zeta potential measurement device.

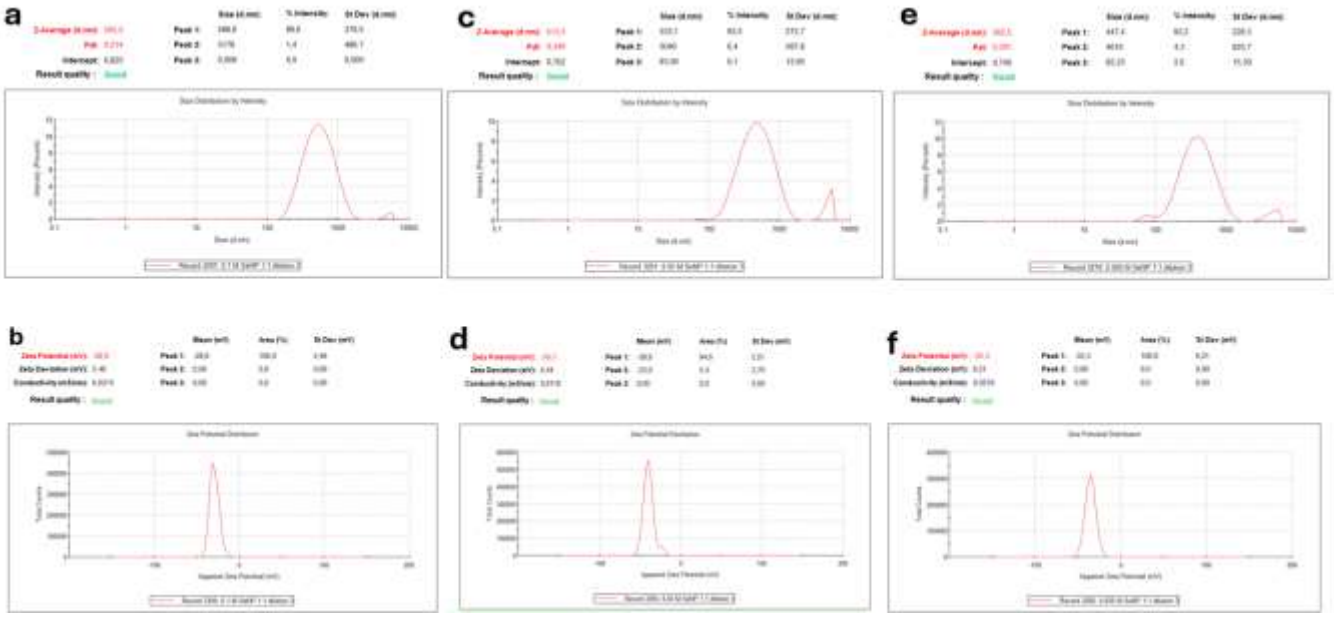

Figure 4 a- SeNP DLS measurement chart prepared with 0.1 M AA, b- SeNP Zeta Potential measurement chart prepared with 0.1 M AA, c- SeNP DLS measurement chart prepared with 0.05 M AA, d- SeNP Zeta Potential measurement chart prepared with 0.05 M AA, e- SeNP DLS measurement chart prepared with 0.025 M AA, f- SeNP Zeta Potential measurement chart prepared with 0.025 M AA

According to DLS measurements of selenium nanoparticles, the nanoparticle prepared with 0.1 M AA was measured as 276.5 nm, the nanoparticle prepared with 0.05 M AA was measured as 272.7 nm, and the nanoparticle prepared with 0.025 M AA was measured as 228.3 nm. Sufficient size was obtained for the nanoparticles to penetrate into the cell. Surface charges are intended to be negatively charged due to the acidic nature of the cancer microenvironment. The surface charges obtained in the measurement are (-) 28.8 mV for SENPs prepared with 0.1 M AA, (-) 39.3 mV for SeNPs prepared with 0.05 M AA, (-) 35 mV for SeNPs prepared with 0.025 M AA. Measured at 3mV.

DISCUSSION

Selenium is an essential micronutrient required for the proper functioning of biological and metabolic mechanisms in the human body. Selenium deficiency causes cancer and various disorders such as neurological, muscular and immune disorders (12). Reactive oxygen species (ROS) and reactive nitrogen species (RNS) free radicals are generally produced in the human body during various physicochemical and biochemical reactions. Intermediate complexes such as superoxide and hydrogen peroxide, produced in high amounts during these reactions, are structures responsible for cellular damage that leads to fatal diseases. SeNPs protect cells from damage and oxidative stress by playing important roles in clearing free radicals such as reactive oxygen and nitrogen species and regulating the contents produced during biochemical reactions (13). Thanks to their antioxidant properties, SeNPs can potentially be used in the treatment of neurodegenerative diseases such as Huntington's, Parkinson's and Alzheimer's diseases (14). Green synthesis applications to eliminate selenium deficiency and as a therapeutic agent provide more advantages than chemical reduction methods due to higher biocompatibility, bioactivity and lower cytotoxicity properties. Since the microenvironment of cancer cells is acidic, it is predicted that the SeNPs we synthesized will be more targeted and taken up by cancer cells due to their negatively charged surfaces. It is also known that selenium compounds are critical in genes related to cell proliferation and apoptosis by molecularly affecting the cDNA microarray (15). Additionally, it eliminates the use of expensive chemicals (12).

CONCLUSION

The synthesized SeNPs were synthesized as Green Chemistry and can be used effectively as candidate drugs because they are soluble in water, biocompatible and have high bioavailability. Since the size of SeNP is around 200 nm and its shape is close to a sphere, it can easily enter the cell and since it is in a water-soluble form within the cell, it can have an effect on the cytoplasm and nucleoplasm. The negative surface charge of SeNPs indicates that they can be used in targeted therapies and medical imaging by targeting the microenvironment of acidic cancer cells. Although selenium is an essential mineral in human metabolism, it can be used more effectively as SeNP, thanks to its physical and chemical properties, being more active in reactions and easily penetrating and invasive.

ACKNOWLEDGMENT

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Kapsayıcı Liderlik Stratejilerinin Çalışan Adanmışlığına Etkisi

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Özet – Liderlik tarzlarının çalışan adanmışlığı üzerindeki etkisi, kurumsal performans açısından önemli bir araştırma alanı olarak kabul edilmektedir. Bu bağlamda, bu çalışma, kapsayıcı liderlik stratejilerinin çalışan adanmışlığı üzerindeki etkisini incelemeyi amaçlamaktadır. Bu amaçla, konuyla ilgili literatürü analiz etmek üzere sistematik literatür taraması yöntemi kullanılmıştır. Web of Science (WoS) ve Scopus veri tabanları üzerinde yapılan sorgulama sonucunda, konuyla doğrudan ilişkili ve geçerli bulunan 14 yayın seçilmiştir. Araştırmanın bulguları, açık iletişim kurma ve erişilebilirlik, destekleyici davranışlar sergileme, psikolojik güvenlik ortamı oluşturma gibi kapsayıcı liderlik stratejilerinin çalışan adanmışlığını artırmada kritik bir rol oynadığını vurgulamaktadır. Bu stratejiler, çalışanların kendilerini değerli ve güvende hissetmelerini, iş süreçlerine aktif katılım göstermelerini ve iş ortamında daha fazla çaba harcamamalarını teşvik etmektedir. Dolayısıyla, bu stratejiler, çalışanların işlerine ve örgütlerine daha sağlam bir bağlılık geliştirmelerine olanak tanıyarak, adanmışlık düzeylerini anlamlı şekilde arttırmaktadır. Ayrıca, kapsayıcı liderlik stratejileri, örgüt içinde yaratıcı düşünceyi teşvik ederek yenilikçi iş modellerinin geliştirilmesine ve işletme performansının artırılmasına katkı sağlamakta, böylece sürdürülebilir rekabet avantajı elde etme sürecinde etkili olmaktadır. Çalışmanın bulgularına dayanarak bir kavramsal model geliştirilmiş ve bu model, kapsayıcı liderlik stratejilerinin işletmelerdeki çalışanların adanmışlık düzeylerine olan etkisini anlamak için önemli bir adım olarak değerlendirilmiştir. Sonuçlar, kapsayıcı liderlik stratejilerinin çalışan adanmışlığını artırmada etkili bir araç olduğunu ve işletmelerin sürdürülebilir başarısına önemli katkılar sunduğunu ortaya koymaktadır.

Anahtar Kelimeler – Liderlik tarzları, kapsayıcı liderlik, işe adanmışlık, örgüte adanmışlık, performans

I. GİRİŞ

Günümüzde çalışan adanmışlığı, organizasyonların sürdürülebilirliği için kritik bir unsurdur. Adanmış çalışanlar, iş gücü devrini azaltarak istikrarlı bir iş gücü oluştururlar. Bu durum, kaliteli ürün ve hizmetlerin sürekliliğini sağlar [1]. Literatürde çalışan adanmışlığı kavramı çeşitli şekillerde tanımlanmıştır. Kahn [2]'a göre çalışan adanmışlığı, işlerine derin bağlılık duyan ve işlerini yaparken fiziksel, zihinsel ve duygusal enerjilerini aktif bir şekilde kullanan çalışanların durumudur. Schaufeli vd. [3] çalışan adanmışlığını, zindelik, adanma ve yoğunlaşma gibi özelliklerle karakterize edilen pozitif, tatmin edici, işle ilişkili bir ruh hali olarak tanımlamaktadır. Bu tanımda yer alan zindelik boyutu, çalışırken yüksek enerji seviyeleri ve zihinsel dayanıklılıkla birlikte işe çaba harcamaya istekli olmayı ve zorluklarla karşılaşıldığında bile azim göstermeyi içermektedir. Adanma boyutu ise önem hissi, heves, ilham, gurur ve meydan okuma duygularıyla belirginleşir. Son olarak, yoğunlaşma boyutu, çalışanın işine tamamen odaklandığı durumu ifade eder. Bu durumda zaman hızla geçer ve işten kopmakta zorluk çekilir. Bu boyutların etkili yönetimi, iş performansını artırmada önemli bir rol oynar.

Öte yandan, çalışma ortamı, işin özellikleri, liderlik tarzı, ekip ve iş arkadaşları, örgüt kültürü, etkili iletişim, özerklik, adalet algılamaları, algılanan örgütsel destek ve psikolojik iklim gibi faktörler, çalışan adanmışlığının temel belirleyicileri arasında yer alır [4]. Özellikle liderlik tarzlarının çalışan adanmışlığı üzerindeki etkisi geniş çapta kabul görmektedir. Örneğin, dönüşümcü liderlik gibi pozitif liderlik

yaklaşımları, adanmış bir çalışma ortamının oluşturulmasında önemli rol oynamaktadır. Bununla birlikte, etik liderlik, otantik liderlik, kapsayıcı liderlik, hizmetkâr liderlik ve işlemci liderlik gibi farklı liderlik yaklaşımlarının çalışan adanmışlığı üzerindeki etkisini anlamak için daha fazla bilimsel araştırmaya ihtiyaç vardır [5]. Özellikle, çalışan adanmışlığı ve kapsayıcı liderlik konusunu ele alan literatürün azlığı dikkat çekmektedir [6].

Nembhard ve Edmondson [7] kapsayıcı liderliği, liderin söz ve davranışlarıyla takipçilerini katkıda bulunmaya teşvik ettiği ve bu katkıları takdir ettiği bir liderlik biçimi olarak tanımlanmıştır. Hollander [8] ise kapsayıcı liderliği, liderlerin takipçilerin ihtiyaçlarını dinlemesi ve onlara erişilebilir olduklarını hissettirmesi üzerine kurulu bir ilişkisel liderlik biçimi olarak görmüştür. Kapsayıcı liderler, bireylerin bir grup içinde hem ait olma hem de özgün kimliklerini koruma ihtiyacını dengeleyerek hareket ederler. Bu çerçevede kapsayıcı liderler, bireyleri grubun bir üyesi olarak görür, adalet ve eşitlik sağlar, karar alma süreçlerini paylaşır ve böylece grup içinde ait olma hissini güçlendirirler. Ayrıca, örgüte katkı sağlamalarını teşvik eder, tam katılımlarını sağlamaya yardımcı olur ve bireylerin özgünlüklerini öne çıkarırlar [9]. Bu tutum ve davranışlar sayesinde, kapsayıcı liderler, çalışanların işlerine daha fazla adanmışlık göstermelerini sağlarlar [10].

Bu çalışma, kapsayıcı liderlik stratejilerinin çalışan adanmışlığını nasıl etkilediğini araştırmayı amaçlamaktadır. Çalışmanın içeriği şu şekilde düzenlenmiştir: Çalışmada kullanılan materyal ve yöntemler tanıtıldıktan sonra, elde edilen bulgular sunulacak ve bu bulgular doğrultusunda kavramsal bir model geliştirilecektir. Ardından çalışmanın ana sonuçları özetlenecektir.

II. MATERYAL VE YÖNTEM

Bu çalışmada, kapsayıcı liderlik stratejilerinin çalışan adanmışlığına etkisi belirlemek amacıyla sistematik bir literatür taraması gerçekleştirilmiştir. 5 Temmuz 2024 tarihinde WoS ve Scopus veritabanlarında gerçekleştirilen arama sorguları şu şekildedir: WoS veri tabanında Topic: “employee engagement” and Topic: “inclusive leadership” şeklinde arama yapılırken, Scopus veritabanında Article title, Abstract, Keywords: “employee engagement” and Article title, Abstract, Keywords: “inclusive leadership” şeklinde arama gerçekleştirilmiştir. Her iki veri tabanında da arama sorguları, İngilizce makalelerle sınırlandırılmıştır. Böylece, WoS veri tabanından 11, Scopus veri tabanından 15 yayın elde edilmiştir. Ardından, tekrarlanan çalışmaları belirlemek amacıyla çapraz kontroller yapılmış ve 9 yayın kapsam dışı tutulmuştur. Ayrıca, 3 yayının tam metnine erişilemediğinden, araştırma kapsamına dâhil edilmemiştir. Nitekim kriterleri karşılayan toplam 14 yayın belirlenmiş ve analiz edilmiştir.

III. BULGULAR

A. *Tanımlayıcı İstatistikler*

Araştırma kapsamında incelenen kapsayıcı liderlik ve çalışan adanmışlığına dair 14 yayının tanımlayıcı istatistikleri şu şekildedir: Çalışmaların tümü uygulamalı olup, Pakistan ve Çin’de üçer, Zimbabve, Vietnam, Portekiz, Kamboçya, Namibya, Suudi Arabistan, Gana ve Irak’ta birer yayın gerçekleştirilmiştir. Sektörel dağılım incelendiğinde, turizm ve konaklama sektöründe altı, telekomünikasyon sektöründe üç, teknoloji sektöründe iki, kamu sektöründe iki ve çeşitli sektörlerde bir yayın yapılmıştır.

B. *Kapsayıcı Liderlik Stratejileri*

Bu çalışma kapsamında incelenen yayınlardan elde edilen temel bulgular, hangi kapsayıcı liderlik stratejilerinin çalışan adanmışlığını etkilediğini ortaya koymaktadır. Buna göre, çalışmalarda, özellikle açık iletişim kurma ve erişilebilirlik, destekleyici davranışlar sergileme ve psikolojik güvenlik ortamı oluşturma gibi stratejiler, kapsayıcı liderlik uygulamalarının temel taşları olarak öne çıkmaktadır.

Açık iletişim kurma ve erişilebilirlik: Kapsayıcı liderlerin çalışan adanmışlığını artırmasında iletişim anahtar rol oynamaktadır [11]. Abdou vd. [12]’nin belirttiği gibi iletişim stratejileri, çalışanların örgütsel değerlerle daha güçlü bir şekilde özdeşleşmelerine yardımcı olabilir. Özellikle açık iletişim, çalışan adanmışlığını artırmak için kritik bir araç olarak tanımlanmaktadır [13]. Örneğin, açık iletişim yoluyla çeşitlilik ve kapsayıcılık uygulamalarına yönelik olumlu algılar, çalışanların örgüte olan bağlılıklarını

artırabilir [14]. Bu nedenle, liderlerin kapsayıcı liderlik davranışlarını benimsemeleri ve çeşitliliği etkin bir şekilde yönetmeleri önemlidir [15].

İşbirliği kültürünü ve ekip çalışmasını teşvik eden kapsayıcı liderlik yaklaşımı [16, 17], açık kapı politikası ve etkili iletişim üzerine odaklanarak, çalışanların görüşlerini özgürce ifade etmelerini ve kurumsal kararlara katkıda bulunmalarını teşvik eder. Bu sayede, çalışanların adanmışlık seviyelerini olumlu yönde etkiler [6].

Çalışanların işlerine ve örgütlerine adanmışlıklarını artırmak için, liderlerin açık iletişim kurmanın yanı sıra erişilebilir olmaları da kritik öneme sahiptir [1]. Liderler, çalışanların ihtiyaç duyduklarında danışabilecekleri ve karşılaştıkları zorlukları paylaşabilecekleri bir ortam sağlamalıdır. Bu yaklaşım, çalışanların önemli ve değerli olduklarını hissetmelerine katkı sağlayarak adanmışlıklarını artırabilir. Bu nedenle, liderlerin açıklık, uygunluk ve erişilebilirlik özelliklerini benimsemeleri tavsiye edilir [16].

Bu özelliklere sahip kapsayıcı liderler, yüksek kaliteli ilişkiler geliştirerek çalışanların kendilerini güçlü hissetmelerine, enerjik bir şekilde çalışmalarına, işlerine adanmalarına ve derinden bağlanmalarına olanak tanırlar [6]. Dahası, çalışanların yeni bilgiler, pazarlar ve ürünler arayışına girmelerini desteklerler [15] ve onları yenilikçi iş davranışlarına katılmaya yönlendirirler [18].

Destekleyici davranışlar sergileme: Kapsayıcı liderler, çalışanlara destekleyici bir çalışma ortamı sağlayarak, karar alma süreçlerinde onların görüşlerine değer verir [6]. Bu doğrultuda, liderlere, çalışanlarının özgünlük ve aidiyet ihtiyaçlarına duyarlılık göstermeleri için eğitim programlarına katılmaları önerilmektedir [6, 16]. Kapsayıcı liderlik becerilerini geliştirmeye yönelik bu eğitim programları, çalışanların bağlılığını, iş tatminini, motivasyonunu ve genel performansını artırmayı hedeflemektedir [17, 18]. Ayrıca, koçluk, mentorluk ve rol oynama gibi liderlik geliştirme programları, yöneticilere iş ortamında kapsayıcı liderlik davranışlarını uygulama fırsatları sunar [6].

Hiyerarşik olmayan karar alma süreçlerini önceliklendiren kapsayıcı liderler, aidiyet duygusu yaratarak çalışanların adanmışlığını artırır [13]. Bunun yanı sıra, esnek çalışma düzenlemeleri de çalışan adanmışlığını artıran önemli kapsayıcı uygulamalardan biridir. Esnek çalışma saatleri, çalışanların iş-yaşam dengesini sağlamalarına yardımcı olarak, onların işlerine daha fazla bağlılık ve motivasyonla yaklaşmalarını sağlar. Kişisel ve mesleki ihtiyaçları daha iyi karşılanan çalışanlar, işlerine daha fazla katkıda bulunma eğiliminde olurlar [13].

Genel olarak, liderleri tarafından desteklenen çalışanlar, iş rollerine daha fazla bağlılık gösterirler. Üst yönetimin kendilerine önem verdiğini fark eden çalışanlar, örgütün beklentilerini karşılamak için kendilerini motive hissederler ve olumlu davranışlar sergilerler [1]. Kapsayıcı liderler, çalışanların enerjilerini, bağlılıklarını ve işlerine adanmışlıklarını maksimize eder [18]. Bu liderler, yenilikçi davranışlar üzerindeki önemli bir etkiye sahiptir ve bu etkiyi algılanan örgütsel destek aracılığıyla çalışan adanmışlığı üzerinden sağlarlar. Dolayısıyla, örgütsel destek, çalışanların yenilikçi davranışlarını artırmada kilit bir başarı faktörü olarak görülmektedir [19].

Psikolojik güvenlik ortamı oluşturma: Psikolojik güvenlik ortamı sağlandığında, çalışanlar bilgi ve düşüncelerini rahatça paylaşarak kendilerini güvende hissederler. Bu sayede, liderler, çalışanların güçlü ve zayıf yönlerini daha iyi anlayarak onların görüş ve deneyimlerinden nasıl faydalanacaklarını belirleyebilirler [1]. Bu nedenle, liderlerin psikolojik güvenlik ortamı oluşturmaları, çalışanların adanmışlıklarını ve üretkenliklerini artırmak açısından kritik öneme sahiptir [13].

Kapsayıcı liderlik ile çalışan adanmışlığı arasındaki ilişkide psikolojik güvenin belirleyici bir rol oynadığı bilinmektedir [1]. Kapsayıcı liderler, olumlu bir çalışma ortamı yaratarak çalışanların iyilik hallerini artırma, memnuniyeti sağlama ve adanmışlıklarını yükseltmede kritik bir öneme sahiptir. Bu liderler, çalışanların görüşlerini ifade etmelerini, karar alma süreçlerine katılmalarını ve çalışma ortamlarını aktif bir şekilde şekillendirmelerini teşvik ederler [13].

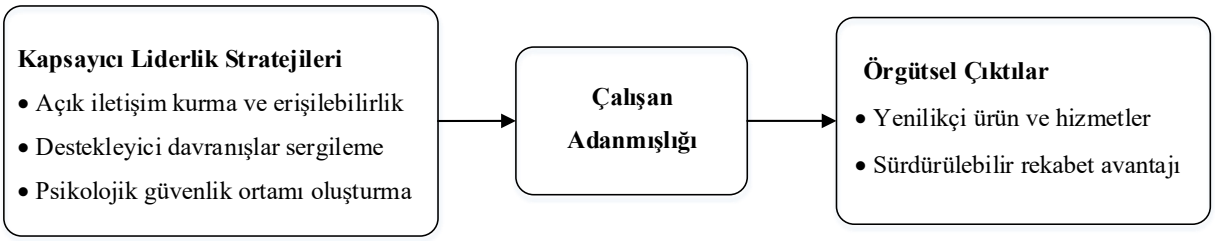
Dolayısıyla, kapsayıcı liderler, çalışanların kendilerini güvende hissetmelerini sağlayarak iş adanmışlıklarını artırmaktadır [20]. Şefkat, empati ve adalet gibi kapsayıcı liderlik uygulamaları, çalışanlarda gönüllü çaba ve dayanıklılığı güçlendirir. Bu uygulamalar, psikolojik olarak güvenli bir ortam yaratarak örgüt içi güveni artırır ve yenilikçi performansa katılımı güçlendirir [13].

C. *Kapsayıcı Liderlik Stratejileri ve Örgütsel Çıktılar*

Araştırmalar, kapsayıcı liderliğin çalışanların algılarını şekillendirerek adanmışlıklarını önemli ölçüde artırdığını ve kapsayıcı liderlik ile çalışanların işe adanmışlığı arasında pozitif bir ilişki olduğunu göstermektedir [6, 14, 17, 21]. Kapsayıcı liderler, çalışanların katılımını ve güçlenmesini sağlayarak, onların bağlılık göstermelerini ve işlerini canlılıkla, adanmışlıkla ve kendilerini işlerine kaptırarak yapmalarını desteklerler [6]. Kapsayıcı liderler, çalışanları karar alma süreçlerine dâhil eder ve onları örgütsel hedeflere ilişkin tam bilgi ile donatır. Bu sayede, çalışanlar olumsuz sonuçlardan korkmadan düşüncelerini rahatça ifade edebilirler. Kapsayıcı liderler, çalışanların özgüvenini artırır [16], yaratıcı düşünmelerini destekler [17, 21, 22] ve yenilikçi iş davranışlarında bulunmalarını teşvik ederler [15, 16, 18]. Dolayısıyla, kapsayıcı liderliğin çalışanların keşif ve yenilik yapma potansiyelleri üzerinde olumlu bir etkisi olduğunu [15] ve sürdürülebilir rekabet avantajına yol açma potansiyeline sahip olduğunu söylemek mümkündür [13].

D. *Kavramsal Bir Model Oluşturma*

Bu çalışmadan elde edilen bulgular çerçevesinde kavramsal bir model geliştirilmiştir. Bu model, kapsayıcı liderlik stratejilerinin örgütsel çıktılarla ilişkisini ve bu ilişkide çalışan adanmışlığının aracı rolünü göstermektedir. Modelin bileşenleri Şekil 1'de görüldüğü gibidir.



Şekil 1. Kapsayıcı liderlik, çalışan adanmışlığı ve örgütsel çıktılar

Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 1'e göre, açık iletişim kurma ve erişilebilirlik, destekleyici davranışlar sergileme ve psikolojik güvenlik ortamı oluşturma gibi kapsayıcı liderlik stratejileri doğrudan çalışan adanmışlığını artırmaktadır. Kapsayıcı liderlerin çalışanlarla kurdukları açık iletişim kanalları ve erişilebilirlikleri, çalışanların kendilerini ifade etmelerine, geri bildirim almalarına ve liderlerine kolayca ulaşmalarına olanak tanır. Bu durum, çalışanların liderlerine duydukları güveni artırarak, işlerine daha fazla adanmışlık göstermelerine katkı sağlar. Destekleyici davranışların sergilenmesi, liderlerin çalışanlarına yönelik empati, anlayış ve yardımseverlik göstermesi anlamına gelir. Bu tür davranışlar, çalışanların kendilerini değerli hissetmelerini sağlar. Psikolojik güvenliğin sağlanması ise, çalışanların fikirlerini ve düşüncelerini özgürce ifade edebildikleri, hata yapmaktan korkmadıkları ve yenilikçi uygulamaları deneyebildikleri bir ortam oluşturur.

Kapsayıcı liderlik stratejileriyle artan adanmışlık düzeyi, çalışanların yaratıcı düşünme ve yenilikçi iş modelleri geliştirme yeteneklerini artırır. Bu süreç, örgütün yenilikçi ürün ve hizmetler geliştirmesini kolaylaştırır. Yenilikçi ürün ve hizmetlerin geliştirilmesi, örgütün piyasada farklılaşmasını, müşteri beklentilerini daha iyi karşılamasını, pazar payını artırmasını ve rekabet avantajı elde etmesini sağlayarak uzun vadeli başarıyı destekler.

Kısaca, kapsayıcı liderlik stratejilerinin uygulanması, çalışan adanmışlığını artırarak, yaratıcı düşünme ve yenilikçi iş davranışları geliştirmeyi teşvik eder. Bu durum, örgütün yenilikçi ürün ve hizmetler geliştirmesine ve sürdürülebilir rekabet avantajı kazanmasına önemli ölçüde katkıda bulunur.

IV. SONUÇLAR

Bu çalışma, kapsayıcı liderlik stratejilerinin çalışan adanmışlığı üzerindeki etkilerini sistematik bir literatür taramasıyla incelemektedir. Bulgular, kapsayıcı liderliğin çalışanların işlerine ve örgütlerine adanmışlıklarını artırdığını göstermektedir. Özellikle, açık iletişim ve erişilebilirlik, destekleyici

davranışlar sergileme ve psikolojik güvenlik ortamı oluşturma stratejilerinin, çalışanların adanmışlık düzeylerini artırmada etkili olduğu belirlenmiştir.

Bu bağlamda, liderlerin çalışanlarla sürekli iletişim halinde olmaları ve açık kapı politikası uygulamaları, çalışanların kendilerini değerli ve önemli hissetmelerini sağlayarak adanmışlıklarını artırmaktadır. Ayrıca, çalışanların başarılarını takdir etme, koçluk ve mentorluk desteği sunma, esnek çalışma programları düzenleme gibi destekleyici davranışların, çalışanların iş süreçlerine daha aktif katılım göstermelerini sağlamaktadır. Dahası, psikolojik güvenlik ortamı oluşturma stratejisi, çalışanların fikirlerini özgürce ifade etmelerini teşvik ederek adanmışlık düzeylerini artırmaktadır.

Çalışmanın önemli bulgularından biri, kapsayıcı liderlik stratejilerinin yaratıcı düşünme, yenilikçi iş davranışları ve örgütsel performans üzerinde olumlu etkiler sağladığı ve bu süreçte çalışan adanmışlığının aracı bir rol oynadığıdır. Bu çerçevede, kapsayıcı liderliğin çalışanlar arasında yaratıcılığı teşvik ettiği, yenilikçi çözümler geliştirme isteğini artırdığı ve sonuç olarak örgütsel performansı iyileştirdiği görülmüştür. Kapsayıcı liderlik uygulamalarının, örgütler için sürdürülebilir rekabet avantajı sağlama potansiyeline sahip olduğu da vurgulanmıştır.

Bu çalışma, kapsayıcı liderlik ve çalışan adanmışlığı arasındaki ilişkiyi anlamak için geliştirilen bir modelle yeni bir bakış açısı sunmaktadır. Elde edilen bulguların, yöneticiler ve araştırmacılar için kapsayıcı liderlik stratejilerinin çalışan adanmışlığını nasıl etkilediğini anlamalarına katkı sağlaması beklenmektedir. Gelecekte yapılacak araştırmaların, farklı endüstrilerde ve kültürel bağlamlarda bu ilişkiyi daha derinlemesine incelemesi önerilmektedir. Ayrıca, bu bilgilerin işletmeler tarafından stratejik olarak nasıl kullanılabileceği konusunda rehberlik sağlanması beklenmektedir. Böylece, kapsayıcı liderlik ve çalışan adanmışlığı arasındaki dinamiklerin daha iyi bir şekilde anlaşılması ve işletmelerin sürdürülebilir başarıları için bir temel oluşturulması mümkün olacaktır.

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Statistical Analysis of Changes in Numbers of Teacher, Student, and School in Turkey: A 2000-2023 Case Study

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Abstract – The purpose of this study is to investigate certain numerical indicators related to the number of teachers, students, and public schools in Turkey between 2000 and 2023, based on the data and research reports provided by the Turkish Statistical Institute (TUIK) and the Ministry of National Education. In the study, data examination was conducted within the scope of the qualitative research method, and the obtained data were analyzed using statistical methods. Firstly, the graph showing the change in the number of students per teacher in Turkey between 2000 and 2023 was presented, and based on this, data on the changes in the number of students per teacher over the years were provided. The next analysis examined the change in the number of students in schools in Turkey between 2000 and 2023. In the mentioned years, an average of 360 students corresponds to each school. This number was lowest in 2001 with 243 students, and highest in 2014 with 546 students. Additionally, the gender distributions of students between 2000 and 2022 were examined, and some inferences were drawn from the obtained ratios. Lastly, the change rates in the number of schools, teachers, and students between 2000 and 2022 were investigated. In these calculations, the fixed base index method was used. Therefore, the year 2000 was taken as a constant, and the changes in the other years compared to this year were examined.

Keywords – Education indicators, school, teacher, constant basis index method

I. INTRODUCTION

Education is considered one of the most important cornerstones of social structure, and the key stakeholders in education are teachers, students, and educational institutions. In recent years, Turkey has experienced significant transformations in the field of education. These transformations have manifested as increases in the number of teachers, changes in student demographics, and differentiations in school structures. This study aims to examine the changes in the number of teachers, students, and schools in Turkey using statistical methods.

Each of these elements in our education system stands out as indicators of social change at both micro and macro levels. Teachers are at the center of knowledge and value transfer, while students, as the recipients of this knowledge and the representatives of the future, are at the heart of the education process. Schools, as the physical spaces where these interactions occur, are among the factors that directly affect the quality of education.

In recent years, especially technological advancements and demographic changes have had noticeable effects on the numbers of teachers, students, and schools. Optimally developing these three elements will enhance the effectiveness of education at every level. Consequently, social welfare and economic development will be positively affected. Therefore, the numbers of teachers, students, and schools hold

central importance in determining the fundamental dynamics of the education system and its impact on society. As a result, numerous studies have focused on these elements. For instance, in their study, [1] examined the preparations for future periods of Turkey's education policies based on the education sections of 10 development plans, investigating current and potential problems, and providing solutions and suggestions for the identified issues. As it is known, tangible returns on educational investments require long periods. Making short and medium-term preliminary assessments of educational investments is crucial for the reliability and continuity of the process. In this context, concrete data provided by some national or international examinations are important indicators in evaluating this process. For example, [2] examined the results of the countries successful in the Program for International Student Assessment (PISA) program and Turkey's results within the scope of the distribution of educational investments. Such examinations have been addressed in different methods and dimensions by many researchers ([2], [4], [5], [16]), as well as by educational policymakers. Based on the statistics and research reports of the Ministry of National Education, [6] studied the educational indicators related to public schools in Turkey between 2000 and 2021. In this study, document analysis was conducted within the scope of the qualitative research method, and thematic analysis technique was used for the obtained data. Changes in the numbers of teachers and students in schools in different regions of Turkey play an important role in shaping educational policies. Statistical analyses are crucial in uncovering the underlying trends and factors of these changes. Additionally, statistical analysis methods have been frequently used in recent periods to obtain qualitative data on various subjects ([7], [8], [9], [10]).

This research aims to conduct a comprehensive statistical evaluation to understand the current state of the Turkish education system and its changes over time. The study will analyze the changes in the numbers of teachers, students, and schools over the years, particularly focusing on these changes' yearly situations. These analyses will enable educational policies to be shaped more consciously and data-driven, shedding light on the future of the Turkish education system.

II. Materials and Method

A. *Data*

The data used in the study were provided from the Turkish Statistical Institute (TUIK) data portal [11]. The number of teachers in the data includes the number of permanent teachers working in the state. The number of graduating students was taken after the academic year was completed, as per the system. In other words, the numbers given in 2023 appear after the 2022-2023 academic year is completed.

B. *What is a Fixed Basis Index?*

A constant basis index is a method used to measure price or quantity changes in other years, based on the price or quantity levels of a particular base year. The base year is chosen as the reference year against which other years will be compared. These indices are used to monitor changes in inflation rates, production levels and other economic variables in the economy over time [12].

C. *Fixed Based Index Types*

Price Indices: These indices measure price changes in other years based on the price levels of a particular base year. For example, the Consumer Price Index (CPI) and the Producer Price Index (PPI) fall into this category [13].

Quantity Indices: These indices measure quantity changes in other years based on the quantity levels of a particular base year. For example, production amounts of agricultural products or industrial production indices fall into this category [14].

Calculation Methods

Fixed basis indices are often calculated using methods such as Laspeyres and Paasche indices:

Laspeyres Index: It measures price changes in other years, keeping the base year's quantities constant. This index may tend to exaggerate cost increases because it ignores the fact that consumers switch from higher-priced goods to lower-priced goods [15].

$$Laspeyres\ Price\ Index = \frac{\sum(P_t.Q_o)}{\sum(P_o.Q_o)}x100$$

Here,
Pt is the current year price,
P_o base year price
Q_o indicates the base year amount.

Paasche Index: It measures price changes in other years, keeping the current year's quantities constant. This index may more accurately reflect how consumers respond to price changes [12].

$$Paasche\ Price\ Index = \frac{\sum(P_t.Q_t)}{\sum(P_o.Q_t)}x100$$

Here,
Q_t displays the current year amount.

III. RESULTS

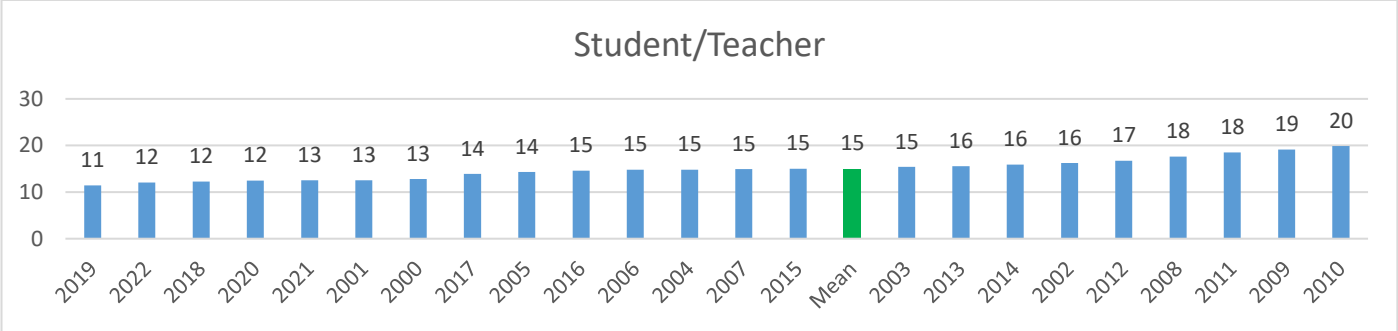


Fig 1. Number of Students per Learner Between 2000-2023

As a result of the analysis, the change graph of the number of students per teacher in Turkey between 2000 and 2023 is shown in the figure is located. According to the figure, the average of the years in question is calculated as 15. In other words, there are 15 students for each teacher in the relevant years. While 2002 and 2003 and 2009-2014 were above this general average, the remaining years remained below the average. The lowest number was calculated as 11 students in 2019. Contrary to 2019, it was determined that the highest number of students per teacher was found in 2010, with 20 students, almost twice the number in 2009.

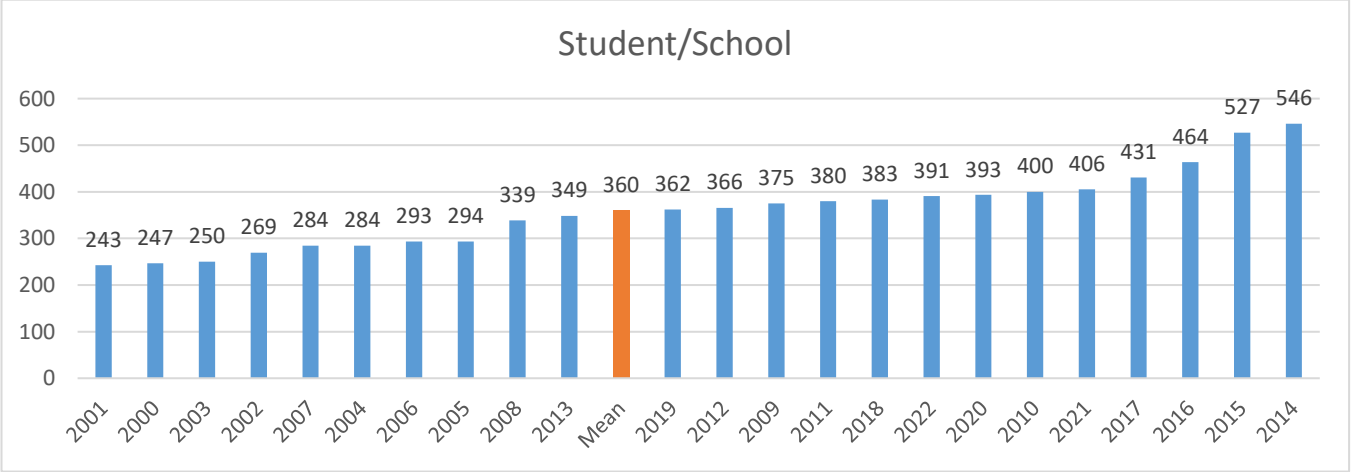
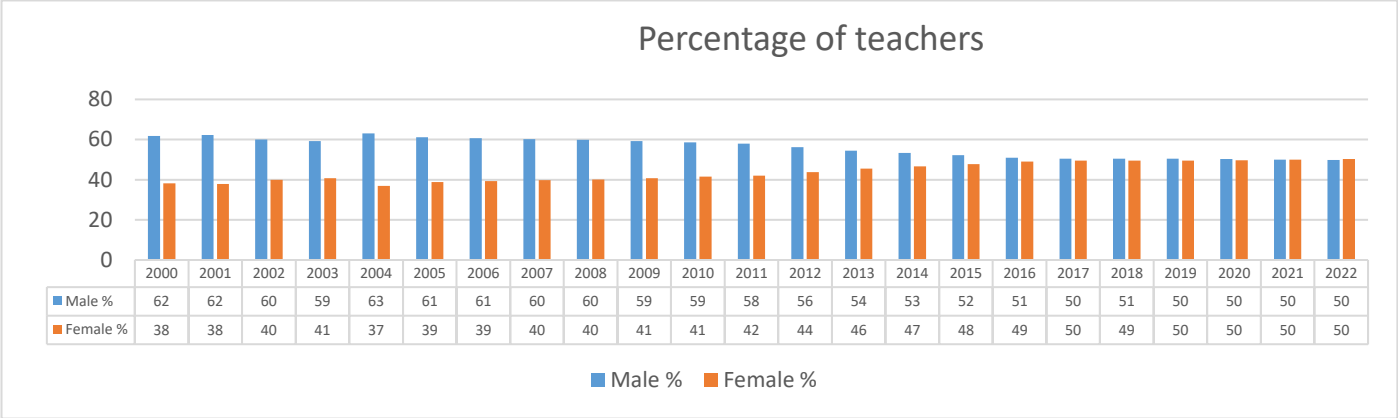


Fig 2. Number of Students per School Between 2000-2023

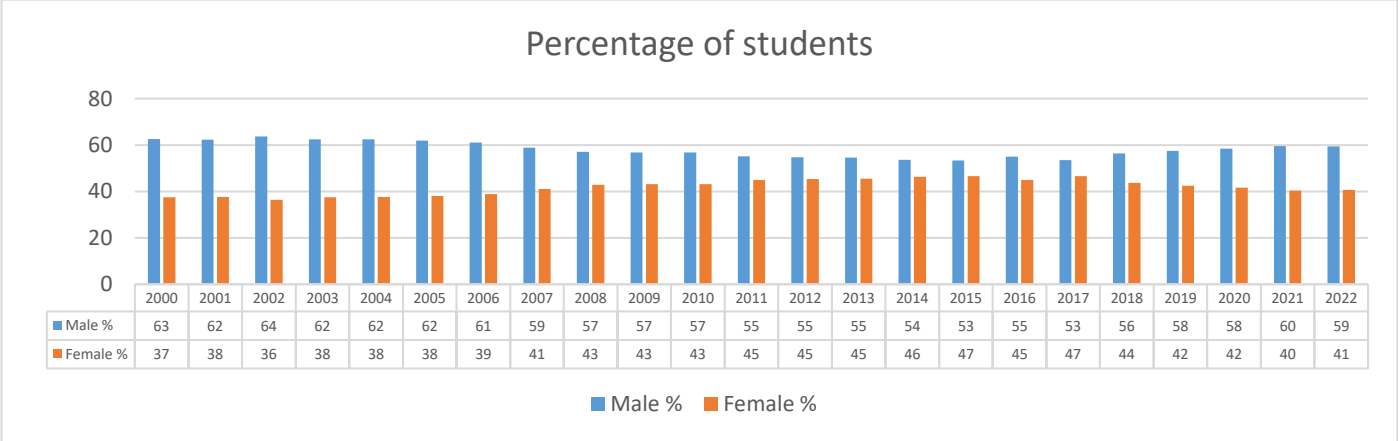
Figure 2 contains a graph showing the change in the number of students in schools in Turkey between 2000 and 2023. The relevant chart shows the average of the years in question, that is, an average of 360 students in each school. While this number was lowest with 243 people in 2001, it was found to be the highest in 2014 with 546 people. While the years 2000-2008 and 2013 remain below the average, the remaining years are above the general average.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Male %	62	62	60	59	63	61	61	60	60	59	59	58	56	54	53	52	51	50	51	50	50	50	50
Female %	38	38	40	41	37	39	39	40	40	41	41	42	44	46	47	48	49	50	49	50	50	50	50

Fig 3. Female-Male Ratios in Learning by Years

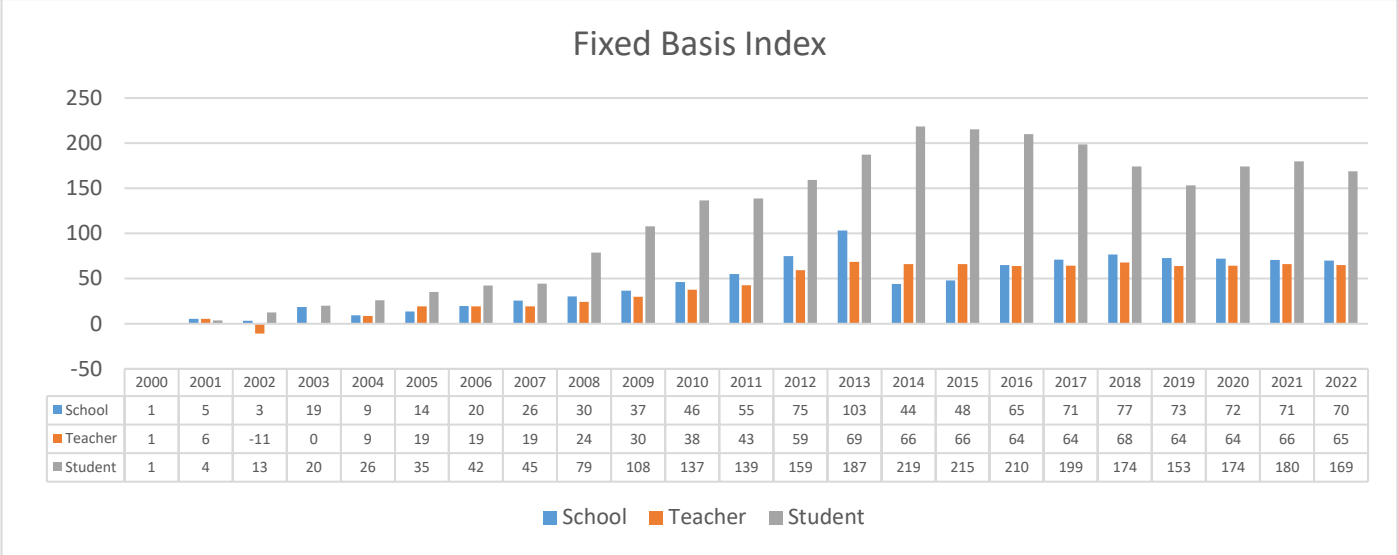
Figure 3 shows the percentage distribution of teachers in terms of gender in Turkey between 2000-2023. As a result of the analysis, it is seen that there was an imbalance in terms of gender in the 2000s. In 2000 and 2001, the proportion of male teachers was 62%, while the proportion of female teachers was 38%. In the following years, the rate of male teachers decreased and the rate of female teachers began to increase. When looking at both genders over time, it is seen that the rates are closer to each other. It has been determined that this gender distribution ratio is equally distributed between women and men, especially in the years 2019-2022. It can be said that between the years in question, the imbalance gradually decreased in the transition from the current year to the next year and the rates became closer to each other. However, it was determined that this situation was not valid from 2003 to 2004. In other words, while the rate of male teachers was 59% in 2003, this rate increased by 4 points and rose to 63% in 2004.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Male %	63	62	64	62	62	62	61	59	57	57	57	55	55	55	54	53	55	53	56	58	58	60	59
Female %	37	38	36	38	38	38	39	41	43	43	43	45	45	45	46	47	45	47	44	42	42	40	41

Fig 4. Female-Male Ratios among Students by Years

In Figure 4, the gender distribution of students between 2000-2022 is determined. As a result of the analysis, it is observed that the difference in gender distribution decreased from the 2000s to 2015. For example, in 2000, while the rate of male students was 63%, the rate of female students was 37%. These rates were calculated as 53% and 47% in 2015. In the following years, if we exclude only 2017, there is a decrease in the rate of female students. By 2022, the rate of male students is calculated as 59% and the rate of female students is 41%.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
School	1	5	3	19	9	14	20	26	30	37	46	55	75	103	44	48	65	71	77	73	72	71	70
Teacher	1	6	-11	0	9	19	19	19	24	30	38	43	59	69	66	66	64	64	68	64	64	66	65
Student	1	4	13	20	26	35	42	45	79	108	137	139	159	187	219	215	210	199	174	153	174	180	169

Fig 5. Changes in Schools, Teachers and Students by Years

Figure 5 shows the change rates in the number of schools, teachers and students between 2000 and 2022. In the calculation made here, the fixed basis index method was used. Taking the year 2000 as constant, it was calculated how much change the other years showed compared to this year. Therefore, the year 2000, taken as a constant, was written as 1, that is, 100%. In the analyses, it is seen that there is a continuous increase in the number of schools until 2013, considering the year 2000 as the starting point. The same situation is seen in the number of students until 2015. When examined in terms of the number of schools, it can be said that 2013 was the peak year, and when examined in terms of the number of students, it can be said that 2014 was the peak year. However, this cannot be said to be the same for the number of teachers. For example, it is seen that there was a serious decline in the number of teachers in 2002, and this decline is explained by a decrease of 11% compared to 2000. It is seen that the number of teachers in 2003 was the same as in 2000. It is seen that there were serious increases in the following years. It can be said that there was no change in the years 2005-2007, there were increases in the remaining years, and recently it generally remained stable, especially in the years 2014-2022.

IV. DISCUSSION

In this study, the number of students per teacher, the number of students per school, gender distribution, and the change rates of schools, teachers, and students in Turkey between 2000 and 2023 were analyzed. The findings reveal significant changes and trends in the education system.

The findings on the number of students per teacher indicate significant fluctuations over the years. The number of students per teacher reached its highest level in 2010 and its lowest level in 2019. These fluctuations can be associated with changes in education policies, teacher appointments, and demographic shifts. The decreasing trend in the number of students over time suggests an improvement in the teacher-student ratio and a potential increase in education quality.

The number of students per school has generally increased over the years. The highest number of students was reached in 2014, which can be explained by the increase in school capacity and population growth. However, the number being below average between 2000-2008 and in 2013 indicates that the number of schools was insufficient or the student distribution was imbalanced during these periods.

When examining gender distribution, it is observed that gender imbalance among teachers has decreased over time. At the beginning of the 2000s, the number of male teachers was significantly higher than that of female teachers. However, in the following years, an increase in the number of female teachers was observed, and the gender distribution became equal between 2019 and 2022. Among students, gender distribution approached balance by 2015, but after 2015, a difference in favor of male students re-emerged. This situation indicates that there are still some challenges regarding girls' access to education.

When examining the change rates of schools, teachers, and students, a continuous upward trend is observed between 2000 and 2022. The peaks in 2013 and 2014 reflect investments in the education system and population growth. However, the drop in the number of teachers in 2002 is notable and suggests a need to revisit teacher policies from that period.

V. CONCLUSION

This study reveals significant changes and trends in the education system in Turkey between 2000 and 2023. The decrease in the number of students per teacher indicates a potential increase in education quality, while the increase in the number of students per school suggests an expansion in educational infrastructure and capacity. The reduction in gender imbalance among teachers can be considered a positive development, whereas the imbalance in gender distribution among students highlights that there is still work to be done to improve girls' access to education.

The findings emphasize the importance of education policies and investments, pointing out crucial aspects to be considered in future educational planning. It can be concluded that more efforts are needed, particularly in teacher appointments and improving girls' access to education. For the overall improvement of the education system and the creation of a more equitable structure, it is essential that policymakers take these findings into account.

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Ebelik Mesleğinde İletişimin Önemi

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Özet – İletişim sağlık bakım hizmetlerinde önemli bir araçtır. Sağlık profesyonellerinin bakım verdikleri bireylerle olan iletişimi bakım kalitesi ve memnuniyetini artıracaktır. İletişim Dünya Sağlık Örgütü'nün önerdiği çerçevede perinatal bakım kalitesinin sekiz alanından biridir. Kadın sağlığını koruma ve geliştirmede birincil sağlık profesyoneli olan ebelerin kadınlar ile olan ilişkisi büyük ölçüde iletişim yoluyla kurulur. Ebe fiziksel, sosyal ve psikolojik destek sağlarken tüm bunları etkili bir iletişim ile gerçekleştirmesi gerekir. Bu anlamda ebelik bakımı ebenin iyi bir iletişimci olmasını gerekli kılmaktadır. Bu derleme makalesinde ebelik bakım uygulamaları sırasında iletişimin öneminin literatür çerçevesinde incelenmesi amaçlanmıştır. Ebeler doğum öncesi, doğum ve doğum sonrası dönemde kaliteli ve etkili iletişim ile kadına sağladıkları bakımın kalitesini ve kadınların bakımdan duydukları memnuniyeti artırabilir. Gebelikte, optimum iletişimin bakımdan memnuniyeti artırdığı, kaygıyı azalttığı ve sağlık davranışı değişikliği için motivasyonu artırmaktadır. İletişim, doğum yapan kadının güvenlik ve öz yeterlilik duygusunu güçlendiren bir unsurdur Doğum eyleminde hormonal değişimler ve kontraksiyonlara bağlı olarak kadın sözel iletişime kapalı olsa da bu dönemde özellikle sözsüz iletişim önem kazanmaktadır. Doğum sonrası dönemde ise kadının bebeğine kavuşması ile tüm dikkati bebeğine yönlenir. Özellikle bu süreçte bebek bakımı konusunda etkili bir iletişime gereksinim duyulmaktadır. Bu bilgiler ışığında ebelik eğitimi ve meslek yaşamı boyunca ebelerin iletişimini geliştirecek teorik ve pratik uygulamalara daha fazla yer verilmesi önemlidir.

Anahtar Kelimeler – ebelik, iletişim, doğum öncesi, doğum, doğum sonrası

I. GİRİŞ

İletişim, sağlık hizmeti uygulayıcısı olmanın temel bir unsurudur. Bakım alan bireyler hakkında gerekli ve hayati bilgiler iletişim yoluyla toplanır. Etkili iletişim, bireylerin aldıkları bakımdan duydukları memnuniyeti etkilerken, aynı zamanda bireylerin zamanında ve uygun bakımı almalarını sağlamada da önemli bir araçtır. Örneğin, iletişimin ilaç uygulama hatalarını azaltmada önemli bir kriter olduğu ve acil durumlarda sağlıklı iletişimin önemli bir rol oynadığı bildirilmektedir [1], [2].

Dünya Sağlık Örgütü'nün önerdiği çerçevede perinatal bakım kalitesinin sekiz alanından biri de iletişimdir. Kadın ile ebe arasındaki ilişki büyük ölçüde iletişim yoluyla kurulur [3]. Ebeler, antenatal, intrapartum ve postpartum dönemde kadınlara doğum bakımı sağlama konusunda dünya çapında uzman sağlık profesyoneli olarak kabul edilmektedir. Hemşirelik ve Ebelik Konseyi (NMC) ebeleri; kadınlara, bebeklere ve ailelere yetenekli, bilgili, saygılı ve şefkatli bakım sağlayan özerk uygulayıcılar olarak tanımlamaktadır [4]. Ebelik uygulamasının temelini oluşturan temel felsefi değerlerden biri, kadını kendi bakımının merkezine yerleştirmek ve karar verme süreçlerine katılımını sağlamaktır [4],[5]. Tüm bu süreçler içinde ebe ve kadın birebir iletişim içinde olmaktadır. Ebe fiziksel, sosyal ve psikolojik destek sağlarken tüm bunları etkili bir iletişim ile gerçekleştirmesi gerekir. Bu anlamda ebelik bakımı ebenin iyi bir iletişimci olmasını gerekli kılmaktadır.

Bu derleme makalesinde ebelik bakım uygulamaları sırasında iletişimin öneminin literatür çerçevesinde incelenmesi amaçlanmıştır.

II. EBELİK MESLEĞİ İÇİNDE İLETİŞİMİN YERİ

Ebeler, kadınların tercihlerini, endişelerini ve ihtiyaçlarını anlamak için kadını bakım sürecine dahil eden ve bu süreçte kadını dinlemeyi gerektiren uygulamalar gerçekleştirir [6]. Ebeler ayrıca antenatal, intrapartum ve postpartum dönemde kadını bakım konusunda bilgilendirme ve bireyselleştirilmiş bakımı sağlamakla ilgili bilgi vermekten de sorumludur. Risk değerlendirmesi, sevk, savunuculuk ve halk sağlığı da ebelik uygulamasının merkezi rolleridir [4]. Tüm bu roller ve sorumluluklar ebenin etkili bir iletişimci olmasını gerektirir. Ancak ebelerin iletişim becerilerini daha çok klinikte geliştirdikleri ve iletişim konusundaki becerilerini kendilerinin değerlendirdikleri bildirilmektedir [7].

Ebelik bakımında iletişim birçok biçimde olabilir. Uluslararası Ebeler Konfederasyonu (ICM) yeterlilik standartları (2019), ebelerin kadınlarla paylaşması ve tartışması beklenen bilgilere kapsamlı bir genel bakış sunmaktadır. Bilgi verme, bilgilendirme, tartışma, danışmanlık yapma, öneride bulunma gibi terimler bu standartlarda defalarca vurgulanmaktadır. Bunlara örnek olarak 'taramayla tespit edilebilecek durumlar hakkında bilgi sağlamak', 'bulguları ve potansiyel sonuçları kadınla tartışmak ve bakım planını karşılıklı olarak belirlemek', 'kadına bakım veya tedavi seçenekleri hakkında danışmanlık yapmak', ‘gebeliği sonlandırmak’ ve ‘kadının kararına saygı duymak’ verilebilir [5]. Benzer şekilde NMC yeterlilik standartları (2019), ebelerin kadınlarla çalışırken sorulara dürüst bir şekilde yanıt vermesi, kanıta dayalı bilgiler sunması, karmaşık ve hassas konuları tartışması ve bireyselleştirilmiş bakımı sağlaması gerektiğini belgelemektedir [4]. Bu standartlar, tüm ebelerin iletişim konusunda iyi eğitimli olmaları ve iletişim becerilerini yeterince geliştirmiş olmaları beklentisiyle iletişim becerilerine merkezi bir odak noktası oluşturmaktadır.

Kadın için en özel dönemlerden biri olan doğum öncesi dönem sunulan ebelik bakımı ebe ve kadın arasında etkili bir iletişim gerektirmektedir. Doğum öncesi dönemde bakım memnuniyetinin sağlanmasında kaliteli iletişim ve kişi merkezli bakımın önemli olduğu vurgulanmaktadır [8]. Gebelikte, optimum iletişimin bakımdan memnuniyeti artırdığı, kaygıyı azalttığı ve sağlık davranışı değişikliği için motivasyonu artırdığı gösterilmiştir [9],[10]. Kaliteli iletişimi kolaylaştırmak için ise bakım sürekliliğinin ve sürekli bakımın sağlanmasında bakım sağlayan ebenin değişmemesinin önemli olduğu bildirilmektedir [10],[11],[12]. Bu durum sürekli ebelik bakımı modelinin önemini desteklemektedir. Ayrıca doğum öncesi bakımda ebenin saygılı annelik bakımı çerçevesinde saygılı, güven veren, etkileşimli ve destekleyici iletişim kurmasının kadınların korku ve endişelerini azaltacağı bildirilmektedir [8]. Doğum öncesi dönemde kaliteli iletişim ile sağlanan bakım, kadının doğuma hazırlanmasını olumlu yönde etkileyerek doğum sürecini kolaylaştırabilir.

İletişim, doğum yapan kadının güvenlik ve öz yeterlilik duygusunu güçlendiren bir unsurdur. Bu durum, doğum sırasında hayati önem taşır ve kadının perinatal bakımdan duyduğu memnuniyeti önemli ölçüde etkilemektedir. Doğum bakım personeli tarafından sağlanan etkili iletişim, bir kadının doğum eylemi ve doğum sırasında olumlu bir doğum deneyimi yaşamasına yardımcı olabilir. Bakımda kadınlar ve aileleriyle etkili ve kaliteli iletişim içinde, onların ihtiyaç ve tercihlerine yanıt verilmesi sağlanmalıdır [3]. Doğum öncesi dönemden farklı olarak doğum sürecinde kadının vücudu bilişsel süreçlerden kısmen çekilir. Hormon salgılanmasıyla ilgili olarak özellikle travay sırasında eylemler içgüdüsel hale gelmektedir. Özellikle kontraksiyonların şiddetlendiği aktif faz, geçiş fazı ve ikinci evrede kadın sözel iletişime kendini kapatabilmektedir. Doğum yapan kadından bir konuşma ve rasyonel tepkiler beklemek doğumun doğal akışını bozabilir. Bu durumda sözel olmayan iletişim ebe ve kadın arasındaki iletişime daha uygun olabilir [13]. Ebelerin iletişim becerileri üzerine yapılan bir araştırma, kadınların memnuniyeti ile ebelerin hem sözlü hem de sözlü olmayan iletişim becerileri arasında bir ilişki olduğunu göstermektedir [14].

Doğum kadının bebeğine kavuştuğu mucizevi bir olaydır. Doğumdan sonra kadının dikkati büyük ölçüde bebeğine ve ona bakmak için gerekli olan bilgi ve desteğe odaklanmaktadır. Bu süreçte kadın bebek bakımı ile ilgili bilgilendirmeye açık, merak ettiği konularda danışmanlık arayan, bebeğinin beslenmesi, hijyeni, bakımı ve sağlığını korumaya yönelik bilgiye meraklı bir tutum sergilemektedir.

Doğum sonrası ilk 24 saatlik süreç olarak nitelendirilen erken portpartum dönemde verilecek bilgi ve destek önemlidir. Erken portpartum dönemde kadının iletişime açık olması verilen bilgi ve desteği daha etkili kılacaktır [3]. Tüm bu fiziksel değerlendirmeler arasında daha az dikkat edilen bir durumsa kadının psikolojik sağlığıdır. Doğum öncesi dönemde doğuma dair hissedilen korku, stres ve kaygı, doğum sırasında yaşanan ağrı, travmatik doğum deneyimi, olumsuz iletişim postpartum dönemde kadını psikolojik yönden olumsuz etkilemektedir. Kadının anneliğe hazır hissedip hissetmediği, önceki deneyimleri, sosyal destek, sağlık desteği, bebek bakımı konusunda yaşadığı zorluklar çoğu zaman kendini yetersiz hissetmesine neden olabilmektedir. Tüm bu durumlar postpartum dönemde ebe-kadın iletişiminin ne derece önemli olduğunu göstermektedir [15]. Bu dönemde özellikle kaliteli iletişimin sağlanması, sürekli ebe desteği ve saygılı annelik bakımı psikolojik komplikasyonların gelişmesini önleyebilir. Zayıf hasta-sağlık hizmeti sağlayıcısı etkileşimi, olumsuz öznel doğum deneyimleri ve doğum sırasında destek eksikliği ile doğum sonrası posttravmatik stres bozukluğu gelişimi arasında güçlü ilişki bulunmuştur [16],[17]. Travmatik bir doğum yaşadığını belirten kadınların doğum deneyimlerine ilişkin geniş bir retrospektif araştırmada, ortaya çıkan temalardan biri ‘bakım verenlerle zayıf iletişim’ olarak bildirilmiştir [18].

Kadın yaşamının önemli dönüm noktalarını oluşturan gebelik, doğum ve doğum sonrası dönemde ebe-kadın arasında kaliteli iletişimin sağlanması bakım memnuniyetini artırırken gelişebilecek komplikasyonları da önleyecektir. Bu anlamda ebelerin sağlıklı ve etkili birer iletişimci olması önemlidir. Ebelerin iletişim becerilerini geliştirmek için ebelik eğitimin içinde iletişim alanında teorik ve pratik derslere yer verilmesinin yanı sıra meslek yaşamlarında da kişisel gelişimleri için hizmet içi eğitimler düzenlenebilir.

III. EBELİK EĞİTİMİ VE MESLEK YAŞAMINDA İLETİŞİM

İletişim becerilerinin klinik uygulamanın anahtarı olduğunu ve diğer klinik beceriler kadar sağlam bir şekilde öğretilmesi gerektiği ileri sürülmektedir [19]. Tıp fakültelerinde iletişim eğitiminin sağlanması artık yaygın olarak müfredatın temel bir unsuru olarak kabul edilmektedir [20], [21]. Bachmann ve ark. (2017) tarafından, iletişimi yapıcı bir şekilde uyumlu hale getiren müfredatların geliştirilmesine ihtiyaç olduğu bildirilmektedir [20].

Klinik iletişim becerilerinin öğretilmesi zordur. Bu durum, klinik iletişimin gerçekleştiği klinik bağlama girmeden önce akademik ortamda temel ve temel becerileri öğrenen lisans öğrencileriyle etkileşimde bulunulurken özellikle geçerlidir. Bu karmaşıklıklara, özellikle ebeliğin temelini oluşturan ve kadının tercihlerinin, ihtiyaçlarının ve isteklerinin bakımın sağlanmasında merkezi kalmasını sağlamayı amaçlayan kadın merkezli felsefe ışığında, güvenliği ve risk yönetimini ve bilgilendirilmiş onayı sağlamak için bir ebenin profesyonel zorunlulukları da eklenmektedir [22]. Bu durum, ebeler ve kadınlar arasındaki iletişimsel alışverişlerin genellikle duygusal, bireysel ve bir dereceye kadar ebeliğin tıbbi odaklı bir sistem içinde yer almasının tarihsel doğasından etkilenmesi ve zaman zaman kadın merkezli yaklaşımla çelişebilmesi nedeniyle daha da karmaşık hale gelmektedir [23]. Ebelik eğitim müfredatlarında iletişim ile ilgili teorik derslere yer verilirken klinik uygulamaların da iletişim pratiğine katkı sağladığı söylenebilir. Ancak ebelerin meslek yaşamında etkili ve kaliteli iletişim sağlamaları için daha fazla teorik ve pratik desteğe ihtiyaçları olduğu görülmektedir.

Sağlık hizmeti verenlerin bakım alan bireyler ile iyi iletişim kurma konusunda gerekli yeteneğe sahip olmadıkları bildirilmektedir [24]. Ebeler arasında sözlü iletişim düzeyinin artırılması gerektiği ve bunların yalnızca %38'inin optimal düzeyde olduğu belirtilmektedir [25]. Ebelerin iletişim becerilerinin zayıf olduğu ve iletişim eğitimi yoluyla geliştirilebileceği bildirilmiştir [24]. Ülkemizde birinci, ikinci, üçüncü basamak ve özel sektör olmak üzere kadın sağlığını koruma ve geliştirme, kadına sağlık hizmeti sunma noktasında birincil sağlık profesyoneli olarak yer almaktadır. Ebelerin meslek yaşamları boyunca iletişim becerilerini geliştirmeye yönelik hizmet içi eğitim ve kurslara katılmaları bakım verdikleri bireyler ile etkili ve kaliteli iletişim kurmalarına katkı sağlayacaktır.

IV. SONUÇLAR

Bakımı geliştirme ve bakım memnuniyetini artırmada önemli bir yeri olan iletişim özellikle sağlık profesyonelleri için temel bir unsur olduğu bilinmektedir. Ebeler, kadının yaşamı boyunca kadına bakım sunan ve danışmanlık sağlayan birincil sağlık profesyonelleridir. Bakım ve danışmanlık süreçlerinde ebe-kadın iletişimi gebelik, doğum ve doğum sonrası dönemin sağlıklı geçirilmesini olumlu yönde etkilemektedir. Ebelik eğitim süreçleri dışında ebelerin meslek yaşamları boyunca da bireyle birebir iletişim halinde olması etkili bir iletişimci olmalarını gerektirmektedir. Bu anlamda ebelik eğitimi ve mesleki gelişim hizmetleri içerisinde iletişim becerilerini geliştirmeye yönelik uygulamaların yaygınlaştırılması önerilmektedir.

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Çimentolu Harçlarda Agrega İkamesi Olarak Atık Kahve Telvesinin Kullanımı

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Özet **–**Harç üretiminde kullanılan agregalar, harç hacminin yaklaşık %60-80'ini oluşturmakta ve harçların işlenebilirliklerini, reolojik özelliklerini, mekanik davranışlarını ve dayanıklılığı dahil olmak üzere birçok özelliklerini etkilemektedir. Dünya'da, çaydan sonra tüketilen en büyük ikinci içecek olan kahve tüketimi sonrasında geriye kalan kullanılmış kahve telveleri, çoğunlukla çöp depolama alanlarına atılmaktadır. Bu çalışmada, Türkiye'deki yerel kafeteryalardan toplanan atık kahve telvelerinin, çimento esaslı harçlarda kum yerine ikame edilmesi sonrasındaki etkileri araştırılmıştır. Bu amaçla, çimento harcındaki kum, atık kahve telvesi ile hacimce; %0, %2.5, %5, %10, %20 ve %30 oranlarında yer değiştirecek şekilde altı serilik harç tasarımı yapılmıştır. Taze harç serilerine işlenebilirlik deneyi uygulandıktan sonra üretilen 50x50x50 mm'lik numuneler üzerinde; birim hacim ağırlık ve basınç dayanım deneyleri uygulanarak, atık kahve telvesinin çimento esaslı harçlarda meydana getirdiği etkiler değerlendirilmiştir. Çimento esaslı harçlarda kum hacmi yerine ikame edilen atık kahve telvesinin kullanım miktarının artması ile her kademede işlenebilirliklerin, birim hacim ağırlıklarının ve basınç dayanımlarının azaldığı, en fazla %5 oranına kadar kullanılabilecek atık kahve telvesinin, harçların basınç dayanımı üzerinde kabul edilebilir kayıplar oluşturabileceği değerlendirilmiştir.

Anahtar Kelimeler – Agrega, Atık kahve telvesi, Harç, Kahve, Basınç dayanımı

I. GİRİŞ

Dünya'da, çaydan sonra en fazla tüketilen ikinci içecek olan kahve, tüketimi sonrasında geriye kalan kullanılmış telveleriyle birlikte, çoğunlukla çöp depolama alanlarına atılmaktadır. Bununla birlikte atık kahve telvesi, genellikle tarım atıkları kategorisine göre değerlendirilmektedir [1]. Kahve telvesinin geri dönüştürülerek beton teknolojisinde kum veya çimento yerine kullanılması, organik atıkların depolama sahalarına atılmasıyla ilgili çevresel kaygıları azaltabilecektir. Ayrıca, bu yöntem beton üretiminde kullanılan doğal kaynakların tüketimini de azaltarak sürdürülebilirliğe katkı sağlayabilecektir [2].

Agregalar, betonun temel bileşenlerindendir ve fiziksel ile kimyasal özellikleri beton dayanımını etkilemektedir. Beton hacminin yaklaşık %60-80'i doğal agregalardan oluşur ve bunların tüketimi inşaat sektörünün büyümesiyle giderek artmaktadır. Günümüzde kullanılan doğal kumların kullanım miktarının artması ve kontrolsüz kum madenciliği; çevresel bozulmalara, erozyona, biyolojik çeşitliliğin zarar görmesine ve ekolojik dengenin bozulmasına neden olmaktadır [3]. Bu nedenle birçok araştırmacı tarafından, beton sektöründe kum yerine kullanılabilecek çeşitli agrega kaynakları üzerine çalışmalar yapılmaktadır.

Bu çalışmanın amacı, Türkiye'deki yerel restoran ve kafeteryalardan temin edilen atık kahve telvelerinin, çimento esaslı harç üretimlerinde kum ikamesi olarak kullanılabilirliğini araştırmaktır. Bu amaçla, karışımlarda kum hacmi yerine; %2.5, %5, %10, %20 ve %30 oranlarında atık kahve telvesi ikame edilerek harç serileri üretilmiştir. Bunlara ilave olarak; agrega olarak sadece standart kumun kullanıldığı kontrol (C)

serisi de üretilerek, tüm harç serilerinin işlenebilirlik, birim hacim ağırlık ve basınç dayanım özellikleri değerlendirilmiştir.

II. MATERYAL VE YÖNTEM

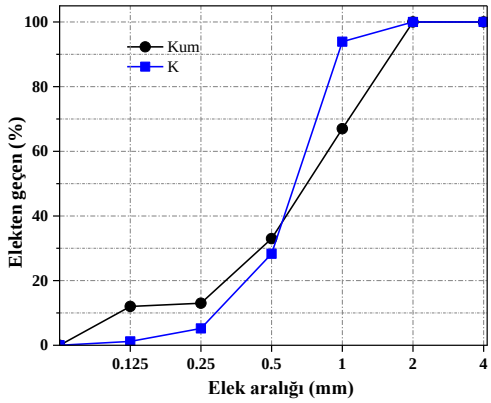
A. Materyal

Çalışmada kullanılan atık kahve telvesi (K), Türkiye'deki yerel kafeteryalardan toplanmış (Şekil 1) ve öncelikle malzemenin gözenek yapısından suyun tamamen uzaklaştırılması için 24 saat sürede 70 ℃ sıcaklıktaki etüvde tutulmuştur. Malzemelerin özgül ağırlığı, malzemenin bilinen hacmi ve kuru ağırlığı kullanılarak hesaplanmıştır. Toplanan atık kahve telvesinin parçacık boyutu 0-1 mm aralığında, özgül ağırlığı ise 0.47'dir. Harç serilerinin üretiminde; yerel kaynaklardan temin edilen ve TS EN 196-1 [4]'e uygun CEN standart kumu ve yerel kaynaklardan temin edilen CEM I 42.5R Portland çimentosu (özgül ağırlık; 3.09 gr/cm3) kullanılmıştır. CEN standart kumunun (özgül ağırlık: 2.56, su emme: %0.63) tanecik boyutu 0-2 mm aralığındadır. Karışımlarda kullanılan CEN standart kumunun ve atık kahve telvesinin (K) granülometrisi eğrisi Şekil 2'de, K ve çimento üzerinde yapılmış analiz (XRF) sonuçları Tablo 1'de sunulmuştur. Harç serilerinde kullanılan K'nin yüzey dokusu ve parçacık şekli, Zeiss LEO 1430VP marka taramalı elektron mikroskobu (SEM) kullanılarak gözlemlenmiştir (Şekil 3). SEM analizine göre; K'nin geometrik şeklinin küresele yakın ve yüzeylerinin pürüzlü taneciklerden oluştuğu gözlemlenmiştir.

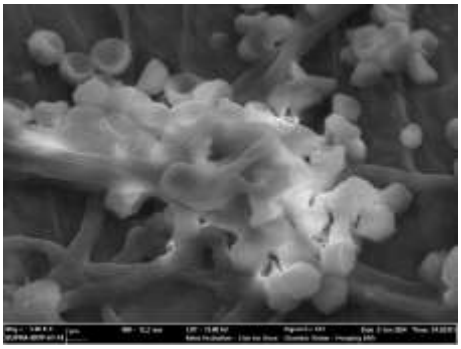
Şekil 1. Atık kahve telvesi (K)

Tablo 1. K ve çimentonun kimyasal özellikleri.

Oksit bileşenleri, %	**K**	**CEM I 42,5R**
SiO_2	0.57	18.7
Al_2O_3	0.1	4.6
Fe_2O_3	0.07	3.4
CaO	6.35	63.7
MgO	7.22	1.3
SO_3	1.65	2.7
K_2O	38.98	0.7
Kızdırma kaybı	34.47	3.9



Şekil 2. Agregalar için granülometri eğrisi.



Şekil 3. K'nin SEM mikrografi (x5000).

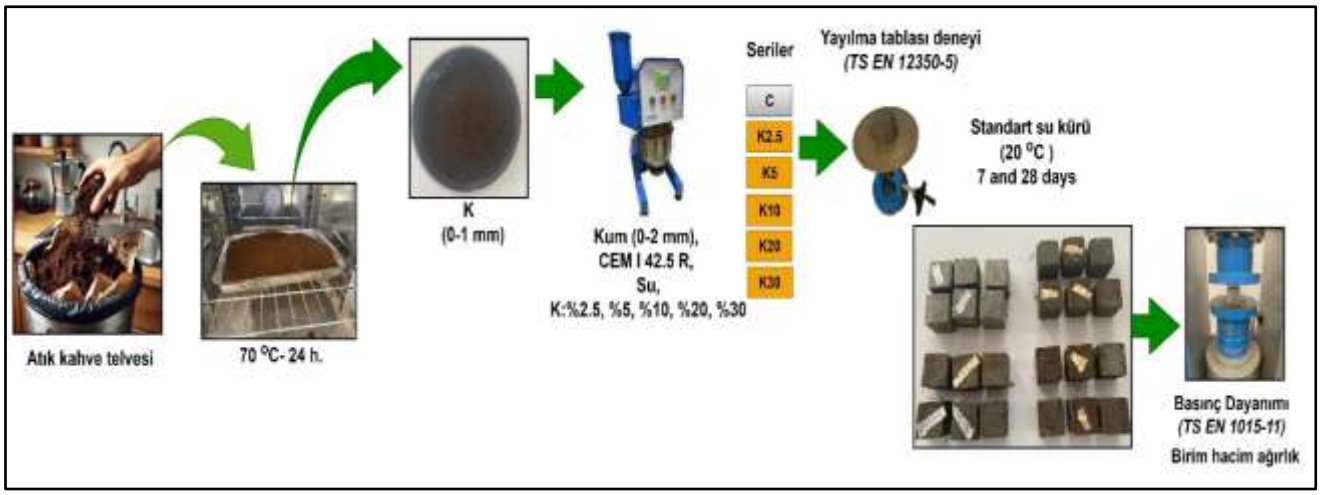
B. Yöntem

Üretilen harç serileri; TS EN 196-1 (2016) [4] standartlarında 6 farklı karışım serisi olarak tasarlanmıştır. K; standart kum ile hacimce; %0 (C), %2.5, %5, %10, %20 ve %30 oranlarında değiştirilmiştir. Tüm serilerde; agrega/bağlayıcı oranı: 3 ve su/bağlayıcı oranı: 0.5 olarak belirlenmiştir. Harç serileri; C, K2.5, K5, K10, K20 ve K30 olarak adlandırılmıştır. Seri kodlarındaki K indisi; atık kahve telvesi agregasını, sayılar ise kumun yerine hacimce ikame edilen agrega yüzdesini temsil etmektedir. Örnek olarak K10; Kum yerine hacmen %10 oranında K agregası içeren harç serisidir. Harç serilerindeki malzeme bileşimleri ve miktarları Tablo 2'de verilmiştir. Harçların üretilmesinde kullanılan harç mikserine ilk olarak bağlayıcı ile su konulup karıştırılmıştır. Su olarak şehir şebeke suyu kullanılmıştır. Ardından karışıma agregalar eklenip, karıştırma işlemine devam edilmiştir. Taze harç serilerinin yayılma tablası ile işlenebilirlik tespiti TS EN 1015-3/A2 (2007) [5] standardına göre ölçülmüştür (Şekil 4). Hazırlanan harç serileri, 50×50×50 mm boyutlarında olan küp şeklindeki kalıplara iki aşamada dökülmüş, her bir aşamada sarsma tablası kullanılarak, harçlar kalıplara yerleştirilmiş ve 24 saat boyunca kalıplarda bekletilmiştir. Kalıplardan çıkartılan harç numuneleri, laboratuvardaki kirece doygun suda (20 ± 2 ºC sıcaklıkta), 7 ve 28 günlük kür sürelerine kadar bekletildikten sonra TS EN 772-4 [6]'e göre birim hacim ağırlık ve TS EN 1015-1[7]'e göre basınç dayanımı deneyleri uygulanmıştır. Çalışmanın akış şeması da Şekil 5'te gösterilmiştir.

Şekil 4. İşlenebilirlik deneyi.

Tablo 2: Harç serilerinin karışım içerikleri.

Seriler	Çimento (gr)	K (gr)	Kum (gr)	Su (gr)
C	450	-	1350	225
K2.5	450	6.2	1344	225
K5	450	12.4	1338	225
K10	450	24.8	1325	225
K20	450	49.6	1300	225
K30	450	74.4	1275	225

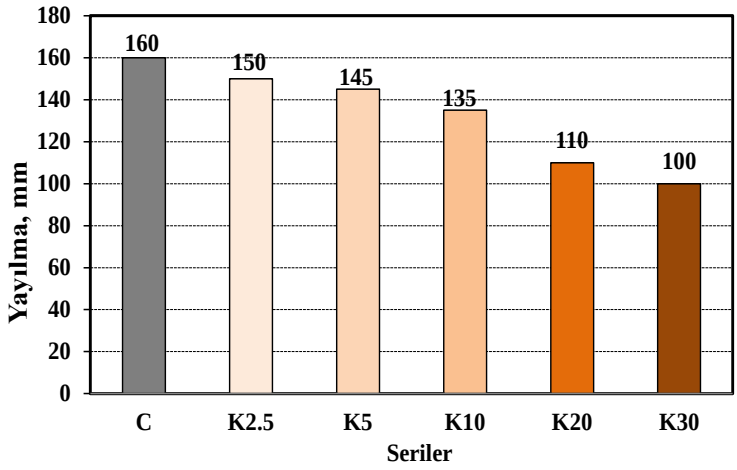


Şekil 5. Çalışmanın akış şeması.

III. BULGULAR VE TARTIŞMA

A. Taze Hal Deney Sonuçları

Üretilen harç serilerinin taze haldeki işlenebilirlik özellikleri, yayılma tablası deneyi ile belirlenmiştir. Belirlenen yayılma çaplarındaki değişimler Şekil 6'da sunulmuştur.



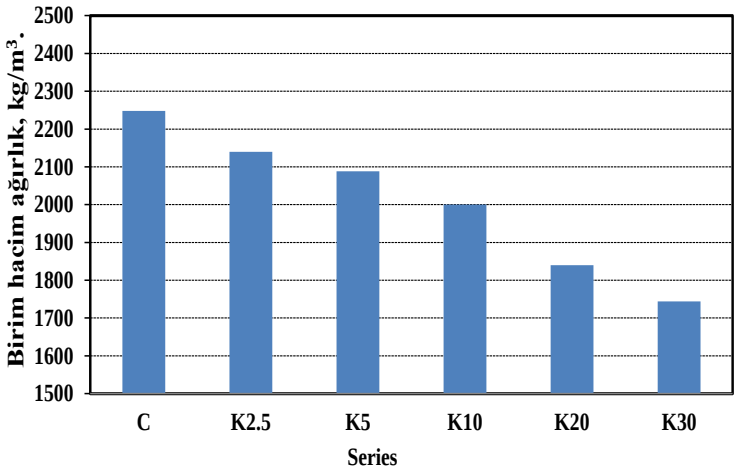
Şekil 6. Serilerin yayılma çaplarına göre değişimi.

Yayılma çapı sonuçlarına göre, karışımda K ikamesi arttıkça yayılma değerleri azalmıştır. C serisine göre K2.5, K5, K10, K20 ve K30 serilerindeki yayılma çapları sırasıyla; %6.3, %9.4, %15.6, %31.2 ve %37.5 oranlarında azalmıştır. Atık kahve telvesinin pürüzlü yüzeye ve yüksek su emme kapasitesine sahip olması harçların işlenebilirliğinin düşmesine katkıda bulunmuştur. Çimentolu harçlara ilave edilecek kahve telvesi külünün (K), %20'den daha fazla olması durumunda, üretilecek standart harcın yayılma değerlerinin de %31'ten daha fazla azalacağı ve karışımda akışkanlaştırıcı kullanımına veya ilave karışım suyuna ihtiyaç duyulacağı değerlendirilmektedir.

B. Birim Ağırlık Deney Sonuçları

Serilerin, 28 günlük kür sonundaki birim hacim ağırlık sonuçlarının değişimi Şekil 7'de verilmiştir. Buna göre, harçların birim hacim ağırlıkları 1744 ile 2248 kg/m^3 arasında değişmektedir. Serilerdeki K artışı ile birlikte birim hacim ağırlıklar azalarak hafif ağırlıkta harç üretimi sağlandığı tespit edilmiştir. Harç

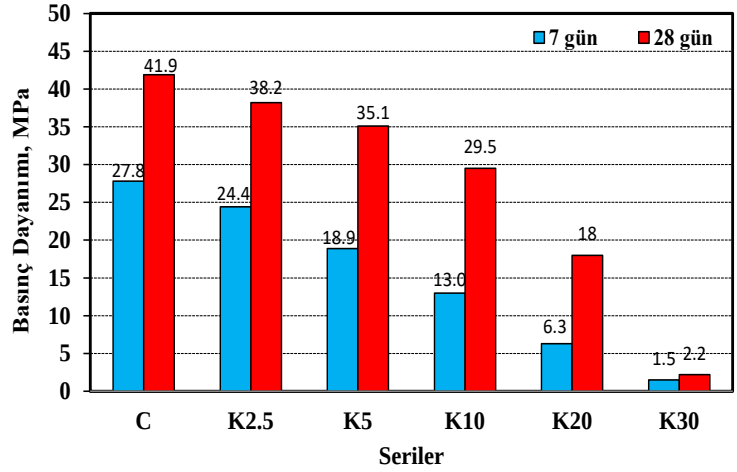
serilerinde K ikamesi arttıkça, 28 günlük kür süresi sonundaki K2.5, K5, K10, K20 ve K30 serilerinin birim hacim ağırlıkları sırasıyla; %4.8, %7.1, %11, %18.1 ve %22.4 oranlarında azalmıştır.



Şekil 7. Serilerin birim hacim ağırlıklarına göre değişimi.

C. Basınç Dayanımı Deney Sonuçları

Serilerin basınç dayanımı sonuçlarının kür sürelerine göre değişimi Şekil 8'de verilmiştir. Harçların 7 günlük basınç dayanımları Şekil 8'de görüldüğü gibi 1,5 MPa ile 27,8 MPa arasında, 28 günlük basınç dayanımları ise 2,2 MPa ile 41,9 MPa arasında elde edilmiştir. Serilerin basınç dayanımları, kürleme süresinin artması ile artarken, K ilavesi ile önemli ölçüde azalmıştır. Buna göre, harç serilerinde K ikamesi arttıkça, 7 günlük kür süresi sonunda; K2.5, K5, K10, K20 ve K30'da sırasıyla; %12.2, %32, %53.2, %77.3 ve %94,6 oranlarında dayanımlar azalmıştır. 28 günlük kür süresi sonundaki basınç dayanımları ise K2.5, K5, K10, K20 ve K30'da sırasıyla; %8.8, %16.2, %28, %57 ve %94,7 oranlarında azalmıştır.



Şekil 8. Serilerin 7 ve 28 günlük basınç dayanımlarına göre değişimi.

IV. SONUÇLAR

Yapılan deneysel çalışmalar sonrasında elde edilen sonuçlar, aşağıda sunulmuştur. Buna göre;

- İşlenebilirlik sonuçlarına göre; harç serilerindeki K miktarının artması, işlenebilirlikleri her seride düşürmüş ve en yüksek işlebilirlik kaybı %37,5 ile K30 serisinde tespit edilmiştir.
- K serisinin 28 günlük basınç dayanımlarına göre; K2.5 ve K5 serilerinin basınç dayanımları, kontrol serisinde göre; %8.8 ve %16.2'lik kayıp ile en yakın ve kabul edilebilir seviyede olurken,

karışımlarda %5'dan daha fazla K kullanılması basınç dayanım kayıplarını önemli ölçüde (K30'da %95 kayıpla) artırmıştır.

- Serilerin birim hacim ağırlıkları incelendiğinde, K miktarının artması ile harçların birim ağırlıklarının azaldığı ve böylece düşük ağırlıklı kompozitlerin üretilebileceği değerlendirilmiştir.
- Genel olarak çimentolu harçlarda kum yerine hacmen belirli oranlarda atık kahve telvesinin (K) kullanılması, 28 günlük süre sonundaki harçların fiziksel ve mekanik özelliklerini düşürürken, en fazla %5 oranına kadar kullanılabilecek atık kahve telvesinin harçların basınç dayanımı üzerinde kabul edilebilir kayıplar oluşturabileceği ve atık kahve telvelerinin geri dönüştürülerek sürdürülebilirliğe katkı sağlayacağı değerlendirilmektedir.

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Çocuklarda Akıllı Telefon Kullanımı ve Dijital Göz Yorgunluğu

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Özet **–** Çocuklar hem sahip olma hem de kullanma açısından en hızlı artış gösteren akıllı telefon kullanıcılarıdır. Akıllı telefon kullanımı çocukların gelişimleri üzerinde olumsuz etkiler bırakabilmektedir. Bu etkilerinden biri de göz sağlığının bozmasıdır. Özellikle küçük çocuklarda göz ve görme gelişimi devam ettiği düşünüldüğünde çocukların akıllı telefona maruz kalması göz sağlığını daha çok tehlikeye sokmaktadır. Akıllı telefon kullanımına bağlı olarak ortaya çıkan en önemli göz sorunlarından biri ise dijital göz yorgunluğudur. Dijital göz yorgunluğu, dijital elektronik cihazların uzun süreli kullanımı nedeniyle ortaya çıkan görsel ve oküler semptomları kapsayan bir sorun olup kuru gözler, kaşıntı, yanma hissi, kızarıklık, yabancı cisim hissi, sulanma, görme bulanıklığı, çift görme ve baş ağrısı ile karakterizedir. Küçük çocuklar yetişkinlere göre daha düşük düzeyde öz kontrole sahip oldukları için dijital göz yorgunluğuna karşı daha savunmasızdırlar. Bu sonuçlar çocukların akıllı telefon kullanımı ile dijital göz yorgunluğu arasındaki ilişkilerin irdelenmesi gerekliliğini ortaya koymaktadır. Bu doğrultuda araştırmada çocukların akıllı telefon kullanımının dijital göz yorgunluğuna neden olup olmadığı ve dijital göz yorgunluğu üzerindeki etkili faktörlerin neler olduğu ilgili çalışmalar ışığında incelenerek rapor edilmiştir.

Anahtar Kelimeler – Akıllı telefon kullanımı, dijital bağımlılık, dijital göz yorgunluğu, çocuk

I. GİRİŞ

İyi gelişmiş teknolojik cihazlar, çocukların büyüme ortamının manzarasını büyük ölçüde değiştirmiştir. Dijital cihazların gelişimiyle çocuklar da dijital çağdan etkilenmekte olup dijital yerliler grubunda önemli bir paya sahip olmaktadır. Dijital yerliler doğumlarından itibaren çeşitli cihazlara maruz kalmaktadır ve konuşmayı veya okumayı öğrendikleri sırada cihazları kullanmayı da öğrenmektedirler [1]. Bu cihazlardan özellikle akıllı telefonların kullanımı çocuklar ve gençler arasında son on yılda dramatik bir biçimde artmıştır. Akıllı telefonlar, beyinlerindeki yüksek dopamin aktivitesi nedeniyle güçlü bir merak veya yenilik duygusuna sahip oldukları kritik gelişim aşamalarında olan çocuklar ve ergenler arasında yaygın olarak kullanılan bir ortam haline gelmiştir [2]. Almanya'da 12-19 yaş arasındakilerin %93'ünün bir akıllı telefona sahip oldukları ve %92'sinin akıllı telefonlarını günlük olarak kullandıklarını belirtmektedir [3]. 5-16 yaş aralığındaki Birleşik Krallık çocuklarının %66'sından fazlası ve 15 yaşına gelen ABD çocuklarının %83'ü akıllı telefona sahiptir. Benzer sahiplik eğilimleri Avustralya, Avrupa ve Güneydoğu Asya dahil olmak üzere dünya çapında okul çağındaki çocuklar arasında görülmektedir [4]. Türkiye'deki 14-18 yaş grubunu kapsayan bir çalışmada, araştırmaya katılan ergenlerin %89,4'ünün akıllı telefona sahip olduğu tespit edilmiştir [5]. Bu oranların daha küçük yaş grubunda da azımsanamayacak düzeyde çok olduğu görülmektedir. Amerika Birleşik Devletleri'nde ise üç ile beş yaş arasındaki çocuklar akıllı telefonlarda, tablet ve kişisel bilgisayarlarda günde 115,3 dakika zaman geçirmektedir [6]. 2006 yılında bile dünya çapında 24 aylıktan küçük çocukların %90'ının ekranlı medyaya maruz kaldığı belirtilmektedir [7].

Akıllı telefonlar iletişim, internet ve multimedya, erişim kolaylığı gibi özellikleri sayesinde bilgiye kolay ulaşma ve sosyal etkileşimler yoluyla eğlence aracı olarak yoğun bir şekilde kullanılmaktadır [8]. Ancak uygun bir şekilde kullanılmadığında sorunlu akıllı telefon kullanımı söz konusu olmaktadır.

Çocuklarda ve ergenlerde sorunlu akıllı telefon kullanımı yaygınlık oranları %5-50 arasında değişmekle birlikte sorunlu akıllı telefon kullanımı duyarlılığı genel olarak yüksek düzeyde seyretmektedir [9]. Sorunlu akıllı telefon kullanımının yaygınlaştığı yaş azalmaktadır, çünkü birçok küçük çocuk artık ebeveynlerinin akıllı telefonları da dahil olmak üzere medya cihazlarına erişme konusunda çeşitli fırsatlara sahiptir [10]. Buna ek olarak, çocukların sınırlı öz kontrolleri göz önüne alındığında sorunlu akıllı telefon kullanma olasılıklarının daha yüksek düzeyde olabileceği söylenebilir [11,12]. Sorunlu akıllı telefon kullanımı çocuklarda artan hareketsiz zaman nedeniyle azalan fiziksel aktivite, kilo alımı, görme bozukluğu, uyku kalitesinin düşmesi, sosyal aktivitelere katılımın azalması, bilişsel gelişim sorunları, uygunsuz ve güvensiz içeriğe maruz kalma, kimlik ifşası tehditleri, depresyon ve anksiyete riskinin artması dâhil olmak üzere çocukların sağlıklı büyümesi ve gelişimi üzerinde birçok soruna yol açabilir [13,14].

Çocuklarda akıllı telefon kullanımının neden olduğu birçok sorununun varlığıyla birlikte üzerinde durulması gereken en önemli sorunlardan biri görme bozukluğudur. Görme en baskın duyu olmakla birlikte görme işlevi, çocuklukta sağlıklı ve sonraki yaşam dönemlerindeki gelişim için çok önemlidir [15]. Görme işlevi, bir çocuğun genel sağlığının ve yaşam kalitesinin ayrılmaz bir parçasıdır ve çocukların fiziksel, entelektüel, sosyal ve duygusal gelişiminde önemli bir rol oynar [16]. Çocuklarda görme yetersizliğinin psikolojik etkileri çok geniş olup üzüntü, depresyon, suçluluk ve kaygıyı içerebilir. Görme kaybı hızla artmakta olup Uluslararası Körlüğü Önleme Ajansı'na göre dünyada 90 milyon çocuk ve gencin görme sorunu ile karşı karşıya geldiğini bildirmektedir [17]. Özellikle akıllı telefonların çocuklar tarafından yaygın bir şekilde kullanılmaya başlanmasıyla görme sorunu daha da artmaktadır. Akıllı telefonlar aşırı kullanıldığında göz sağlığını etkileyebilecek en önemli elektromanyetik dalga kaynaklarından biridir [18]. Bunun bir sonucu olarak göz ve görme yetisi ile ilgili birçok sorun ortaya çıkmaktadır. Akıllı telefon kullanımına bağlı olarak ortaya çıkan en önemli göz/görme işlevi sorunlardan biri dijital göz yorgunluğudur. Amerikan Optometri Derneği'nin tanımına göre, "dijital göz yorgunluğu" terimi, dijital cihazların uzun süreli kullanımıyla oluşan bir dizi görme ve göz bozukluğunu ifade eder. Uzun süre ekrana odaklanılması sonucu ortaya çıkan en yaygın dijital göz yorgunluğu semptomlarının kuru gözler ve bununla ilişkili semptomlar olan gözyaşı, akomodatif stresle ilişkili semptomlar olan göz yorgunluğu, baş ağrısı ve boyun veya omuz ağrısı olduğu olduğu bildirilmiştir [11]. Dijital göz yorgunluğu, çocukların fiziksel, sosyal ve psikolojik sağlıklarını olumsuz yönde etkileyebileceği gibi diğer görme sorunlarının ortaya çıkmasına da neden olabilir. Bu nedenle çocuklar özelinde dijital göz yorgunluğu ile ilişkili faktörlerin incelenmesi önemli görülmektedir. Bu kapsamda araştırmada akıllı telefon kullanımı ile dijital göz yorgunluğu arasındaki ilişkilere ve dijital göz yorgunluğunu etkileyen faktörlere odaklanılmış, konuyla ilgili araştırmalardan elde edilen sonuçlar doğrultusunda öneriler sunulmuştur.

Akıllı Telefon Kullanımı ve Dijital Göz Yorgunluğu

Dijital göz yorgunluğu, dijital elektronik cihazların uzun süreli kullanımı nedeniyle ortaya çıkan görsel ve oküler semptomları kapsayan bir varlıktır. Bu sorun kuru gözler, kaşıntı, yabancı cisim hissi, sulanma, görme bulanıklığı ve baş ağrısı ile karakterizedir. Göz yorgunluğuyla ilişkili oküler olmayan semptomlar arasında ense sertliği, genel yorgunluk, baş ağrısı ve sırt ağrısı bulunur [19]. Dijital göz yorgunluğu akıllı telefon kullanımının etkisine de bağlı olarak yakın çalışma mesafesi, yoğun ışığa aşırı ve daha küçük yazı tipi boyutuna maruz kalma sonucu düzeltilmemiş refraktif hata (presbiyopi dahil), akomodatif ve yakınsama anomalileri, değişmiş göz kırpma düzeni (azalmış hız ve eksik göz kırpma) gibi sorunların ortaya çıkmasına neden olabilir [20].

Chu ve ark., [11], Hong Kong'da okul çağındaki çocuklarda akıllı telefonlarda geçirilen zaman ile dijital göz yorgunluğu arasındaki ilişkiyi inceledikleri araştırmalarında 8-14 yaş aralığındaki çocukların bir yıllık takibi sonucunda en sık bildirilen semptomların göz yorgunluğu (n = 804, %53,3), bulanık görme (n = 586, %38,9) ve tahriş olmuş veya yanan göz (n = 516, %34,2) şikayetleri olduğunu bildirmişlerdir. Akıllı telefon kullanan çocukların bir yılın sonunda dijital göz yorgunluğu puanlarının arttığını, başlangıç akıllı telefon kullanımı günde 241+ dakika olan çocukların başlangıç toplam dijital göz yorgunluğu puanının, başlangıç akıllı telefon kullanımı günde 0-60 dakika olanlara kıyasla önemli ölçüde daha yüksek olduğunu; başlangıç akıllı telefon kullanımı günde 181-240 dakika olan çocukların bir yıllık takip sonucu toplam

dijital göz yorgunluğu puanının, başlangıç akıllı telefon kullanımı günde 0-60 dakika olanlara kıyasla önemli ölçüde daha yüksek olduğunu tespit etmişlerdir.

Mohan ve ark. [21], Hindistan'da yaptıkları çalışmalarında COVID-19 salgını sürecinde dijital göz yorgunluğunun yaygınlığını, semptom sıklığını ve ilişkili risk faktörlerini belirlemeyi amaçlamışlardır. Ebeveynlerin (n=217) çocuklarını (yaş ortalaması: 13 ± 2,45) değerlendirdikleri araştırmalarında dijital göz yorgunluğu ile ilişkili bildirilen en yaygın semptomların kaşıntı (*n* = 117, %53,9) ve baş ağrısı (*n* = 117, %53,99) olduğu; çift görme (*n* = 24, %11,1) ve gözde uçuşan cisimler görmenin (*n* = 44, %20,27) ise en az görülen semptomlar olduğu belirlenmiştir. Dijital göz yorgunluğu yaygınlığı %50,23(109/217) olup bunlardan %26,3'ünün hafif dereceli (*n* = 57), %12,9'unun orta dereceli (*n* = 28) ve %11,1'inin şiddetli dereceli (*n* = 24) dijital göz yorgunluğu puanlarına sahip olduğu saptanmıştır. Tek değişkenli analizde dijital göz yorgunluğunun erkek cinsiyeti, akıllı telefon kullanımı, dijital cihaz kullanım süresi (>5 saat), dijital cihaz mesafesi (< 18 inç) ve mobil oyun oynama (>1 saat) ile önemli ölçüde ilişkili olduğu bulunmuştur.

AlHarkan, Alazmi veAl-Mutairi [22], Suudi Arabistan'daki çocukların (n= 704, yaş=8+) ebeveynleri ile yaptıkları araştırmalarında sanal öğrenmeden bir yıl sonra ebeveynlerin dijital göz yorgunluğu sendromu algılarının yaygınlığını ve risk faktörlerini ortaya koymayı amaçlamışlardır. Araştırma sonucunda çocuklarda dijital göz yorgunluğunun yaygınlığı % 59,4 olup %24'ü şiddetli ve %14'ü orta dereceli semptomlar göstermiştir. Baş ağrısı (%20,9), görme bozukluğu (%14,5), odaklanma zorluğu (%12,5), göz sulanması/yaşlanması (%10,1) ve bulanık görme (%10,8) dijital göz yorgunluğunun başlıca semptomları olarak kaydedilmiştir. Kızlar, ortaokul öğrencileri, gözlük kullananlar, günde dört saatten fazla ekran süresi olanlar veya cihazları gözlerinden 25 cm veya daha az uzağa yerleştirenler ve sanal sınıfa günde dört saatten fazla katılanların önemli ölçüde şiddetli dijital göz yorgunluğu derecelerine sahip olduğu bulunmuştur.

Taylan'da 8-18 yaş aralığındaki çocukların ebeveynleri (n=782) ile dijital cihazlar kullanan çocuklarda dijital göz yorgunluğu yaygınlığı, göz semptomlarını ve özelliklerinin incelendiği araştırmada COVID-19 salgını sırasında dijital cihazları kullanmanın en yaygın süresi >8 saat (%39,90), öncesinde ise yalnızca 2-4 saat(%36,70) olarak tespit edilmiştir. Dijital göz yorgunluğu prevalansı %42,2 (330/782) olup, hafif (%29,8), orta (%8,1) ve şiddetli (%4,3) semptomlar olarak belirlenmiştir. Dijital göz yorgunluğunun en yaygın semptomları gözlerde yanma hissi (%55,24), görme yeteneğinin kötüleşmesinden korkma (%53,07) ve gözleri aşırı kırpma (%48,33) olarak rapor edilmiştir. Dijital göz yorgunluğu ile ilişkili özelliklerin ise ileri yaş, düzeltmeli-düzeltmesiz refraktif hata ve bilinmeyen refraktif hata olduğu saptanmıştır [23].

Wartiningsih [24], Endonozya'da 9-12 yaş grubu (n=62) üzerinde yaptığı çalışmasında, Ekran Tabanlı Aktivite ile dijital göz sendromu insidansı arasındaki ilişkinin ve etkinin tahminini belirlemeyi amaçlamıştır. Bu çalışmada kullanılan analiz tekniği, SmartPLS (v3.2.9) gibi yazılımlar kullanılarak test edilen Kısmi Leas Kare (PLS) modelleme tekniğidir. Araştırma sonucunda Ekran Tabanlı Aktivitenin dijital göz yorgunluğu üzerinde etkili olduğunu; Ekran Tabanlı Aktivite ne kadar yüksekse dijital göz yorgunluğu riskinin de o kadar yüksek düzeyde seyrettiğini tespit etmiştir. Ayrıca cep telefonu kullanımının çocuklarda dijital göz yorgunluğu oluşumunu etkileme konusunda en yüksek korelasyona sahip olduğunu saptamıştır.

Chidi-Egboka, Jalbert veGolebiowski [4], 6-15 yaş aralığındaki 36 çocuğun bir saat boyunca sürekli olarak akıllı telefonda oyun oynadığı prospektif bir müdahale çalışması yapmışlardır. Araştırmada oyun oynamadan önce ve sonra gözyaşı, göz kırpma ve kuru göz düzeyleri incelenmiştir. Göz kırpma hızı ve göz kırpma arası aralık, oyun oynamadan önce ve oyun sırasında sürekli olarak bir göz izleme başlığı kullanılarak ölçülmüştür. Araştırma sonunda çocuklarda akıllı telefon kullanımı, kuru göz semptomlarına ve göz kırpmanın ani ve sürekli yavaşlamasına neden olmuştur, ancak gözyaşı fonksiyonunda bir saate kadar belirgin bir değişiklik gözlenmemiştir.

Ojaghi ve ark. [25], İran'daki bir hastanenin göz kliğine başvuran 4-18 yaş arasındaki çocuklarda (n=110) dijital göz sendromunun şiddetini ve risk faktörlerini araştırmışlardır. Klinik semptomlara göre dijital göz sendromunun varlığını ve şiddetini değerlendirmek için bir anket kullanılmıştır. Araştırma sonucunda dijital göz yorgunluğu sendromunun şiddeti ile birden fazla elektronik cihaz kullanımı, elektronik ekran kullanım süresi, karanlık odalarda dijital ekran kullanım süresi, sürekli/aralıklı ekran kullanımı, refraktif kusurların varlığı ve dijital ekran kullanım yılı gibi faktörler arasında anlamlı ilişkiler bulunmuştur. Ancak cinsiyet, ekran parlaklığı, dijital ekran kullanım zamanlaması (gündüz/gece) ve daha önce teşhis edilmiş kuru göz hastalığı ile dijital göz sendromunun şiddeti arasında doğrulanmış bir ilişki bulunamamıştır.

Sonuç

Bu araştırmada akıllı telefon kullanımı ile dijital göz yorgunluğu arasındaki ilişkiler incelenmiş ve dijital göz yorgunluğu üzerinde hangi faktörlerin etkili olduğu konuyla ilgili yapılan çalışmalardan elde edilen sonuçlarla rapor edilmiştir. Çalışmalar çocuklar akıllı telefon kullandığında bulanık görme, tahriş olmuş veya yanan göz, kaşıntı, baş ağrısı, çift görme, gözde uçuşan cisimler görme, odaklanma zorluğu, göz sulanması/yaşlanması, yanma hissi, görme yeteneğinin kötüleşmesinden korkma, gözleri aşırı kırpma ve kuru göz gibi dijital göz yorgunluğuyla ilişkili semptomların ortaya çıktığını kanıtlamıştır. Bu sonuçlar akıllı tefon kullanımının çocukların göz sağlığı üzerinde birçok olumsuz etki bıraktığını göstermektedir. Amerikan Pediatri Akademisi'nin önerisine göre, beş ile dokuz yaş arasındaki çocukların ekran süreleri günde iki saatle, iki ile beş yaş arasındaki çocukların ise bir saatle sınırlandırılmalıdır. 18 ile 24 aydan küçük çocuklara ise hiç ekran süresi (görüntülü sohbet hariç) önerilmemektedir [26]. Akıllı telefonla 10 dakika zaman geçirmek bile dijital göz yorgunluğuyla ilişkili semptomların ortaya çıkmasına neden olmaktadır [27]. Çocukların dijital elektronik alet kullanımındaki son artış nedeniyle ebeveynleri, bakıcıları ve gençleri ekran süresi sınırları koyma ve riskleri azaltmaya yönelik uygulamaları kullanma konusunda bilinçlendirmeye acil ihtiyaç duyulmaktadır [28]. Ayrıca araştırmalardan elde edilen sonuçlar farklılık gösterse de dijital göz yorgunluğu üzerinde cinsiyet, yaş, dijital cihaz kullanım süresi, dijital cihaz kullanım mesafesi, mobil oyun oynama, gözlük kullanma, refraktif kusurların varlığı, sanal sınıfta ders alma süresi, açık hava aktivesi süresi, birden fazla elektronik cihaz kullanımı, karanlık odalarda dijital ekran kullanım süresi, sürekli/aralıklı ekran kullanımı, dijital ekran kullanım yılı, kullanılan dijital cihaz türü (akıllı telefon, tablet, bilgisayar vs.) gibi faktörlerin etkili olduğu söylenebilir. Bu sonuçlar dijital göz yorgunluğunu hafifletmek için çocuklar dijital cihazlarla zaman geçirirken optimum bir ortam yaratılması, sık sık mola verilmesi ve günlük ekran süresinin sınırlanmasının önemine işaret etmektedir. Göz sağlığı uzmanları tarafından danışmanlık/kamuoyu farkındalığı çalışmalarının yapılması, öğretmenlerin ve ebeveynlerin duyarlı hale getirilmesine yönelik uygulamalara yer verilmesi de önemli görülmektedir [29]. Çalışma saatleri arasında uygun dinlenmenin sağlanması, göz kırpma hızının uygun tutulması ve ekran kullanımıyla ilgili sorunların azaltılması için 20-20-20 kuralı (mola verme) uygulanarak günlük rutin oluşturulabilir, ekran başında kalma süresinin neden olduğu göz yorgunluğu ve rahatsızlığı önemli ölçüde azaltabilir ve daha iyi göz sağlığına katkıda bulunabilir. Ek olarak, olası göz sorunlarının izlenmesi ve ele alınması açısından bir göz uzmanıyla düzenli göz muayeneleri yapılabilir [30]. Sonuç olarak çok küçük çocukların bile akıllı telefonlarla meşgul oldukları dijital dünyada çocukları akıllı telefondan tamamen uzak tutmak mümkün görünmemektedir. Ancak çocukların akıllı telefon kullanım süresinin sınırlandırılması, telefonu kullanırken sık sık mola verilmesi, telefonu göze çok yaklaştırmadan kullanması, düzenli olarak göz muayenelerinin yapılması, açık hava aktivitelerine yönlendirilmesi konusunda ebeveynlerin bilinçlendirilmesine yönelik çalışmalar yapılması önerilebilir.

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Emerging Ecologies and the Nascent Paradigm: Reconceptualizing Architectural Design in the Current Interregnum. The New that cannot be Born

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Abstract – Since the mid-1960s, global discussions in philosophy, epistemology, science, and technology have engaged in a critical examination of the concepts and applications of anthropocentrism [1], [2], [3]. This scrutiny has subsequently stimulated new discussions on how various fields of knowledge, spanning from science to humanism, should grapple with the inclusion of external agents that were previously excluded or overlooked.

In the last decades, philosophical circles represented by thinkers such as Braidotti [4] and Delanda [5] have raised inquiries into the operational value of the concept of "progress." This concept, central to the ideologies and practices of Modernity, has been scrutinized for its role in perpetuating a worldview founded on binary oppositions and polarities—the typical "black or white" litany.

The scope of challenging anthropocentric thought extends beyond considerations of species other than humans; it encompasses, perhaps above all, the sustainability of our planet intricately interwoven with its political and economic dimensions. Concepts like assemblage, emergence, difference, agency, affect, immanence, sympathy, ecology, and symbiosis, among others, have undergone a gradual migration into various subject areas and realms of contemplation. These terms are now intricately interlinked, establishing new ecologies, connections, and continuities across diverse academic domains. Indeed, we find ourselves immersed in what can be described as a Gramscian interregnum, characterized by the simultaneous decline of established paradigms and the hesitant emergence of new ones. This transitional phase is marked by the poignant sentiment that "the old is dying and the new cannot be born." The challenge lies in determining the nature of novelty we should advocate for the creation and identification of specific forms, materials, styles, and substances that should be attributed to the emerging paradigm to distinguish it from the outgoing one.

Keywords – architectural design, interregnum, new ecologies, ontology, Gaia

I. INTRODUCTION

The last decades have seen an ever-growing criticism regarding the notion of anthropocentrism and the incidence of this 'belief' in the contemporary world. If we focus on the word's etymology, it denotes a human-centred perspective and assumes paramount significance in philosophical discourse, particularly concerning ethics, wherein it signifies the doctrine that assigns exclusive intrinsic worth to the human species [6], [7]. Therefore, the idea of "Human" implied in the field of "Humanities", where the man is the chosen animal endowed with the capacity of the language, goes along with a set of spiritual, discursive and mental values that have no other comparison in the animal world [8], [9].

Permeating this man-centric discussion and vision of the world stands the concept of 'intelligence', considered for centuries as a specific prerogative of humankind and something not to be argued to the

supremacy of our species fostered by art, science and philosophy at the same time. Nevertheless, more and more we have seen the rise of different and related considerations that refute these assumptions. The first concerns the ontological shift in the conceptualization of intelligence, transitioning from its historically human-centric characterization as solely emanating from the human brain to its reconceptualization as an emergent quality arising from specific contextual conditions applicable to both human and non-human entities, including artificial systems [10]. This evolution signifies a departure from the traditional notion of intelligence as exclusively tied to human cognition. Secondly, intelligence is no longer perceived as the product of a solitary organ or centre but rather as an emergent property arising from the dynamic interplay among a "brain" (whether human or non-human), a corporeal entity, and the encompassing environmental milieu [11]. This reconceptualization underscores the inseparable interconnectedness between cognitive faculties and their embodied instantiation, as well as their reciprocal interaction with the surrounding environment. In light of this, we should reconsider the presence of man as an interconnected part of a new worldview, not as the master of a piece of an entangled reality in an extended and interconnected technological world. Such a paradigmatic shift affects also all the different activities and fields of creation related to humans. Therefore, in light of contemporary challenges, the architectural domain confronts a significant epoch of turmoil, as it endeavours to navigate a complex terrain marked by the gradual obsolescence of entrenched architectural conventions and the incipient emergence of novel design paradigms. This transitional phase can be likened to a Gramscian interregnum, denoting a period characterized by the concurrent decline of established architectural frameworks and the tentative emergence of nascent ones [12]. Architecture, as a discipline deeply intertwined with societal and cultural dynamics, finds itself grappling with the task of discerning elements undergoing obsolescence from those poised to shape future architectural discourse. This entails a critical reflection on the evolving needs, values, and aspirations of contemporary society, as well as an exploration of innovative approaches that respond adeptly to emerging challenges and opportunities [13]. Moreover, this period of architectural flux underscores the imperative for architects and urban planners to adopt a forward-thinking and adaptive mindset, capable of embracing ambiguity and uncertainty while fostering creative experimentation and interdisciplinary collaboration [14]. By engaging in a reflective dialogue with the shifting socio-cultural landscape, architects can play a pivotal role in catalyzing transformative architectural practices that resonate with the evolving ethos of the 21st century. To shed light on these changes, and position ourselves as architects in these major changes the discipline is undertaking, this paper aims to scrutinize the shift from a human to a post-human ecology [4] and includes a critical examination of the integration of novel technologies and tools, such as AI and neural networks, disrupting the traditional perception of 'design' as an exclusive realm of human intellect. To do so, a series of examples and critical reflections will be presented to the reader to assess our capabilities to design for Gaia moving away from an approach initially centered only on human intellect and refocusing toward a broader perspective beyond the exclusive interests of humanity.

II. From the Human to the Post-human Ecology: Questioning the Concepts of Predominance and Evolution

The subtle notion of human dominance over the Earth has pervaded history and various domains of knowledge and practice since ancient times [4] Protagoras famously asserted that "man is the measure of all things," encapsulating this perspective [15]. This belief was further enshrined in the arts during the Italian Renaissance, notably exemplified by Leonardo da Vinci's Vitruvian Man. Da Vinci's depiction symbolizes the embodiment of mental, discursive, and spiritual ideals within an archetypal human form [16]. The Humanistic ideal turned into a hegemonic cultural model with Heidegger and his philosophy of history where he conveys the message that Europe is not just a mere geo-political location but a proper intellectual device – and reflection of the human mind – that can lend its quality on every object while orbiting around it. This flattering vision of the Human is more than a question of attitude: it is a structural element of our intellectual practice and it permeates our consciousness reverberating on the big to the small scale, giving birth to extreme distortions and tendencies such as nationalism and totalitarian regime fueled

by the idea of a main position that a population should gain on the other thanks some unclear ‘divine’ attribution. Furthermore, this idea is not just man-centric but also male-centric. The predominance of the masculine gender and "otherness" is delineated by its negative and mirrored opposite irrationality, immorality, femininity, and non-Westernness. When difference is perceived as synonymous with inferiority, it assumes essentialist and potentially harmful implications for those categorized as "others." These individuals, often sexualized, racialized, or naturalized, are relegated to a dehumanized status, viewed as disposable bodies to be moved and abused from a masculine predominant counterpart [17]. The death of Man, anticipated by Michel Foucault in his book, *The Order of Things* [18] claims for a self-criticism on the part of men and a critical study of the actions carried out by him from a universal and interconnected perspective into the void the disappointment and depression of an evolutionary condition that is increasingly elusive and a progressive failure of a now Marxist materialist logic unable to contemplate the complexity of the story. Man is therefore no longer seen in a predominant position as a precedent established by Renaissance and socialist humanism but seen as a component shaped by places and history where he is not the one to impose values but rather to absorb them and be influenced by them.

In his *The Post-Human Condition* [19], Robert Pepperell states that the demarcation between the body and the external world constitutes a fundamental aspect deeply ingrained within our conventional understanding of personal existence. This conceptual partition, prevalent in philosophical and cultural discourses, delineates the perceived boundary between the embodied self and the surrounding environment. Such a dichotomy shapes not only individual perceptions but also societal constructs and behavioural diverse realms ranging from psychology to social theory. According to him, we should overcome this reminiscence of a Cartesian dichotomy and look at an inseparable interconnection between man and the environment. Even when we sleep, we are stimulated by a series of contextual agents (light, dust, sounds) that form and influence our perception in a continuum localized in space and time. For this reason, it is difficult to consider the end of human experience and the beginning of external experience and vice versa [20]. Consequently, as already stated previously by Foucalt, it is impossible to consider man as split and predominant concerning a context that continually stimulates him but which is also stimulated by his presence. Recalling *Complexity Theory*, the Post-Human assumption is then a non-linear model where dispersed factors collectively generate sensation and consciousness. Complexity theory [21] posits that the collective behaviour of a complex system transcends the explanatory scope of its components. While it may be feasible to dissect a system into its constituent parts, such an approach fails to elucidate the holistic behaviour of the system as a whole. This principle underscores the inherent interconnectedness and emergent properties inherent within complex systems, necessitating an integrative perspective to comprehend their dynamics effectively [22]. Expanding upon this premise, contemporary scholarship within complexity theory explores the dynamics of diverse complex systems, ranging from biological ecosystems to social networks and economic structures. By adopting a transdisciplinary approach, researchers seek to unravel the underlying principles governing the self-organizing, adaptive, and nonlinear behaviours exhibited by complex systems [23].

All these mutations and theories show how man must be understood more and more strongly as one of the individual portions of a more complex system. This completely dismantles the centuries-old relationships and hierarchies and the marginalization of certain groups, human and otherwise, which have always been relegated to a subordinate condition compared to ours. As the hegemony of anthropocentrism wanes, it paves the way for the recognition and empowerment of diverse human experiences and identities. This emancipatory process not only challenges conventional notions of identity and agency but also fosters greater inclusivity and equity within society.

What needs to be highlighted at this point is that the post-human question is not relegated only to gender, racial, cultural factors, etc. The emergence of new types of intelligence, and the non-predominance of man in a complex ecology like the one we live in, also puts into crisis a system, that of architecture, linked to design and representation. If previously a total prerogative of the sphere of our intellect, the emergence of new types of intelligence - of a non-biological nature – gives us the possibility to assimilate, exploit and turn into practices the cognitive possibilities opened up by any technological innovation that question the precedent paradigm [24]. The evolving understanding of intelligence significantly impacts the

contemporary discourse surrounding the design of the built environment across various scales and stages of the design process. This conceptual shift necessitates reevaluations and implementations of novel conceptualizations on innovation, creativity, and imagination—integral components that propel the design endeavour forward. This transformative trajectory in design thinking is underscored by the interdisciplinary insights garnered from fields such as cognitive science, neuroscience, and psychology. As scholars delve deeper into the complexities of human cognition and creativity, they offer fresh perspectives on the conceptual underpinnings of design theory and practice [25]. Moreover, this evolving understanding of intelligence necessitates a reexamination of conventional design methodologies and pedagogical approaches within architectural education [26]. By integrating insights from cognitive psychology and neuroscience into design pedagogy, educators can cultivate a more nuanced understanding of the cognitive processes underpinning design thinking, thereby fostering the development of innovative and imaginative design solutions [27]. In essence, the evolving conception of intelligence engenders a reimagining of design as a dynamic and iterative process that harnesses the full spectrum of human cognitive capacities to address complex challenges and catalyze transformative change within the built environment. The automation of creativity has been one of the major fields of interest of scholars over the last two centuries. The idea of being able to open processes to different and non-human intelligences has permeated the minds of scholars since the appearance of the first software dedicated to design and the possibility of delegating certain tasks to new combinatorial and creative systems. One of the first attempts to implement artificial intelligence into a design process was made by the English architect and artist Cedric Price in 1976 [28]. This intricate project, supported by numerous drawings and diagrams, constituted a modular system comprising cubelike elements designed for adaptability and versatility. These elements could be repositioned and interconnected, either with each other or with supplementary components, to fabricate temporary structures suitable for diverse purposes such as rehearsal or performance spaces, habitation, or quiet contemplative areas set amidst verdant natural surroundings.

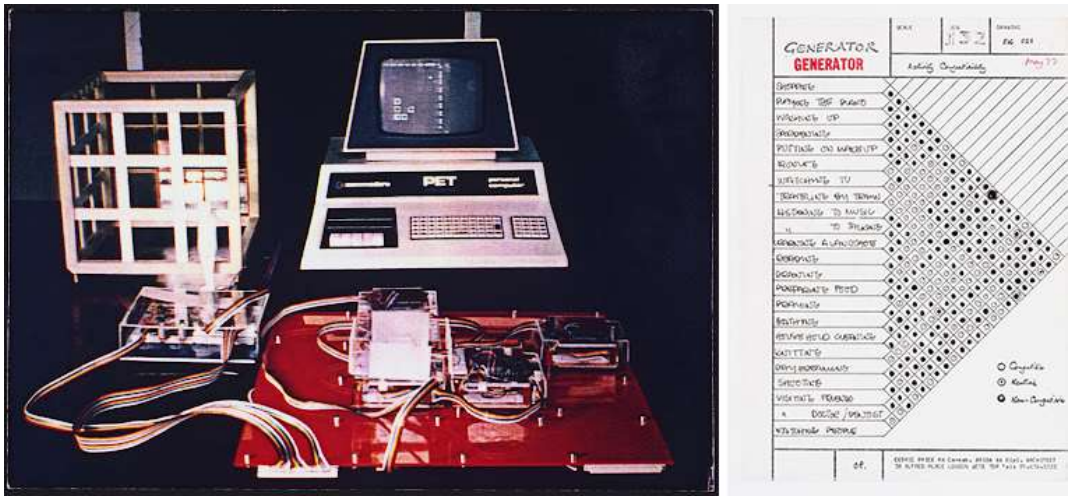

Figure 1 Cedric Price (1970). Generator: the device and the card underlying the operation of the device

The operational framework of this system revolved around a central computer interface, through which visitors could manipulate a selection of 150 fully equipped, four-by-four-meter cubes along with ancillary components such as walls, screens, walkways, and communication channels to configure personalized structures. The computer interface was programmed to guide users in iterative refining and enhancing their designs. Central to the ethos of the Generator project were notions of change and artistic autonomy, deemed essential prerequisites. Accordingly, the computer system was designed to autonomously introduce alterations to the framework in instances where stagnation was detected, thereby fostering an environment conducive to ongoing innovation and creative expression. The project remained a sort of folie for the architect but it represented one of the first combinatorial possibilities of two different intelligences within the same context where neither of the two possessed the exclusive decision-making capacity to direct the choices of others.

The unpredictability underlying the device also demonstrated the possibility of a non-predictive relationship with the machine itself where the response, influenced by the components of space and time, remained uncertain and linked to a series of emerging behaviours [29] dependent not only on the machine itself but also from human interaction with the latter. This discussion on creativity finds in post-human design a close relationship with the very concept of intelligence. If intelligence is based on a series of abstractions (pattern recognition and categorizations) and hierarchical classification (association), creativity is the possibility of generating new patterns and associations starting from pre-established and pre-memorized ones. In the context of the interplay between human and non-human intelligence within the mind-body-environment continuum, the presence of abstractions facilitated by non-human agents assumes significance as a catalyst for novel associations of creative intelligence [30]. This entails recognizing the capacity of non-human entities to contribute to creative processes without being influenced by human biases or value judgments. After this theoretical excursus on overcoming the anthropocentrism prevalent in society and also in the classical notion of design, we will analyze the new directions undertaken in this research thanks to the diffusion, in the last decade, of neural networks and diffusion models in contemporary architectural practice. By doing this, we will analyze some of its theoretical components and focus on some examples capable of shedding light on what a synergy between two intelligences means: the human one and the artificial one in the present unfinished interregnum in which we find ourselves.

III. Diffusion Models in Architecture. Venturing in the realm of AI

Since the early 90's, the advent of digitalization heralded profound transformations in our society [31] We found ourselves immersed in a landscape where an abundance of digital objects reshaped our interactions with the environment, rendering our experiences increasingly intangible and virtual. The role of the designer has undergone significant evolution. In addition to adhering to traditional principles of aesthetics and practicality, contemporary designers integrate concepts such as communication, multimedia, and virtuality into their toolkit. This expanded skill set enables designers to create immersive and interactive experiences that resonate with modern audiences and adapt to the digital landscape. This transformation reflects broader shifts in design theory and practice, where the boundaries between disciplines blur, and interdisciplinary collaboration becomes increasingly prevalent [32]. Designers draw inspiration from diverse fields such as psychology, sociology, and technology, leveraging insights from these domains to inform their creative process [33].

In the last 5 years, we have seen the natural prosecution of this very discourse in the spreading of AI-based tools or AI visual generative media that captured the attention of the architectural community and have found a large space of debate among practitioners and scholars. Neural networks are used today as a kind of speculative tool in almost every creative field: from architecture to design; from music to video; from photography to editing. They are trained on an infinite database made of images collected from the web and from which the model is trained to generate new abstractions and associations. Whether we refer to *diffusion models, text-to-image models, generative adversarial networks (GAN), and transformers*, the core is always the same: the creator or the artist, more precisely the *intelligence* behind the work is everything but physical. It is a huge unstructured constellation of cultural content stored somewhere in a structure that resembles our brain and activates our synapsis thanks to the collaboration with the human being that requests its help. While having had their pros: they are fast in computing, they estrange components from some of their datasets to mix them with others upon our request; they paraphrase and reshape what we write (text-to-image tools are among the most diffused ones); they simulate new cultural artefacts as we do throughout our life with the incremental knowledge we develop; they also have some limitations: they rely on what they know and they cannot immediately invent something that they do not process into the atoms or particles they have trained with. They do not deal with the uncommon and, for such reasons, they need the human intelligence to guide them on what we are looking for. In a few words, they the know *subject* and *style*, but they are not able to come out with a new *crasis* of pre-existing datasets even though maybe this is not the right question we should be asking them [34]. Therefore, we are

confronted with the imperative to augment both our individual and collective cognitive capacities through active engagement in diverse intellectual collaborations. These collaborations serve as crucibles for the invention, innovation, and creation of a novel human reality within the evolving landscapes of the 'new reterritorialized agora' of cyberspace and the techno-cultural milieu of the post-human era. This contemporary challenge underscores the transformative potential inherent in collective endeavours aimed at reshaping human cognition and societal structures. Drawing inspiration from the interdisciplinary perspectives of scholars and practitioners, we navigate the complex interplay between technology, culture, and human agency in shaping our shared reality [35], [36]. In this context, the notion of the 'new reterritorialized agora' in cyberspace serves as a metaphor for the dynamic spaces of digital interaction where diverse voices converge, interact, and negotiate meaning. These virtual arenas offer fertile ground for the cultivation of collective intelligence, where individuals from diverse backgrounds collaborate in the co-creation of knowledge and cultural artefacts [37]. The explosion of the tools we are discussing did not create just a bunch of beautiful images to be admired on the web but provoked theoretical inquiries within the realm of the architectural discipline shaking from the foundation the consolidated relation between the human and the non-human in the creative act. Furthermore, after a long time, they reintroduced again into the architectural community a linguistic attitude towards the design. This linguistic turn[34], as it has been called, grounds the work of thinkers such as Wittgenstein, De Saussure, Merleau-Ponty, and Austin; as it happened during the 70s when we had the explosion of linguistic studies in the architectural panorama, through this critical lens we can create associate among different styles and times, we decompose the architectural body in a series of predicates to be placed side by side without any superstructure or cultural imposition (the work of Eisenman on Terragni – 1971, 2004 - it is still exemplary in this sense). In such context, considering still the uncertainties around the further evolution of AI in architecture for the years to come, we want to interpret them at the current stage as a tool following Koyre's vision where: "*an instrument, or something that - as the ancient thought had rightly observed - extends and strengthens the action of our limbs, of our sensory organs, is something that belongs to the world of common sense. And it can never lead us beyond it. This is instead the proper function of the tool, which is not an extension of the senses, but in the strongest and most literal sense of the term, an embodiment of the spirit, a materialization of thought*." It is still unclear where this venture into the realm of AI will conduct us in the years to come. Even if it disappears as it never happened, it will help us to dwell towards more informed human design categories even though assimilating, exploiting, and translating the cognitive possibilities unleashed by technological innovations could be a long and time-consuming endeavour, we can already start discussing with a specific focus on fostering novelty of sustainability, resilience and style combination in architectural production to design for Gaia (Planet Earth) in a more comprehensive human perspective. In pursuit of this objective, our inquiry will pass through the analysis of some case studies where the design process is orchestrated by the synergy of two intelligences: human intellect and artificial intelligence based on neural networks.

IV. DATALAND – LNM | LARGE NATURE MODEL

The Studio Refik Anadol is currently working on the first Large Language Model (LLM) based on nature that was provocatively defined as LNM – Large Nature Model. In a few words, the work is presented as the inaugural open-source, generative AI model meticulously crafted to immerse itself in the wonders of nature. DATALAND stands apart as a monumental stride towards leveraging artificial intelligence for the preservation and exploration of our planet's biodiversity. At its core lies a vast reservoir of ethically sourced data, meticulously curated to encapsulate the splendor of the natural world. Following experiences such as GPT-3 (Generative Pre-trained Transformer) by OpenAI and BERT (Google) DATALAND claims to open a new era of AI-driven innovation tailored specifically for nature enthusiasts, conservationists, and researchers alike. The studio aims to blend art, technology, and nature, raise awareness about environmental issues and inspire innovative solutions by finding connections among isolated archives. Topics such as resilience and sustainability have been always part of the studio's work and this dataset is their effort the

push the boundaries of post-human design towards more responsible and inform-ed solutions. Also, one of their previous works *Artificial Realities: Coral* used approximately 100 million coral images as raw data to raise awareness of climate change. The model was trained on data from National Geographic, the Smithsonian Institute, CornellLab, the Natural History Museum in London, and the Conservation Research Foundation Museum, as well as data his team has personally collected at locations around the world, including deep in the Amazon rainforest.

Figure 2 DATALAND - one of the images generated with the datasets mixing different natural elements and environmental conditions

The applied philosophy behind the work is common to some other image generators: you can merge the tropical forest with a more temperature one or you can mix different flowers in the same environment and check their modification according to some language insertion within the requested prompt. At the same time, it is enriched by a full set of real-time data about weather and environmental conditions in real-time from forests around the world giving full control to the generated environments within the experimentations. The idea behind the dataset created by Anadol claims also to advocate more conscient behaviour towards the environmental crisis with the active engagement of the people visiting the exposition where the digital realm is showcased. According to him, engaging the people through multi-sensory levels the outputs generated by the DATALAND model serve as a bridge between the abstract concept of environmental conservation and tangible action. By harnessing the power of generative AI, DATALAND breathes life into complex ecological data, transforming raw information into vivid simulations, visualizations, and narratives that resonate with people on a deeply human level.

Through immersive virtual environments, DATALAND paints a vivid picture of our planet's delicate ecosystems, allowing individuals to explore and interact with virtual representations of diverse habitats and species. These simulations not only educate but also instill a sense of wonder and appreciation for the natural world, fostering a deeper connection with nature and a heightened awareness of its fragility. For a full coherence with the purposes of this work, together with Google engineers, the team has developed a platform to see the environmental impact their model has and claimed that it is has been trained only using renewable energy.

V. SPAN Architects – Urban Fictions

Founded by professionals and scholars, Matias Del Campo and Sandra Manninger, SPAN Architects has always been one of the studios at the forefront of technological advancement in architecture. With an

Austrian/American education, since their earliest works the studio has always been pushing the boundaries of the discipline thanks to the implementation of the latest tool. Their architectural style is defined by blending sophisticated methods with philosophical exploration, questioning the fundamental nature of existence and knowledge generation within a framework focused on advanced technology's role in shaping culture. Their work covers the range from text, installations, industrial design to buildings and urban concepts

Even before the major diffusion of Creative AI in architecture, the duo has been experimenting with custom-trained datasets and intelligent enzymes in their projects. Urban Fictions is their contribution in the field of AI-speculative design and it is intended as an exploration of the combination of real scenarios and patterns created by the studio. Urban Fictions can also be interpreted as a response to contemporary critiques of urban life in the context of the ongoing Covid-19 crisis. Rather than echoing the widespread sentiment favouring rural living as a solution to social distancing measures, Urban Fictions celebrates the vitality and density of urban environments as a potential, even essential, direction for the future. The rationale behind this perspective is multifaceted, but in essence, architects recognise that cities, besides being emblematic of human culture, play a crucial role in promoting sustainable resource consumption. Rather than presenting a bleak dystopian vision dominated by pathogens, Urban Fictions embraces the prospect of praising urban life and advocating for a reassessment of cities, leveraging the potential of machine learning technologies. In this specific application, created by Del Campo, Manninger and Alexandra Carlson, the system is based on a neuron that mathematically calculates the total amount of the inputs weights and applied a threshold to understand if it has been activated or not. All the info filtered from the neurons through the applied threshold is then sent to the next layer for different values and the following inputs to be used by each neuron. Since each one of the latter is activated in subsequent phases, according to what they receive they can also independently decide do erase, recombine and modify information during the process in a continuous communication with the other knots of the network. Urban Fictions then explores the potential of employing AI technologies for generating design processes, specifically focusing on the use of style transfers with neural networks. This method not only scrutinizes the distinct role of the human mind in creative endeavors but also challenges notions of creativity in planning procedures. In a design landscape where the lines between human and computational cognition are becoming increasingly indistinct, the proposed process merges the capacity of neural networks to interpret and identify features of a style image and integrate them with a target image.

The conveyed result, besides questioning the possibility of AI inventing and discussing again the fundamentals of architecture – and its ontology – from a given dataset of information also challenges the post-COVID idea of sustainability and resilience of isolation and depolarization of urban center following the opposite directions. It proposes an AI-based approach to investigate the possibility of density with the injection and the mix of external green and nature-based patterns to be over-imposed on the existing layers. The result is a set of hallucinated urban landscapes where the different pixels are enriched by new semantic layers to be questioned in further architectural design implementations.

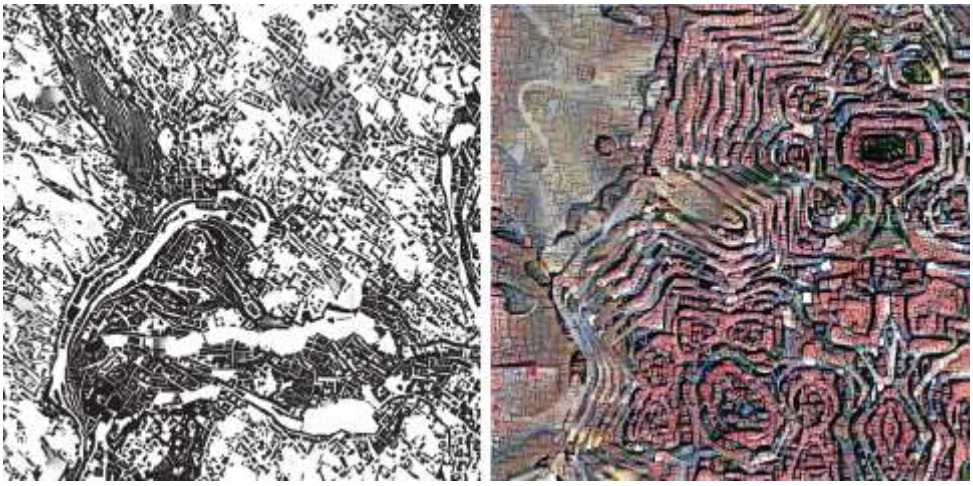

Figure 3 SPAN Architectes - Vienna, the speculative realism of a possible city. Urban Fictions

VI. When Machines Hallucinate – A Pedagogy Design Process

The last case study presented comes from a teaching experience carried out during the Master in Digital Architecture at POLIS University in Tirana, Albania. During the educational program, students are exposed to the presence of novel technologies in the field of architecture and design not so much from an instrumental point of view but from a conceptual one. The software is seen not as a pre-compiled response package but as an investigation tool capable of opening new ontological directions for the development of design know-how. In the last two years, thanks to its explosion on a global scale, creative AI has also become part of the educational program. Through a reverse engineering process, students during the dedicated module start with the elaboration of a design brief to be then developed with the help of neural networks which can then be re-modelled using more consolidated technologies. The challenge for students is not only to generate good-looking images but, above all, to push the limits of the various text-to-image tools to the point of generating hallucinations capable of transcending the limits of the pre-compiled dataset. The idea is that of creative error, already present in the design practice of Bruno Munari and Gianni Rodari [38], to challenge AI to do 'something that was not previously possible'.

In the proposed exercise, the class was challenged in the construction and deconstruction of a specific architectural typology - specifically the cause - and through the practice of estrangement of inserting external components from the natural world into the prompt. The basic idea was to challenge the pre-established spatiality in the archetype of the home and to test its versatility when an emerging component from the natural world emerges. The software used was different and the opportunity for the students was to test the performance of different datasets and their response to different prompt-engineering methods.

Figure 4 First results obtained from Dall-e 2. Prompt: "Photography of a private living room in a wooden model of a building that looks like a tree, in the style of abstract and conceptual sketches, fantastical machines, floating structures, intricate webs"

After an initial phase in Dall-e 2 and Stable Diffusion, the final choice fell on the productions obtained from the interaction and dialogue with Midjourney AI. Not only that, among the various versions (to date Midjourney has 6 different versions) the choice fell on number 3. To date the one that is even more dreamlike and capable of hallucinating more convincingly when it works on heteronomies coming from different fields.

In undertaking this endeavour, we aimed to emphasize the significance of the semantic aspect of architecture by harnessing the potential of learning to extrapolate from a curated pre-trained dataset. Through this approach, we sought to enable students to discern and articulate the features they aspire to achieve while envisioning future scenarios that address contemporary architectural imperatives and crises. By engaging with this process, students not only develop a deeper understanding of architectural semantics but also cultivate the ability to envision innovative solutions that respond effectively to the evolving needs of our built environment. The final result is a corollary of speculative images in which the very essence of the architectural typology has been questioned and merged with elements external to it. Although the images may seem excessively dreamlike, the original idea was to question the possibility of neural networks to extrapolate elements from both datasets (the house and the tree) and fusing them under the aegis of a non-uniform architectural spatiality present but potential.

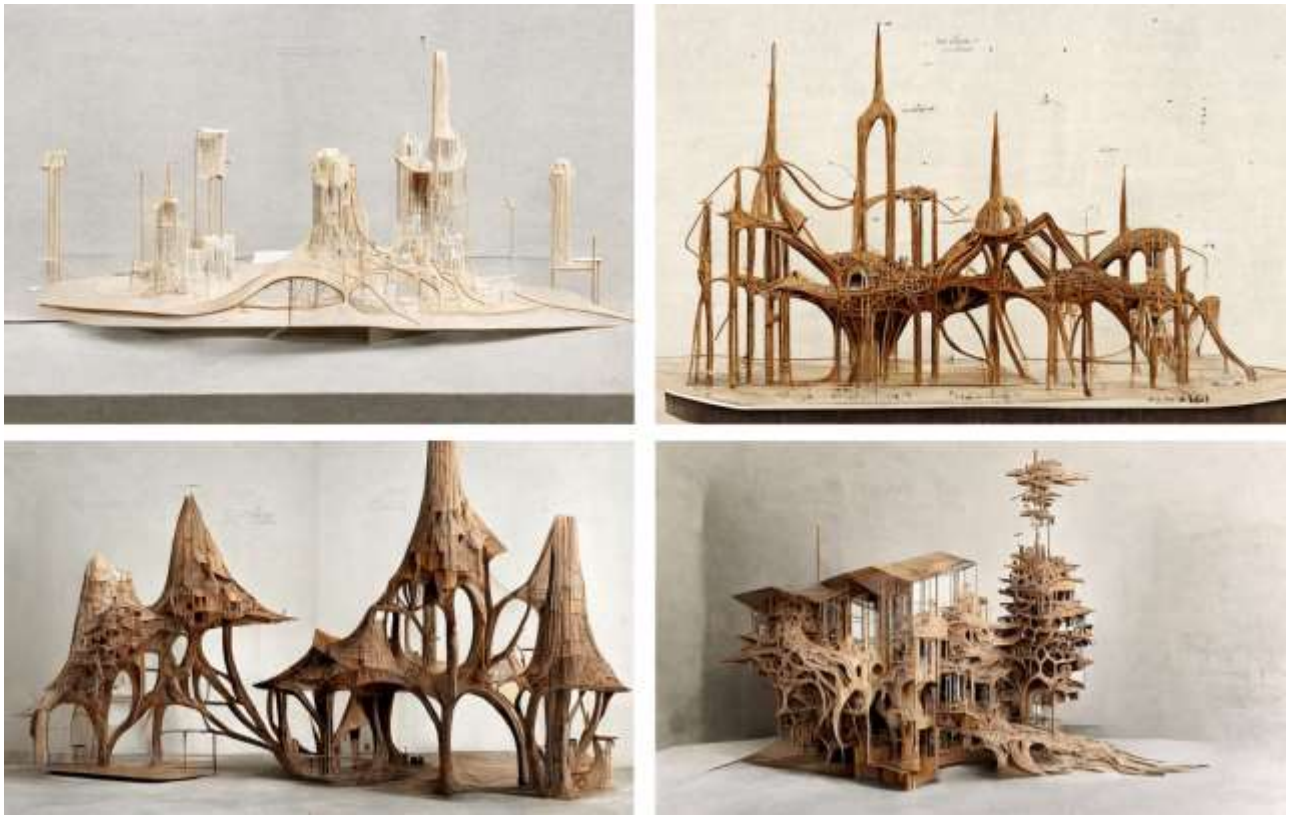

Figure 5 Midjourney v3: a wooden model of a building that looks like a tree, in the style of abstract and conceptual sketches, fantastical machines, floating structures, intricate webs, columns and totems, organic forms, muted tones, panoramic scale

In the end, some quick tests were also done with version 5 of Midjourney. Certainly more inclined to results aimed at a more defined spatiality in terms of semantic components. With a series of inpaintings and blends from the original drawings, the results obtained represent a series of architectural ideas aimed at the possibility of construction inspired by nature and in whose DNA there may be more sustainable solutions.

In the end, the process was structured into several distinct phases. Initially, students engaged in an analytical analogical phase, wherein they formulated their prompts through concise written texts. These prompts served as the foundation for subsequent experimentation. In the second phase, students incrementally implemented their drafted prompts, gradually increasing the complexity of their explorations. This iterative approach allowed them to validate the efficacy and feasibility of their concepts. Subsequently, the outputs generated were subjected to interpolation and blending using a variety of digital techniques, which facilitated the refinement and enhancement of the diffusion model itself. Through this multifaceted process, students were able to iteratively refine their ideas, experiment with diverse methodologies, and ultimately produce sophisticated and nuanced architectural solutions.

Figure 6 The last case study presented comes from a teaching experience carried out during the Master in Digital Architecture at POLIS University in Tirana, Albania. During the educational

VII. CONCLUSIONS AND FURTHER DISCUSSION

The last case studies presented comes from a teaching experience carried out during the Master in Digital Architecture at POLIS University in Tirana, Albania. During the educational path, the class had been exposed to several AI-based technology and tried to find its own way to master and use them in an architectural design process.

Many of the students seemed triggered by the possibility of having novel technologies at-hand that empowered them in quickly visualize and analyze what their mind was thinking. The possibility of inserting again a linguistic nuance into the architectural process makes AI technologies an interesting facilitator to push the boundaries of the discipline over the tradition tools for drafting and modeling. More than 100 students have attended the class and 80% of them completed successfully while a 30% started using the above-mentioned tools daily into their academic and professional engagement. What we discussed in this paper is just the beginning of a possible turning point for architects, designers, and creative actors, thanks to the emergence and diffusion of artificial intelligence through platform that make them comprehensible and usable from a broader number of users. The next steps of this research will focus on how it is possible to guarantee a better adherence between the drawings produced during a traditional design phase and their upload into AI-based platform to generate endless possibilities and opportunities without losing the connection with the original inputs. This represents at the moment one of the main challenges of this approach: while many platforms offer a wide number of results – even though very heterogeneous among them – a few of them allow the designer to completely control the generation in each of its steps. The classes of 2023 and 2024, have focused more a typology of tools that could enlarge the creative opportunities rather that guarantee a so-called consistency among the results. Researches were done by the teaching staff in this direction and updates in the curricula have prepared the next cycle for a better and more fruitful experience in terms of design.

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Water quality of Shkumbini River, Albania, evaluated by physical-chemical parameters and nutrient content

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Abstract – Monitoring of freshwater quality is important for water quality assessment and good quality objective. This study deals on water quality assessment of Shkumbini River. It is focused on the distribution and level of physical-chemical parameters and nutrient along the Shkunbini River. The study is performed on March 2022 by applying in-situ mesurements of water quality parameters combined with chemical analysis. The results showed that the geographical position, the related urbanization and human activity, as well as weather variation along the river catchment affect the changes in river water quality. Although the number of sampling sites is small (N=4), it is noted that the measured results for all parameters obey the normal distribution (tested by Anderson-darling test, $p > 0.05$) and were characterized by low variation (CV% < 25%), with the exception of TSS which shoed a moderate variation (CV% = 49%). The investigated water quality parameters resulted in lower level than the permitted values, by indicating good water quality of Shkumbini River. It is confirmed by WQI index which showed a good water quality ($71 < WQI < 90$) for all monitoring stations, which is probably related to low water temperatures and a rainy period of March. The obtained results demonstrate the efficiency of the water quality parameters and the model used for water quality classification.

Keywords – river water, sampling, water quality, physical-chemical parameters, nutrient.

I. INTRODUCTION

The surrounding environment is a complex system that consists of land, water, air, and living organisms that are influenced by various natural and human factors, establishing certain balances between them. As a result of intense human activity, these balances have changed, which has caused the destruction of natural ecosystems. Pollution is a serious problem as it passes into the soil, water, and air and then passes into the food chain, posing a risk to human health and living organisms. Water is a key resource for the development of every human activity and is the most important natural resource of life throughout the world. The world's freshwater resources are very unevenly distributed, compared to the world population density [17]. Regional and seasonal differences in the study area, land use and erosion processes, the spatial scale of sampling sites, the extent and type of human activities in the catchment, and the time of sampling all affect river water quality [16],[13]. Urban areas with intensive human activity and rapid land use change are vulnerable to water degradation [4]. As a result of human activity in the downstream regions of most river

basins, the water quality of these basins exhibits significant changes that have a detrimental impact on the rivers' health, particularly in terms of their water supply for daily life, industry, and agriculture [18].
Limited water resources and water quality have become major problems throughout the world, resulting in a global water crisis for billions of people [14], [17]. Water quality monitoring following the Water Framework Directive (WFD) shows that the study of the environmental situation and water quality is complex, including various biological, chemical, and physical-chemical parameters. The balance between water demands, water quantity, and water quality is a critical problem in many regions of the world, increasing the demand for a sustainable water resources management approach [14]. Waste disposal and the use of various chemicals in urban, industrial, and agricultural processes can cause serious water pollution. Water eutrophication is an important environmental issue in surface water, groundwater, and marine systems that is strongly related to the increase of nutrient content in water, mainly affected by human activities and atmospheric deposition [2].
The presence of macronutrients like carbon, nitrogen, and phosphorus is essential for the growth of aquatic life in freshwater [15], but high levels are dangerous for aquatic life. In addition to natural sources, manmade inputs and erosion carried out by runoff are the main sources of nutrients in fresh water [15]. Changes in nutrient flux in heavy populated areas can induce spatial and temporal variations in nutrient and physical-chemical parameters in water. The level and the technology used for sewage treatment and nutrient removal are significant factors contributing to the fluctuations in nutrient and physical-chemical parameters in water [4] that cause the eutrophication of water ecosystems. Eutrophication of waters is associated with the enrichment of nitrogen (N) compounds like nitrite (NO_2^-), nitrate (NO_3^-), ammonium (NH_4^+), and phosphate (PO_4^{3-}) content in water that can cause the presence of algal blooms and macrophytes in certain waters, depletion of dissolved oxygen in water, degradation of aquatic ecosystems, and loss of key aquatic species. EPA water quality standards [7] include several parameters, such as chemical, physical, and biological parameters, that directly affect the water quality.
This study is focused on the water quality of the Shkumbini River, an important river located in the central part of Albania. Water quality assessment was based on water physico-chemical parameters such as temperature, pH, dissolved oxygen (DO), TSS, nutrients ($N\text{-}NO_2^-$, $N\text{-}NO_3^-$, $N\text{-}NH_4^+$, $P\text{-}PO_4^{3-}$).

II. Materials and Method

A. *Level 2 - General view of Shkumbini River*

The Shkumbini River i is positioned in central Albania, originating from the mountainous area of Valmara (Korce), and flows into the Adriatic Sea near the Karavasta Lagoon. Since it passes through areas with high chrome, nickel, and iron minerals, the industrial area of Elbasan with high industrial activity of chrome, nickel, and iron metallurgy, as well as cement, as well as urban and industrial area of Elbasan, it is affected by various manmade factors.
Four monitoring sites along the Shkumbini River were selected in this study (Fig. 1) . The selection of the monitoring sites was carried out taking into account the geographical position, urban, industrial, and agricultural pollution factors, erosion conditions, etc. The hydrological parameters of the Shkumbini River are shown in Table 1, and the map of the area and sampling positions are shown in Figure 1.

Level 3 – Water sampling method

Sampling was performed based on the standard methods "Standard Methods for the Examination of Water and Wastewater" with the APHA standard method [1] and ISO Standard 5667-1: 2006 [12]. The samples were filtered with 0.45 μm Millipore nitrocellulose filters. To clean the membrane, the initial part of the filtered water was poured. Water samples for metal analysis were taken in 0.5 PET bottles pre-cleaned in the laboratory. Water samples for nutrient analysis were taken in 100 ml glass bottles. For metals, the PET bottles were washed with 10% v/v nitric acid, and then rinsed several times with pure deionized water. The samples were transported during the same day to the laboratory using cold boxes to maintain the temperature of +4 ° C. The samples were stored under standard conditions until analysis. During

transportation, the water samples were treated with chemicals to maintain the stability of the parameters taken in the study, as shown in Table 2.

Level 4 - Determination of physico-chemical parameters

Physico-chemical parameters such as water temperature, pH, dissolved oxygen (DO), total dissolved solids (TDS), salinity and electrical conductivity were measured in situ using a portable multiparameter apparatus (HACH type sension156). Suspended solids (TSS) were determined by filtration on a pre-weighed filter with a pore size of 0.42 μm. The filter was weighed again after drying at 105° C for 2 hours to constant weight. Nutrient content ($N\text{-}NO_3$-, $N\text{-}NO_2$-, $N\text{-}NH_4$ +, $P\text{-}PO_4^{3-}$) was determined according to standard APHA (1998) procedures using UV-Vis spectrophotometric methods using Specord 40 spectrophotometer.

Level 5 - Data analysis

Water quality monitoring is essential for assessing and controlling water quality and protecting human and environmental health. We used water quality index to predict the water quality classification. WQI) is calculated by averaging the individual index values of some water quality parameters used. In order to measure the pressures of natural and anthropogenic effects to water bodies, the aquatic classification system, which covers rivers, estuaries, coastal and groundwater bodies [11], is used. Classification of water quality means the categorization of water bodies based on water quality parameters, which have a certain effect to the pollution level of water bodies. Classification takes in consideration two main criterias such as the destination of use like as drinking water, for aquatic life, agricultural, or industrial use, and commercial, industrial, navigational, recreational, wildlife conservation and aesthetic purposes, and the second taking into consideration the environmental lealth of water bodies. Simple water quality index (WQI), which is based at five water quality parameters, temperature, biological oxygen demand (BOD), total suspended sediment (TSS), dissolved oxygen (DO), and conductivity, is used in this study. A higher value of WQI indicates better water quality. Surface water bodies are classified using a system of five quality classes that varies from 0 to 100, with five different ranges from 91 to 100 as excellent water quality, 71 to 90 as good water quality, 51 to 70 as average water quality, 26 to 50 as fair water quality, and 0 to 25 as poor water quality [11]. WQI is calculated by the following equation [3]:

$$WQI = \frac{\sum qn * Wn}{\sum Wn}$$

Where, qn = Quality rating of n^{th} water quality parameter. Wn= Unit weight of n th water quality parameter. All WQI data of this study were calculated through the online simple index calculator.

B. Figures and Tables

Fig. 1 The position of sampling sites: St.1- Qukes; ST.2 – Fushe Labinot; St.3 - Mjekes; St.4 – Rogozhina

Table 1. Hydrological parameters of the Shkumbin River (Duka et al. 2017)

Length	Surface	Altitude	Flow	Modulus of flow	Average amount of mineralization
km	km^2	m	m^3/sec	$l/sec/km^2$	mg/L
181.4	2445	753	61	25.2	317

Table 2. Samples storage conditions

Parameter	BOD	NH_3, NO_2^-, NO_3-	DO
Consevation conditions	4^o C, dark bottles	pH<2, H_2SO_4	In the presence of chemical fixation reagents for DO, dark bottles

Table 3. Experimental results of chemical-physical parameters

S.sites	Temperature	pH	Alkalinity	EC	TSS	DO	BOD	WQI
	°C		(mg/l)	(µs/cm)	(mg/l)	(mg/l)	(mg/l)	
St1	13.7	7.82	187	315	38.2	10.6	3.5	87
St2	16.4	8.01	203	348	69.5	9.1	4.7	78
St3	17.8	7.77	192	323	137	9.3	4.2	73
St4	17.6	8.18	265	344	97	8.9	5.1	74

Table 4. Results of the statistical analysis performed by "descriptive statistics" (* in mg/l)

Variable	Temp (°C)	pH	Alkalinity*	EC (µs/cm)	TSS*	DO*	BOD*	WQI
Mean± StDev	16.4 ± 1.9	7.9 ± 0.19	212 ± 36	333 ± 16	85 ± 42	9.8 ± 0.8	4.4 ± 0.7	78 ± 6
CV%	12	2	17	5	49	8	16	8
Minimum	13.7	7.8	187	354	38.2	8.9	3.5	73
Median	17	7.9	198	333	83.3	9.8	4.5	76
Maximum	17.8	8.2	265	348	137	10.7	5.1	87

Table 5. The content of the nutrients (mg/l) in the samples of the Shkumbin River

Stations	NH_4^+-N	NO_2^--N	NO_3^--N	P-PO_4^{3-}-P
St1	0.062	0.004	0.45	0.023
St2	0.187	0.006	0.31	0.039
St3	0.275	0.011	0.23	0.034
St4	0.386	0.014	0.29	0.048

Table 6. Results of the statistical analysis performed by "descriptive statistics"

	NH_4^+-N	*NO_2^--N*	*NO_3^--N*	*P-PO_4^{3-}*
Mean	0.228	0.0088	0.320	0.0360
Median	0.231	0.0085	0.300	0.0365
St. Deviation	0.137	0.0046	0.093	0.0104
CV %	60	52	29	29
Minimum	0.062	0.004	0.230	0.0230
Maximum	0.386	0.014	0.450	0.0480

III. RESULTS

The experimental results of the chemical-physical parameters of the Shkumbini River samples are presented in Table 6.

Temperature

The temperature level depends mainly on the temperature of the environment and the speed of the water flow. The temperature of the samples taken in the study ranged from 13.7 to 17.8 °C. The minimum temperature (13.7 °C) was measured at station St1 followed by station St2 (16.4° C). Both of these stations are located in mountainous areas with different geographical heights, which has affected the temperature of the environment in these areas, as well as the speed of water flow in these areas. The other two stations (St3 and St4) positioned in plain areas and closer to the Adriatic Sea, show higher temperatures. Changes in the temperature values of water systems are caused by changes in various chemical processes in water, such as the dissolution of oxygen in water, in various chemical reactions, or in the activity of organisms or microorganisms in water that affect the fermentation of pollutants and the eutrophication of natural waters. With all that, the level of temperature variance is low (CV % = 12 %), which is not the main reason for the level of pollution of the Shkumbin River during the spring season when the monitoring was carried out.

pH

Monitoring the pH of water systems is of particular importance as it is a very important parameter which mainly depends on the nature of the ions dissolved in them, with a tendency of basic values mainly in carbonate areas. On the other hand, pH is an indicative parameter of the degree of eutrophication of waters when it goes to acidic values, indicating the presence of urban discharges, urban waste, industrial discharges, or biological processes of plants or aquatic algae such as photosynthesis or respiration of algae. The pH values of the samples taken in the study fluctuate in a fairly narrow range (7.8 to 8.2) with values within the range of normal values (6 to 9) recommended by the EPA for surface waters [7].

Alkalinity

The alkalinity of Shkumbin river samples fluctuated from 187 to 265 mg/l (CaCO3). The minimum value was observed at station St1 and the maximum value at station St4. The alkalinity of natural water samples is related to the presence of carbonate salts, hydrogen carbonate, or oxide-hydroxides in the water. It indicates the presence of carbonate, bicarbonate, or hydroxide in water. It shows how able the water is to neutralize the acids.

Electrical Conductivity (EC)

The EC values of the samples taken in the study fluctuate in a fairly narrow range, from 315 µS/cm (St4) to 348 µS/cm (St2) accompanied by a very low variation (CV% = 5%), showing a stable situation during the monitoring period. High conductivity values are thought to be influenced by industrial, agricultural, and rural activities. The conductivity value in water is affected by the presence of dissolved solids such as anions or cations, and higher salinity in water indicates higher water conductivity.

Total suspended matter (TSS)

The TSS values of the samples taken in the study fluctuate in a wide range, from 37.2 mg/l (St1) to 137 mg/l (St3), associated with a very high variation (CV% = 49%). The TSS values in the samples taken in the study are higher than the values recommended by the European Community (< 10 mg/L). Such a situation can be caused by different conditions of erosion in different areas, by different parameters of the speed of water flow in areas with high slopes, as well as by the conditions of anthropogenic pollution in areas where spills can be identified as solid in water.

Disolved oxygen (DO)

The DO content in Shkumbini river water varies from 8.9 mg/l in summer (S4) to 10.6 mg/l (ST1). The content of DO in surface waters is related to the dissolution of oxygen present in the air and the process of photosynthesis in water. The level of DO in surface waters depends on a number of factors, such as water temperature (the amount of DO increases with increasing temperature), the speed of water flow, which

positively affects the values of DO, the level of pollution, which negatively affects the values of DO, etc. The DO level is essential for the survival of aquatic creatures and an important indicator of surface water pollution or eutrophication. The highest levels of DO were found in the first station (St1), which is favored by a high flow rate due to the area's fraction as well as by low levels of pollution as it is located far from urban and rural areas.

Biological oxygen demand (BOD)

The content of BOD in the Shkumbini River water varies from 3.5 mg/l to 5.1 mg/l. The lowest BOD content was found at station St1, near the source of the Shkumbin River, which is associated with a fairly low level of pollution in it. The highest value of BOD was found in station St4 (Rrogozhina), a rural area with high agricultural activity.

Nutrients

The content of nutrients (mg/l) in the water of the Shkumbin River is given in Table 5, while the results of the statistical analysis in "descriptive statistics" are given in Table 6.

From the results of the statistical analysis, it is noted that the average values of each parameter are quite close to the median values, accompanied by relatively low variation for NO_3—N and $P\text{-}PO_4^{3-}$ (CV % = 29 %) and moderate for NH_4^+-*N* and NO_2—*N* (CV % resulted 60 % and 52 % respectively). This shows that the values of NO_3—N and $P\text{-}PO_4^{3-}$ are more stable than those of NH_4^+-N and NO_2^- —N.

Nitrate ($N\text{-}NO_3^-$)

The concentrations of NO_3^- - N (mg/l) in the samples taken in the study varies from 0.230 mg/l to 0.450 mg/l with an average value of 0.320 mg/l. The content of nitrates in water is related to the oxidized form of nitrogen compounds in it. Higher levels of nitrates resulted in stations St3 and St4 which may be related to the discharge of urban waste and livestock waste in this area. Nitrates themselves are quite well assimilated by plants as a nutrient for them, but in high content it can stimulate the proliferation of phytoplankton or macrophytes.

Nitrite ($N\text{-}NO_2^-$)

The concentration of NO_2^- - N (mg/l) in the Shkumbini river water samples is relatively low and fluctuates in the levels from 0.004 mg/l to 0.014 mg/l with an average concentration of 0.0088 mg/l. According to the results shown in Table 5 it turns out that the profile of the change in the concentration of NO_2^- - N increases by passing from the source (St1) with minimum content to other stations which for the same reason as for nitrates may have been influenced by levels of different discharges of urban waste and livestock waste in these areas. Another possible source of nitrites could be hydroplankton and sewage discharges, which are also related to the degree of urbanization of the areas where the samples were taken. On the other hand, nitrites in fresh waters are found as intermediate compounds obtained through the microbial reduction of nitrates or from the process of ammonium oxidation. The level of nitrites in unpolluted waters is usually lower than 0.01 mg/l (www.epa.ie/pubs/…) expressed as nitrogen (N) content. The level of NO2- — N content in the water samples of stations St1 and St2 was lower than 0.01 mg/l, while in stations ST3 and St4 it was higher than this level. As expected, this shows different levels of pollution of these stations, Stations St3 and St4 located in urban and urban-rural areas present a higher level of pollution than stations St1 and St2 located in residential areas.

Ammonium ($N\text{-}NH_4^+$)

Ammonium present in water systems originates from the microbiological decomposition of nitrogenous compounds, organic matter and from secretion by various aquatic organisms. Ammonium also derives from

anthropogenic sources, such as industrial processes, urban sewage discharge, animal stables or fermentation of urban waste discharged into the environment. Unpolluted natural waters contain relatively small amounts of ammonium, usually at a level lower than 0.02 mg/l NH_4^+ - N (www.epa.ie/pubs/...). Ammonium content in Shkumbini river water ranges from 0.062 mg/l to 0.386 mg/l NH_4^+ - N. The lowest level was found at stations ST1 and the highest level was found at station S4. The profile of the change of ammonium content in the station obtained in the study varies according to the order NH_4^+ - N (ST1) NH_4^+ - N (S2) < NH_4^+ - N (S3) < NH_4^+ - N (S4) which is related to the degree of urban emissions and livestock in these areas. The levels of NH4+ - N in the samples taken in the study are several times higher than normal values, which indicates a high level of pollution. This can be caused by eutrophication of water.

Phosphate (PO_4^{3-}-P)

The content of phosphates in the studied stations along the Shkumbin River varies in values from 0.023 to 0.048 mg/l PO_4^{3-}—P. All measured values are lower than the recommended level (0.1 mg/l PO_4^{3-}—P) (www.epa.ie/pubs/...). The phosphate concentration values show a low variation (CV % = 29 %), which indicates a stable state along the Shkumbin River. Phosphates in water come mainly as a result of human activity, among the main sources of phosphates in the environment we can mention sewage discharges in urban areas, urban water discharges with phosphorus content from the use of different detergents, etc. The monitoring period (March) is characterized by abundant rainfall, therefore pollution from areas with high agricultural activity is another factor of anthropogenic phosphate pollution. Likewise, the erosion or washing away of soils and rocks in the areas where the river passes are another source of phosphates in the water. Mention that the two extremes of minimum and maximum phosphate values were found respectively in stations St1 (clean area near the source of the Shkumbin river) and St4 (rural area with agricultural and industrial activity).

IV. DISCUSSION

As the number of sampling sites is small (N=4), it is noted that the measured results for all parameters obey the normal distribution (tested by Anderson-darling test, $p > 0.05$). With the exception of TSS (CV% = 49%), all other parameters result in a fairly low variation (CV% < 25%), and vary in a narrow range. Quite important are the results of the WQI index, which show a good water quality (71 < WQI < 90) for all monitoring stations, which is probably affected by low water temperatures and a rainy period of March.
Discussion of water quality is strongly related with population and land use along the water bodies [5]. It is verified in our result which consisted with higher WQI values near the river spring in mountain area with scarce population, and an increase in lowland characterized by relatively high population and industrial, agricultural, and daily life.

V. CONCLUSION

This study shows that the parameters taken in the study are the basis for the environmental assessment of surface waters.
Parameters such as temperature, pH, electrical conductivity, BOD and nutrients are mostly varied according to the position of the stations in relation to urbanization and human activity in them.
The investigated water quality parameters resulted in lower levels than the permitted values. The concentrations of nitrate and nitrite were generally lower than the level established by WHO (2004) for surface water (50 mg/l for nitrates and 1.0 mg/l for nitrites). On the other hand, ammonium has high concentration levels, which exceed the recommended level of surface water (0.3 mg/l) set by WHO (2004).
Statistical analysis can be successfully used in the interpretation of environmental data as it highlights the phenomena that lead to the classification of the environmental status of the studying object.

WQI index showed a good water quality (71 < WQI < 90) for all monitoring stations, which is probably affected by low water temperatures and a rainy period of March. The method usedin this study for fresh water quality monitory is a simle, effective and low cost method. The obtained results demonstrate the efficiency of the water quality parameters and the model used for water quality classification.

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Integrating Haar Cascade, CNN and SVM for Advanced Facial Recognition

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Abstract – Facial recognition systems have become integral in various applications, ranging from security and access control to user authentication. This study presents a robust facial recognition system leveraging the combined strengths of Haar Cascade, Convolutional Neural Networks (CNN), and Support Vector Machines (SVM). The system begins with face detection using Haar Cascade, a well-established technique for identifying facial regions in images. Following detection, the detected faces are processed through a CNN, specifically the VGG16 model, for feature extraction. The high-level features extracted by the CNN are then classified using an SVM, which excels in handling high-dimensional data and providing precise classification.

The proposed system undergoes rigorous training and evaluation using a comprehensive dataset of facial images organized by individual directories. The dataset is split into training and testing sets to validate the model's performance. Experimental results demonstrate the efficacy of this approach, with the SVM classifier achieving high accuracy in facial recognition tasks.

In addition to evaluating the system's performance, the study includes a visual inspection of the results through plots of test images, showcasing actual and predicted labels. This highlights the model's ability to accurately identify and verify individuals based on facial features.

The integration of Haar Cascade, CNN, and SVM in this facial recognition system underscores the importance of combining different methodologies to enhance accuracy and reliability. This study contributes to the development of advanced facial recognition technologies, providing a valuable tool for applications requiring precise identification and verification.

Keywords – Face Recognition, Support Vector Machine (SVM), Haar Cascade, Convolutional Neural Network (CNN), Feature extraction

I. INTRODUCTION

Facial recognition technology has become a cornerstone in modern biometric systems, providing a non-intrusive and efficient means of identifying and verifying individuals [1]. The advancement of this technology over the past two decades has been driven by the need for improved security and convenience across various applications such as surveillance, access control, and personal device authentication. Despite significant progress, achieving high accuracy in facial recognition under diverse conditions including variations in lighting, pose, and facial expressions remains a primary challenge [2].

To address these challenges, we propose an advanced facial recognition system that integrates Haar Cascade, Convolutional Neural Networks (CNN) [3][4], and Support Vector Machines (SVM). This hybrid approach leverages the strengths of each method to create a robust and reliable system.

The Haar Cascade classifier, developed by Paul Viola and Michael Jones, is a proven method for rapid and accurate face detection. It uses a cascade of simple classifiers based on Haar-like features, allowing for real-time face detection. Once the face is detected, the system employs a Convolutional Neural Network (CNN) for feature extraction. CNNs are highly effective in learning and representing complex patterns in images, making them ideal for capturing the unique characteristics of a face.

Following feature extraction, a Support Vector Machine (SVM) classifier is utilized for the final classification. SVMs are well-known for their ability to handle high-dimensional data and establish optimal decision boundaries between different classes. By combining Haar Cascade for detection, CNN for feature extraction, and SVM for classification, the proposed system aims to achieve superior accuracy and reliability in facial recognition tasks.

The performance of the proposed system was tested using the Labeled Faces in the Wild (LFW) dataset, which comprises over 1,800 images of celebrity faces collected from the internet, each labeled with the individual's name. The dataset's diversity in lighting, pose, and expressions makes it an ideal benchmark for face recognition systems. Experimental results demonstrate the effectiveness of the integrated approach, showcasing its potential for enhancing security and user interaction in various domains.

This paper will delve into the implementation details, experimental setup, and performance evaluation of the integrated system, highlighting the advantages and potential applications of combining Haar Cascade, CNN, and SVM for advanced facial recognition.

II. Materials and Method

A. Dataset

Images were sourced from celebrity Face image dataset [6]. This dataset contains images of 18 Hollywood celebrities with 100 images of each celebrity. The dataset includes variations in lighting, pose, and facial expressions, providing a comprehensive testbed for evaluating face recognition systems.

Fig 1. Samples from the celebrity faces images in the used datasets

B. Face Detection

The Haar Cascade Classifier was employed for face detection. Haar Cascade is a machine learning object detection method used to identify objects in an image or video. OpenCV's pre-trained Haar Cascade model (haarcascade_frontalface_default.xml) was utilized due to its effectiveness in real-time face detection [5]. The classifier scans the image and identifies regions where a face is likely present, allowing for efficient extraction of facial regions for further processing [7].

C. Feature Extraction

For feature extraction, the VGG16 Convolutional Neural Network (CNN) model was used. VGG16 is a deep learning model pre-trained on the ImageNet dataset. The model's weights are fine-tuned for feature extraction, focusing on the 'fc1' layer to capture deep features from the facial images [8]. This process involves the following steps:

1. *Image Preprocessing:* Each face image is resized to 224x224 pixels and converted to an array suitable for input into the VGG16 model.
2. *Normalization:* Images are normalized using the preprocess input function to ensure consistency with the VGG16 training process.
3. *Feature Extraction:* The VGG16 model processes each image and outputs a feature vector representing high-level features of the face.

D. Classification

A Support Vector Machine (SVM) classifier with a linear kernel was employed for the classification task. SVMs are effective in high-dimensional spaces and are well-suited for face recognition tasks. The extracted feature vectors from the CNN model serve as input to the SVM classifier, which is trained to differentiate between the faces of different individuals [9][10].

E. Training and Evaluation

The dataset was split into training and testing sets, with 80% of the images used for training and 20% for testing. The training process involved the following steps:

1. *Feature Extraction:* Features were extracted from all images in the training set using the VGG16 model.
2. *SVM Training:* The SVM classifier was trained on the extracted features and corresponding labels.
3. *Evaluation:* The trained SVM classifier was evaluated on the testing set. Performance metrics such as accuracy, confusion matrix, and classification report were computed to assess the model's effectiveness.

F. Results Visualization

To visualize the results, the program plots the confusion matrix and sample predictions. The confusion matrix provides a summary of prediction accuracy across different classes, while sample predictions help in understanding the model's performance on individual test images. *Matplotlib* and *Seaborn* libraries were used for plotting.

Implementation Details

The implementation was carried out using Python, with the following libraries:

- *OpenCV:* For image processing and face detection.
- *TensorFlow/Keras:* For utilizing the VGG16 model.
- *Scikit-learn:* For SVM classification, model evaluation, and performance metrics.
- *Matplotlib and Seaborn:* For visualization of results.

The main steps of the implementation are as follows:

1. *Loading Dataset:* Reading and preprocessing images from the dataset.
2. *Face Detection:* Detecting faces using Haar Cascade.
3. *Feature Extraction:* Extracting features using VGG16.
4. *Training SVM:* Training the SVM classifier on extracted features.
5. *Evaluation and Visualization:* Evaluating the model and visualizing results.

III. Results

A. Dataset and Training

The dataset used for this study comprised a diverse set of facial images organized into subdirectories based on the individual's name. The dataset was split into training and testing sets with an 80-20 split. The training set was used to train the Support Vector Machine (SVM) classifier on the features extracted by the VGG16 model

B. Performance Metrics

The performance of the face recognition system was evaluated using several metrics, including accuracy, classification report, and confusion matrix. The following results were obtained:

1. *Accuracy:* The accuracy of the SVM classifier on the testing set was found (100%). This indicates the percentage of correctly classified images out of the total number of test images.
2. *Classification Report:* The classification report provides detailed insights into the precision, recall, and F1-score for each class (individual). The report is summarized as follows:
    - *Precision:* Measures the accuracy of the positive predictions.
    - *Recall:* Measures the ability to find all the positive samples.
    - *F1-score:* The harmonic means of precision and recall.

Table 1. Performance evaluation to f-score on the LFW dataset.

Classification Report:

	precision	recall	f1-score	support
Nicole Kidman	1.00	1.00	1.00	27
Sandra Bullock	1.00	1.00	1.00	23
Tom Hanks	1.00	1.00	1.00	26
Scarlett Johansson	1.00	1.00	1.00	52
Megan Fox	1.00	1.00	1.00	23
Leonardo DiCaprio	1.00	1.00	1.00	22
Natalie Portman	1.00	1.00	1.00	18
Robert Downey Jr	1.00	1.00	1.00	18
Tom Cruise	1.00	1.00	1.00	18
Will Smith	1.00	1.00	1.00	20
Jennifer Lawrence	1.00	1.00	1.00	26
Johnny Depp	1.00	1.00	1.00	24
Brad Pitt	1.00	1.00	1.00	21
Kate Winslet	1.00	1.00	1.00	22
Angelina Jolie	1.00	1.00	1.00	27
Hugh Jackman	1.00	1.00	1.00	19
Denzel Washington	1.00	1.00	1.00	27
accuracy			1.00	413
macro avg	1.00	1.00	1.00	413
weighted avg	1.00	1.00	1.00	413

Accuracy: 100.00%

3. *Confusion Matrix:* The confusion matrix shows the number of correct and incorrect predictions for each individual. It provides a visual representation of the classifier's performance.

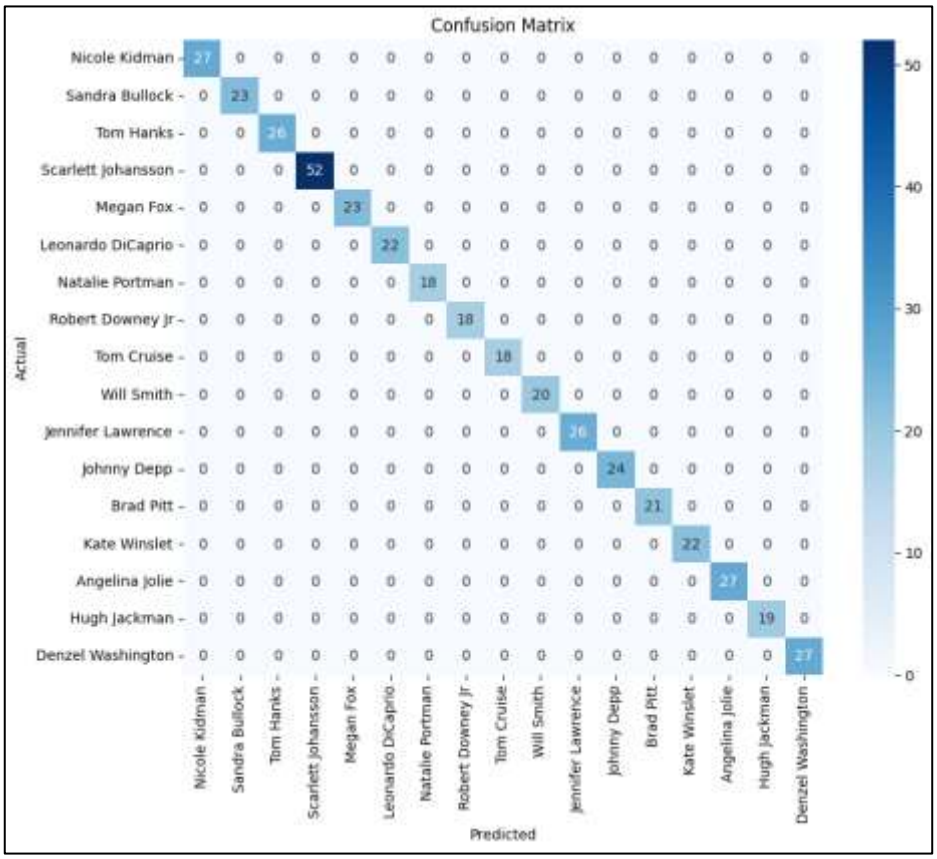

Fig 2. Confusion Matrix for Performance of the Facial Recognition System

4. *Visualizing Results:* To better understand the model's performance, the results were visualized using *Matplotlib* and *Seaborn* libraries. The following visualizations were created:

Fig 3. Samples from tested images alongside their actual and predicted labels

IV. Discussion

The integration of Haar Cascade, Convolutional Neural Networks (CNN), and Support Vector Machines (SVM) in facial recognition system has shown promising results in both accuracy and reliability. This

section delves into the implications of our findings, the strengths and limitations of our approach, and potential future work.

- *Strengths and Implications*

1. *Effective Face Detection:* The use of Haar Cascade for face detection proved efficient, demonstrating real-time performance in locating faces within various image contexts. Its ability to quickly detect faces makes it suitable for applications requiring immediate responses, such as surveillance and security systems.
2. *Robust Feature Extraction:* CNNs, particularly the VGG16 model used for feature extraction, have shown significant strength in capturing intricate details and variations in facial features. This deep learning model effectively handles variations in lighting, pose, and facial expressions, which are critical for accurate face recognition.
3. *High Classification Accuracy:* The SVM classifier, trained on features extracted by the CNN, exhibited high accuracy in distinguishing between different faces. This combination leveraged the high-dimensional feature space provided by CNNs and the effective decision boundaries established by SVMs.

- *Limitations*

1. *Dataset Size and Diversity:* Although our system performed well on the given dataset, the diversity and size of the dataset are crucial factors. A more extensive and varied dataset would provide a better evaluation of the system's generalizability and robustness.
2. *Computational Complexity:* The CNN-SVM approach, while accurate, is computationally intensive. Real-time applications may require optimization strategies or the use of more efficient models to reduce processing time without sacrificing accuracy.
3. *Environmental Variations:* While our system handles common variations in lighting and pose, extreme conditions (such as very low light or severe occlusions) can still pose challenges. Further enhancements in preprocessing steps or additional training on such variations might be necessary.

- *Future Work*

1. *Dataset Expansion:* Future work could involve expanding the dataset to include more diverse and challenging images. This would help in further testing and improving the system's robustness and accuracy.
2. *Model Optimization:* Exploring model optimization techniques, such as pruning or quantization, could make the system more efficient, enabling real-time applications on resource-constrained devices.
3. *Hybrid Approaches:* Combining our current approach with other emerging techniques, such as facial landmark detection or generative adversarial networks (GANs), could further enhance performance, especially under challenging conditions.
4. *Cross-Domain Evaluation:* Testing the system across different domains (e.g., different demographic groups, various environments) would provide a more comprehensive understanding of its strengths and weaknesses, guiding future improvements.

V. CONCLUSION

In this research, we introduced a novel facial recognition system that integrates Haar Cascade for face detection, Convolutional Neural Networks (CNN) for feature extraction, and Support Vector Machines (SVM) for classification. Our approach demonstrated high accuracy and reliability, making significant strides in addressing the challenges associated with facial recognition under diverse conditions.

The results of this study demonstrate the potential of this method for practical applications, and future work will aim to further enhance its performance and broaden its applicability in the field of biometric identification.

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Facial Recognition: Employing Histogram of Gradients and Support Vector Machines

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Abstract – An innovative face recognition system is introduced in this research. It integrates Histogram of Oriented Gradients (HOG) for feature extraction with Haar Cascade Classifier for face detection and Support Vector Machine (SVM) for classification. The system starts off by using Haar Cascade Classifier which is a pre-trained model capable of real-time and effective face detection using HOG post detection to extract important facial features that are structural as well as gradient-based and help differentiate between faces. The SVM classifier is then trained based on these features; SVM is suitable for handling high-dimensional data and establishing optimal decision boundaries among classes. The system's performance was tested on a large dataset consisting of images of celebrities and it has shown high accuracy and reliability in tasks related to recognizing faces. The Haar-like feature selection combined with the Histogram of Oriented Gradients (HOG) ensures precise extraction of characteristics, and a strong identification of the face's location. The SVM classifier is capable of providing high performance in applications, since it is known to be one of the most accurate classifiers. Tests show that this system can work well for finding celebrities as well as verifying their identity, meaning it could be successfully applied in practical tasks related to security, social media or show business.

Keywords – Face Recognition, Histogram of Oriented Gradients (HOG), Haar Cascade Classifier, Support Vector Machine (SVM), Feature Extraction, Face Detection, Image Processing, Machine Learning, Computer Vision.

1. INTRODUCTION

Face recognition technology plays a pivotal role in modern biometric systems, providing a non-intrusive and efficient means of identifying and verifying individuals. This technology has seen significant advancements over the past two decades, driven by the need for improved security and convenience in various applications such as surveillance, access control, and personal device authentication [1].

The primary challenge in face recognition lies in achieving high accuracy under diverse conditions, including variations in lighting, pose, and facial expressions. To address these challenges, we propose a face recognition method that combines histogram of oriented gradients (HOG) for robust feature extraction [2], Haar Cascade classifier for precise face detection, and support vector machine (SVM) for effective classification.

2. MATERIALS AND METHOD

2.1 MATERIALS

2.1.1 HARDWARE

The development and testing of the face recognition system were carried out on the following hardware setup:

- Computer**:** Laptop with Intel Core i7- 8650U processor 1.90 GHz Base Frequency, 8 GB DDR4 RAM, Intel UHD Graphics 620 GPU and 512 GB SSD.

2.1.2 DATASET

Celebrity images were sourced from a labeled Faces in the Wild (LFW) dataset was utilized for training and testing. It comprises over 1,800 images of faces collected from the internet, each labeled with the individual's name. The dataset's diversity in lighting, pose, and expressions makes it an ideal benchmark for face recognition systems.

Fig 1. Samples from the celebrity faces images in the used datasets [3].

2.1.3 SOFTWARE AND LİBRARİES

- Operating System: Windows 11 Pro
- Python: Version 3.8
- OpenCV: Version 4.5.1 for image processing and Haar Cascade face detection
- Scikit-learn: Version 0.24.1 for SVM implementation
- Scikit-image: Version 0.18.1 for HOG feature extraction
- Numpy: Version 1.20.1 for numerical computations
- Matplotlib: Version 3.3.4 for plotting and visualization

2.2 METHOD

The proposed face recognition system comprises three main stages: face detection, feature extraction, and classification.The first step in the recognition process is face detection. We utilize the Haar Cascade Classifier, a machine learning-based approach that employs Haar-like features to detect objects. This classifier is trained on a large dataset of positive and negative images to identify faces accurately. The Haar Cascade algorithm efficiently scans the input image, identifying regions with significant intensity changes that typically correspond to facial features [4] .

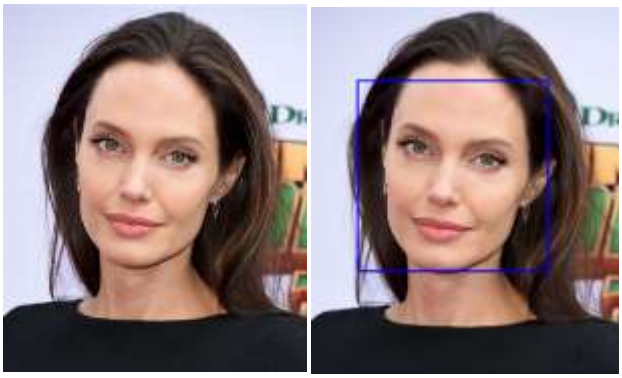

Fig 2.Face detected using Haar Cascade face detection algorithm**.**

Following face detection, the next critical step is feature extraction. We employ the Histogram of Oriented Gradients (HOG) method, which has proven highly effective in capturing the structural and appearance-related characteristics of faces. HOG works by dividing the image into small cells, computing gradient directions for each pixel within the cells, and forming histograms of these gradient orientations. These histograms are concatenated to form a feature vector that robustly represents the face's visual information[5].

Fig 3. Face detected using Histogram of Oriented Gradients (HOG).

The final stage is classification, has been shown in figure 4, where the extracted HOG features are used to train a Support Vector Machine (SVM) classifier. SVM is a powerful supervised learning model that constructs a hyperplane in a high-dimensional space to separate different classes. It is particularly effective for binary classification tasks and can handle high-dimensional data efficiently. In this study, we employ a linear SVM to classify the HOG features of faces, ensuring high accuracy in distinguishing between different individuals [6].

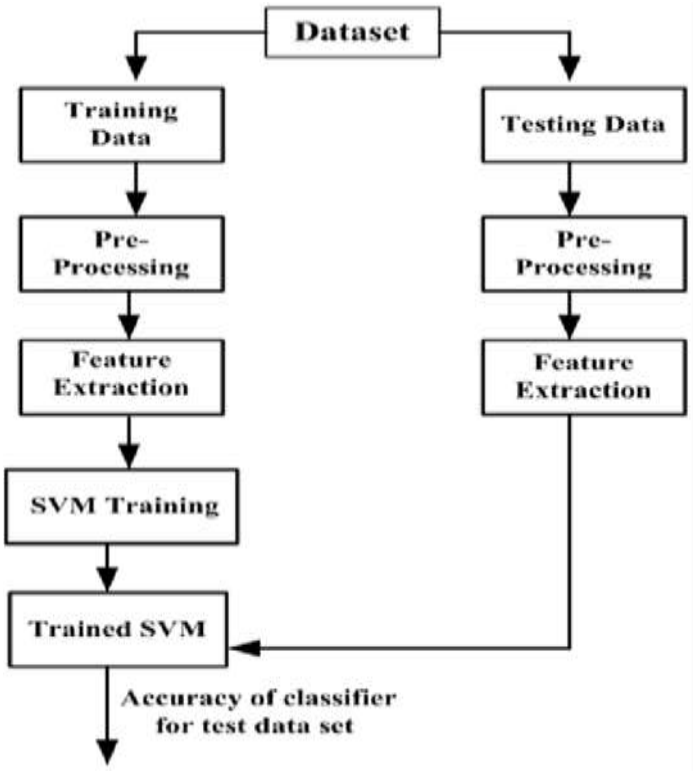

Figure 4. Different stages of SVM classification [7].

2.3 IMPLEMENTATION STEPS

1. Data Preparation: Load the LFW dataset, resize images, and convert them to grayscale.
2. Face Detection: Use Haar Cascade Classifier to detect faces in images.
3. Feature Extraction: Extract HOG features from detected faces.
4. Model Training: Train the SVM classifier with HOG features from the training set.
5. Evaluation: Test the SVM model on a separate set of images and evaluate performance using accuracy, precision, recall, and F1-score metrics.

3. EXPERIMENTAL RESULTS

To evaluate the performance of our proposed face recognition system, we conducted extensive experiments using the Labeled Faces in the Wild (LFW) dataset. This dataset provides a diverse collection of face images, making it an ideal benchmark for testing the robustness and accuracy of face recognition algorithms.

3.1 DATASET

Celebrity images were sourced from a labeled Faces in the Wild dataset. This dataset contains images of 18 Hollywood celebrities with 100 images of each celebrity. The dataset includes variations in lighting, pose, and facial expressions, providing a comprehensive testbed for evaluating face recognition systems.

3.2 PERFORMANCE METRICS

The assessment performance of this face recognition system using metrics such as accuracy, precision, recall, and F1-score. These metrics provide a detailed evaluation of the classifier's effectiveness in identifying and verifying individuals.

3.3 RESULTS AND DISCUSSION

Table1 presents the proposed method achieved an accuracy of 80% on the LFW dataset. The use of HOG features provided a robust representation of facial structures, while the Haar Cascade Classifier ensured

precise face detection. The SVM classifier effectively separated different individuals, demonstrating the system's high classification capability.

Table 1. Performance evaluation to f-score on the LFW dataset.

SVM Classification report with face detection:

	precision	recall	f1-score	support
Nicole Kidman	0.76	0.76	0.76	25
Sandra Bullock	0.68	0.85	0.76	20
Tom Hanks	0.79	0.93	0.85	28
Scarlett Johansson	0.79	0.95	0.86	59
Megan Fox	0.77	0.71	0.74	24
Leonardo DiCaprio	0.88	0.82	0.85	34
Natalie Portman	0.83	0.77	0.80	26
Robert Downey Jr	0.73	0.84	0.78	19
Tom Cruise	0.95	0.83	0.89	24
Will Smith	0.73	0.84	0.78	19
Jennifer Lawrence	0.94	0.61	0.74	28
Johnny Depp	0.69	0.76	0.72	29
Brad Pitt	0.93	0.86	0.89	29
Kate Winslet	0.85	0.57	0.68	30
Angelina Jolie	0.69	0.80	0.74	25
Hugh Jackman	0.96	0.85	0.90	27
Denzel Washington	0.83	0.80	0.82	25
accuracy			0.80	471
macro avg	0.81	0.80	0.80	471
weighted avg	0.82	0.80	0.80	471

4. Conclusion

This paper presents an effective method for face recognition that integrates HOG features, Haar Cascade Classifier, and SVM. The experimental results on the LFW dataset demonstrate that our proposed approach achieves high accuracy and reliability. Future work will focus on optimizing the system for real-time applications and exploring the integration of deep learning techniques to further enhance performance.

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Biyopolimerler ve Önemi

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Özet **–** Biyopolimerler, son yüzyılda önemli hale gelmiştir. Özellikle petrol türevli termoplastiklerin kullanım yaygınlığı çevresel kaygıları da beraberinde getirmiştir. Bu sebeple araştırmacılar daha çevreci polimerler üzerine araştırmalar yürütmektedir. Biyopolimerler çevre dostu ve sürdürülebilir malzemeler olması sebebiyle son yıllarda ümit vadeden polimerler haline gelmiştir. Biyopolimerler, çevre dostu özelliklere sahip olup doğal kaynaklardan türetilen fonksiyonel malzemelerdir. Bu polimerler genellikle biyolojik materyallerden kimyasal yollarla sentezlenir veya canlı organizmalar tarafından biyosentezlenir. Geliştirilme amaçları arasında çevresel etkileri azaltmak ve fosil yakıtlara olan bağımlılığı düşürmek yer alır.

Biyopolimerler üç ana sınıfa ayrılır: polinükleotidler, polipeptidler ve polisakkaritler. Bu sınıflar, yapı taşlarının türü, aralarındaki bağlar ve konformasyonel ilkeler gibi özelliklere göre incelenir. Biyopolimerler, geniş bir endüstri yelpazesinde kullanılır. Gıda endüstrisinde ambalaj malzemesi olarak, tıbbi alanda ise yara iyileştirici malzemeler, ilaç taşıyıcıları ve biyomedikal hidrojel yapımında kullanılırlar. Çevre dostu ve biyobozunur özellikleri, biyopolimerleri sentetik polimerlere kıyasla daha cazip kılar.

Biyopolimerlerin üretim yöntemleri çeşitlilik gösterir. Bu yöntemler arasında mikrobiyal üretim, organik atıklardan üretim, enzimatik ve metabolik mühendislik, alglerden üretim, çift biyopolimer üretim stratejileri, elektro-kimyasal sistemler ve ışınlama teknikleri bulunur. Bu yöntemler, biyopolimer üretiminde maliyetleri düşürürken çevresel sürdürülebilirliği de artırmaktadır. Bu çalışmada biyopolimerler hakkında genel bilgiler verilerek önemi vurgulanmıştır.

Anahtar Kelimeler – Biyopolimer, çevre dostu, kimyasal sentez, fosil yakıt, biyobozunur

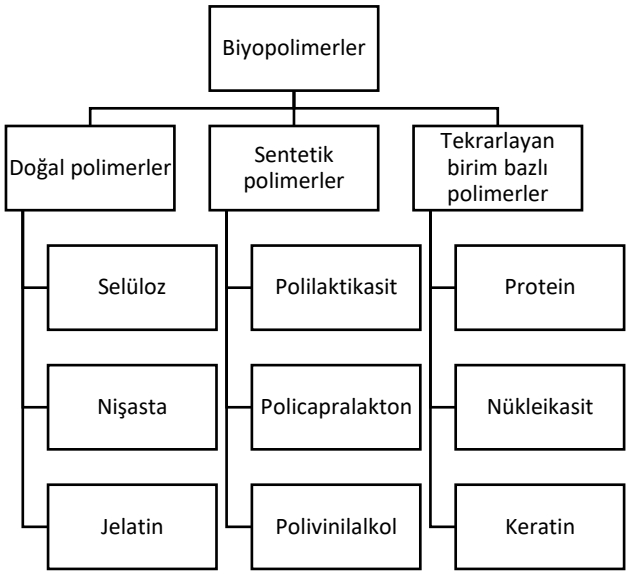
I. GİRİŞ

Biyopolimerler, doğal kaynaklardan üretilen ve yüksek değerli uygulamalar için uygun olan fonksiyonel malzemeler sınıfının önde gelen örneklerindendir. Genellikle biyolojik materyallerden kimyasal olarak sentezlenirler veya tamamen yaşayan organizmalar tarafından biyosentezlenirler (Tablo 1) [1]. Biyopolimerler, çevresel etkileri azaltmak ve fosil yakıtlara olan bağımlılığı azaltmak amacıyla sentetik polimerlerin yerini almak üzere geliştirilmiştir (Şekil 1) [2].

Biyopolimerler genel olarak üç ana sınıfa ayrılır: polinükleotidler, polipeptidler ve polisakkaritler. Bu polimer sınıfları, yapı taşlarının doğası, aralarındaki bağlar, konformasyonel ilkeler ve tekrar eden (sekonder) yapı türleri gibi temel özellikler açısından incelenir [3]. Polinükleotidler, DNA ve RNA gibi genetik materyallerden oluşurken; polipeptidler, proteinlerin temel yapı taşlarıdır. Polisakkaritler ise selüloz, nişasta ve kitin gibi karbonhidratlardan meydana gelir [4].

Biyopolimerler, gıda, tıp ve eczacılık gibi çeşitli endüstrilerde geniş bir kullanım yelpazesine sahiptir. Gıda endüstrisinde biyopolimerler, ambalaj malzemeleri olarak kullanılırken, tıbbi alanda yara iyileştirici malzemeler, ilaç taşıyıcıları ve biyomedikal hidrojel yapımında kullanılırlar [5], [6].

Biyopolimerlerin sürdürülebilirliği ve çevre dostu özellikleri, onları fosil yakıtlara dayalı polimerlere göre daha cazip kılar. Bu özellikleri, biyopolimerlerin yenilenebilir kaynaklardan elde edilebilmesi ve biyobozunur olmaları ile ilişkilidir [7]. Ayrıca, biyopolimerlerin çeşitli kimyasal modifikasyonlar ile işlevselliği artırılabilir ve bu da onları daha geniş uygulama alanları için uygun hale getirir [8].



Şekil 1. Orijinlerine göre biyopolimerlerin sınıflandırılması [1]

Tablo 1. Örnek bir tablo

Biyopolimerler	Avantajları	Dezavantajları	**Referans**
Doğal Biyopolimerler	Biyolojik olarak yenilenebilir, biyolojik olarak parçalanabilir, biyouyumlu, toksik olmayan, biyoyapışkan malzeme, biyofonksiyonel	Daha az kararlı, düşük erime noktası, yüksek yüzey gerilimi, yapısal olarak daha karmaşık.	[9]
Sentetik Biyopolimerler	Biyouyumluluk, daha yüksek tekrarlanabilirlik, daha iyi mekanik ve kimyasal kararlılık	Daha az kararlı, düşük erime noktası, yüksek yüzey gerilimi, yapısal olarak daha karmaşık.	[10]

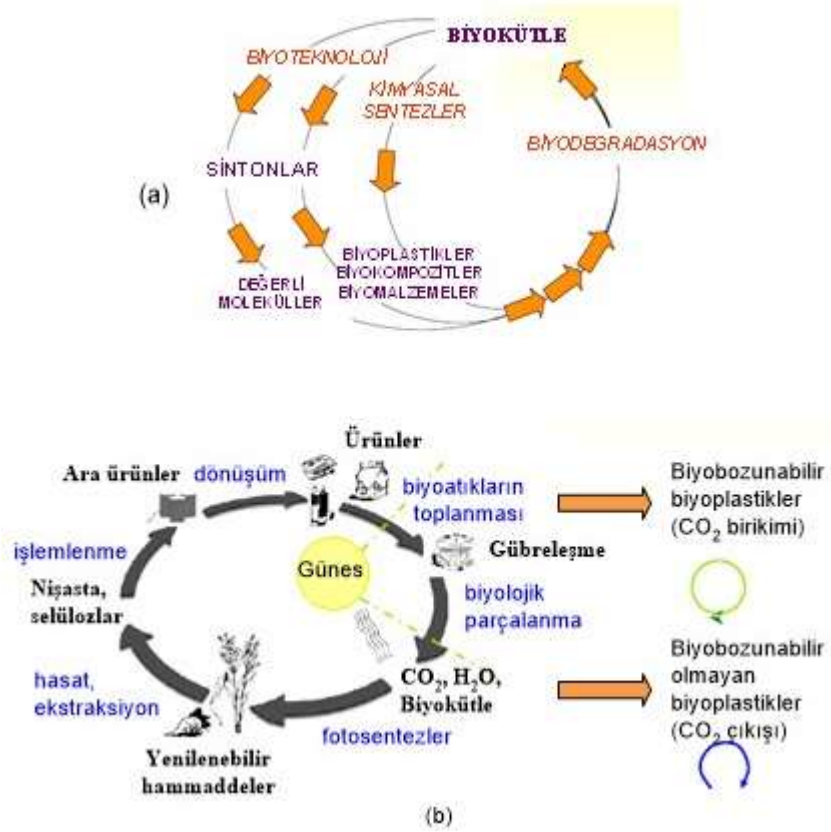
II. BİYOPOLİMERLERİN ÜRETİM YÖNTEMLERİ

Biyopolimerler, doğal kaynaklardan elde edilen ve biyolojik olarak parçalanabilen polimerlerdir. Bu polimerlerin üretim yöntemleri, kimyasal sentezden mikrobiyal fermantasyona kadar çeşitli teknikler içermektedir.

A. Mikrobiyal Üretim

Mikrobiyal üretim, biyopolimerlerin elde edilmesinde yaygın bir yöntemdir. Mikroorganizmalar, polihidroksialkanoatlar (PHA) gibi biyopolimerleri sentezleyerek enerji ve karbon depolama bileşenleri olarak kullanırlar. Bu biyopolimerlerin üretim süreci, genetik mühendislik ve biyoteknolojik yöntemlerle optimize edilebilir [11]. Aynı şekilde, Rhizobium türleri gibi mikroorganizmalar, düşük mannitol konsantrasyonları ve düşük karıştırma ve havalandırma koşulları altında biyopolimer üretebilirler [12].

Biyokütle ve biyoplastikler arasındaki döngü ve biyobazlı plastiklerin yaşam çevrimi Şekil 2'de gösterilmiştir.



Şekil 2. Ürünlerin yaşam çevrimi, (b) biyobazlı plastiklerin yaşam çevrimi [13]

B. *Organik Atıklardan Üretim*

Organik atıklardan biyopolimer üretimi hem çevresel sürdürülebilirliği artırır hem de maliyetleri düşürür. Örneğin, deri ve kürk endüstrisinden gelen organik atıklardan biyopolimer üretimi, teknolojik döngüyü optimize ederek üretim süresini önemli ölçüde kısaltabilir [14].

C. *Enzimatik ve Metabolik Mühendislik*

Enzimatik ve metabolik mühendislik, mikrobiyal biyopolimerlerin üretiminde önemli bir rol oynar. Bu yöntemler, mikroorganizmaların metabolik yollarını değiştirerek yeni ve işlevsel biyopolimerlerin üretilmesini sağlar [15]. Ayrıca, rekombinant cationic biyopolimerlerin üretiminde genetik mühendislik teknikleri kullanılmaktadır [16].

D. *Alglerden Üretim*

Algler, biyopolimer üretiminde önemli bir kaynak olarak görülmektedir. Algler, yüksek büyüme hızı ve atık su içinde yetiştirilebilme avantajları ile dikkat çekerler. Alglerden biyopolimer üretimi, geleneksel solvent ekstraksiyon yöntemlerine kıyasla daha verimli olan mikrodalga destekli ve ultrasonik ekstraksiyon gibi yenilikçi yöntemler kullanılarak gerçekleştirilebilir [17].

E. *Çift Biyopolimer Üretim Stratejileri*

Çift biyopolimer üretim stratejileri, maliyetleri düşürmek amacıyla geliştirilmiştir. Örneğin, Bacillus subtilis kullanılarak hem P(3HB) hem de γ-PGA üretimi, tek bir partiden iki biyopolimerin elde edilmesini sağlar [18].

F. Elektro-kimyasal Sistemler

Biyo-elektro-kimyasal sistemler, biyopolimer üretiminde yenilikçi bir yaklaşımdır. Bu sistemler, atık suyu işleyerek elektrik üretir ve aynı zamanda değerli kimyasallar ve biyopolimerler elde eder (Tablo 2) [19].

Tablo 2. Biyo elektrokimyasal yöntem ile üretilen biyoplastikler

Alt Madde	Arıtma Tipi/Reaktör	Biyopolimer Tipi	İnokulum/Kültür	Biyopolimer Verimi	Referans
Belediye katı atıkları	Parti işlemi	Polihidroksialkanoat	Karışık mikrobiyal kültür	0.24g kuru PHA/L/saat	[20]
Sentetik atıksu	Bakteriyel arıtma	Polihidroksialkanoat	Hydrogenophaga palleroni	30 mg/L	[21]
Belediye atıksu	Sekansiyel kesikli reaktörler	Polihidroksialkanoat	Karışık mikrobiyal kültür	%49	[22]
Sentetik atıksu	Bakteriyel arıtma	Polihidroksialkanoat	Serratia sp.	0.3368±0.13 g/L	[23]
Belediye ikincil atıksu	-	Polihidroksialkanoat	Karışık mikrobiyal kültür	0.605 g	[24]
Belediye ikincil atıksu çamuru	-	Polihidroksibutirat	Karışık mikrobiyal kültür	-	[25]
Zeytinyağı fabrikası atık suyu	Sekansiyel kesikli reaktör	Polihidroksibutirat	Karışık mikrobiyal kültür	%74±8	[26]
Peynir altı suyu atık suyu	-	Polihidroksibutirat	Bacillus sp. CYR1	151 mg/L	[27]

G. Işınlama Teknikleri

Işınlama teknikleri, biyopolimerlerin üretimi ve modifikasyonu için kullanılan bir diğer yöntemdir. Bu yöntem, polimerlerin kimyasal saflığını artırır ve biyolojik işlevselliğini geliştirir [28].

III. KULLANIM ALANLARI GELECEĞİ VE GELİŞİM POTANSİYELİ

Biyopolimerler, çevre dostu ve biyolojik olarak parçalanabilir özellikleri nedeniyle geniş bir uygulama yelpazesine sahiptir. Günümüzde biyomedikal, gıda ambalajı, enerji depolama, su arıtma ve tarım gibi birçok alanda kullanımları artmaktadır. Biyopolimerler, biyouyumluluk ve düşük toksisite özellikleri sayesinde doku mühendisliği, yara iyileşmesi ve ilaç taşıma sistemlerinde yaygın olarak kullanılmaktadır [29]. Polimer kaplamalar, biyomedikal cihazların yüzey özelliklerini iyileştirerek hücre proliferasyonunu ve doku büyümesini teşvik etmektedir [30]. Biyopolimerler, gıda endüstrisinde geleneksel plastiklerin yerine geçerek çevresel etkiyi azaltmakta ve gıda güvenliğini artırmaktadır [31]. Ayrıca, bu polimerler gıda paketleme malzemeleri olarak kullanıldığında antimikrobiyal ve antioksidan özellikler sunmaktadır. Biyopolimerler, lityum ve çinko bazlı bataryalar ile kapasitörlerde sürdürülebilir malzemeler olarak kullanılmaktadır [32]. Bu polimerler, enerji yoğunluğunu artırmak ve toksik metallerin sızıntısını önlemek için kullanılır. Biyopolimerler, su arıtma ve atık su arıtma süreçlerinde koagülant ve flokülant olarak kullanılmaktadır [33]. Bu polimerler, biyobozunur ve çevre dostu olmaları nedeniyle tercih edilmektedir. Biyopolimerler, tarımda gübreler, su tutucu maddeler ve biosensörler olarak kullanılmaktadır [34].

Biyopolimerlerin geleceği, çevresel sürdürülebilirlik ve yenilikçi teknolojilerle birleştiğinde parlak görünmektedir. Mikroalgler ve bakteri kaynaklı biyopolimerler gibi yenilikçi kaynaklar, biyoplastik

üretiminde büyük potansiyele sahiptir [35]. Ayrıca, biyopolimerler için iyonik sıvıların kullanımı, ilaç ve gen taşıma sistemlerinde yeni çözümler sunmaktadır [36].

3D baskı teknolojisi, biyopolimerlerin karmaşık yapılar oluşturmasını sağlayarak tıbbi ve gıda alanlarında kullanım potansiyelini artırmaktadır [37]. Sonuç olarak, biyopolimerlerin geniş kullanım alanları ve çevre dostu özellikleri, gelecekte daha fazla araştırma ve uygulama alanı bulacaklarını göstermektedir.

IV. SONUÇ VE ÖNERİLER

Biyopolimerler, doğal kaynaklardan türetilen ve çevre dostu özellikleriyle öne çıkan fonksiyonel malzemelerdir. Sentetik polimerlere sürdürülebilir bir alternatif sunan biyopolimerler, kimyasal sentez, mikrobiyal fermantasyon, enzimatik ve metabolik mühendislik gibi çeşitli yöntemlerle üretilebilir. Biyopolimerlerin üretim yöntemleri, çevresel sürdürülebilirlik ve ekonomik verimlilik açısından önemli avantajlar sunmaktadır. Özellikle organik atıklardan üretim ve mikroalgler gibi yenilikçi kaynakların kullanımı, bu polimerlerin üretiminde maliyetleri düşürmekte ve çevresel etkileri azaltmaktadır.

Biyopolimerlerin geniş kullanım alanları, onların fonksiyonel ve sürdürülebilir özellikleriyle doğrudan ilişkilidir. Tıp ve eczacılık alanında biyopolimerler, biyouyumluluk ve düşük toksisite özellikleri sayesinde yara iyileşmesi, ilaç taşıma sistemleri ve doku mühendisliği gibi uygulamalarda yaygın olarak kullanılmaktadır. Bu alandaki araştırmalar, biyopolimerlerin biyomedikal cihazlar için yüzey kaplaması olarak kullanılabileceğini ve hücre proliferasyonunu teşvik edebileceğini göstermektedir. Gıda endüstrisinde ise biyopolimerler, geleneksel plastiklerin yerine geçerek ambalaj malzemesi olarak kullanıldığında antimikrobiyal ve antioksidan özellikler sunmaktadır. Bu da gıda güvenliğini artırmakta ve çevresel etkileri azaltmaktadır.

Enerji depolama ve su arıtma gibi alanlarda da biyopolimerlerin kullanımı giderek artmaktadır. Lityum ve çinko bazlı bataryalarda biyopolimerler, enerji yoğunluğunu artırmak ve toksik metallerin sızıntısını önlemek için kullanılmaktadır. Su arıtma süreçlerinde ise biyopolimerler, koagülant ve flokülant olarak görev alarak çevre dostu ve biyobozunur çözümler sunmaktadır. Tarımda biyopolimerler, gübreler, su tutucu maddeler ve biosensörler olarak kullanılarak bitki büyümesini ve verimliliği artırmaktadır.

Biyopolimerlerin geleceği, yenilikçi teknolojiler ve sürdürülebilirlik hedefleri doğrultusunda parlak görünmektedir. 3D baskı teknolojisi, biyopolimerlerin karmaşık yapılar oluşturmasını sağlayarak tıbbi ve gıda alanlarında kullanım potansiyelini artırmaktadır. Mikroalgler ve bakteri kaynaklı biyopolimerler gibi yenilikçi kaynaklar, biyoplastik üretiminde büyük potansiyele sahiptir. Ayrıca, biyopolimerlerin kimyasal modifikasyonları ve iyonik sıvıların kullanımı, ilaç ve gen taşıma sistemlerinde yeni çözümler sunmaktadır.

Sonuç olarak, biyopolimerler çevresel sürdürülebilirlik, ekonomik verimlilik ve geniş uygulama alanları açısından büyük bir potansiyele sahiptir. Bu nedenle, biyopolimerler üzerine yapılan araştırmaların ve geliştirilen teknolojilerin artarak devam etmesi, daha çevre dostu ve sürdürülebilir bir geleceğe katkıda bulunacaktır. Biyopolimerlerin kullanımının yaygınlaşması, fosil yakıtlara bağımlılığı azaltarak çevresel etkileri minimize edecek ve yenilikçi çözümler sunacaktır. Biyopolimerlerin gelecekte daha fazla araştırma ve uygulama alanı bulacağına şüphe yoktur, bu da onların sürdürülebilir kalkınma ve çevre koruma hedeflerine katkı sağlayacağını göstermektedir.

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Karışık Meyve Sularında Pestisitler ve Sağlık Riski Değerlendirmesi

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Özet **–** Nüfus artışına bağlı olarak gerekli gıda ihtiyacını karşılamak için her yıl tarımsal verimliliği artırmak için pestisit kullanımı da artmaktadır. Bitki ve ürünleri korumak için yirmi bin pestisit ve karışımlarından oluşan ticari ürün mevcuttur. Düşük dozlarda dahi uzun süre pestisitlere maruz kalmak olumsuz sağlık etkilerine neden olabilir. Kısa sürede mide bulantısı ve baş ağırsı gibi etkileri bulunan pestisitler kronik maruziyet durumunda nörotoksisite, sitogenetik hasar, kısırlık, endokrin bozulması ve kanser oluşumuna neden olabilir. Gıdalardaki pestisit kalıntılarının insan sağlığı açısından kabul edilemez bir risk oluşturmamasını sağlamak için pestisitlerin kullanımı sıkı bir şekilde düzenlenmektedir. Ülkemizde de Türk Gıda Kodeksi Pestisitlerin Maksimum Kalıntı Limitleri Yönetmeliği kapsamında belirli gıdalarda yasal olarak izin verilen maksimum pestisit kalıntısı konsantrasyonları belirlenmiştir. Ülkemizde meyve ve sebzelerde pestisit kalıntıları üzerine birçok araştırma gerçekleştirilmiştir. Ancak özellikle çocukların sıklıkla tükettiği meyve sularında pestisit kalıntıları ve sağlık riski üzerine sınırlı sayıda araştırma vardır. Meyve yetiştiriciliğinde verim ve ürün kalitesini artırmak için yaygın olarak kullanılan pestisitler doğal yollarla parçalanmaz ise meyve posası ve meyve suyunda kalmaktadır. İçecek sektöründe sıklıkla tüketilen meyve suları özellikle çocuklar tarafından daha çok tüketilmektedir. Meyve suyunda bulunan pestisitler yetişkinler ve özellikle çocuklar için potansiyel sağlık riski sergilemektedir. Çalışma kapsamında piyasada satışa sunulan farklı markalara ait karışık meyve suyu örneklerinde 325 pestisitin kalıntısı araştırılmıştır. Tespit edilen pestisit kalıntı değerleri Türk Gıda Kodeksi Pestisitlerin Maksimum Kalıntı Limitleri Yönetmeliği göre değerlendirilmiştir. Tespit edilen pestisitlerin yetişkin ve çocuk için sağlık risk değerlendirmesi gerçekleştirilmiştir. Karışık meyve suyu örnekleri QuEChERS (Quick, Easy, Cheap, Effective, Rugged, and Safe) metoduna göre ekstrakte edildikten sonra LC-MS/MS ve GC-MS/MS cihazları ile pestisit okumaları gerçekleştirilmiştir. Analizleri gerçekleştirilen meyve sularında insektisit ve fungisit grubunda beş farklı pestisit türü tespit edilmiştir. Tespit edilen pestisitler yetişkinler için akut ve kronik sağlık riski oluşturmazken, chlorpyrifos pestisitinin çocuklar için akut ve kronik sağlık riski sergilediği tespit edilmiştir.

Anahtar Kelimeler – Pestisit, meyve suyu, gıda, insan sağlığı, sağlık riski.

I. GİRİŞ

Pestisit meyve ve sebzeleri yetiştirirken bakteri, virüs ve haşerelerin zararlı etkilerinden korumak amacıyla kullanılan kimyasal maddelerdir. Pestisitler yetiştirilen ürünlerin zararlılar ve bitki hastalıklarından korunması, ürün kalite ve miktarının artırılması amacıyla modern tarım uygulamalarında yaygın olarak kullanılmaktadır. Pestisitler kullanıldıkları alana göre gruplandırılabilir. Böcek ve haşerelere karşı kullanılanları insektisit, istenmeyen ot ve bitkilere karşı kullanılanları herbisit, kemirgenlere karşı kullanılanları redontisit, bakterilere karşı kullanılanları ise bakterisit olarak isimlendirilir. Pestisitler tarım ürünleri ve gıdalarda yanlış uygulamalar neticesinde kalıntı olarak kalabilir ki bu durum istenilmeyen insan sağlığı ve çevre kirliliği problemlerine neden olabilir. Pestisitlere maruz kalmanın sağlık riskleri arasında akut zehirlenmeler, mide bulantısı, baş ağrısı, alerjik reaksiyonlar,

kronik maruziyetlerde ise nörotoksisiteye, sitogenetik hasara, kısırlığa, endokrin bozulmasına ve kanser oluşumuna neden olabilir. Pestisitlerin uygulamaları esnasında toprak, hava ve su kirliliği problemlerine neden olabilir. Ayrıca pestisitler doğal yaşam alanlarının kirlenmesi ve bazı canlı türlerinin yok olmasına neden olarak biyoçeşitliliğin azalmasına neden olabilir [1], [2].

Gıda da pestisit kalıntıları, risk değerlendirmesi açısından yüksek öncelikli gıda kaynaklı tehlikeler olarak tanımlanmaktadır. Bu amaçla gıdalarda kalıntı pestisitler mevzuata uygunluk açısından izleme çalışmaları gerçekleştirilmektedir. Kanserojen olmayan etkiler için maruziyet toksikolojik referans değerlere göre değerlendirilir. Akut toksisite akut referans doza (ARfD), kronik toksisite ise kabul edilebilir günlük alım miktarına (ADI) göre değerlendirilir. Birden fazla kimyasala maruz kalma kümülatif toksisiteye neden olabilir [3]. Gıdalardaki pestisit kalıntılarının insan sağlığı açısından kabul edilemez bir risk oluşturmamasını sağlamak için pestisitlerin kullanımı sıkı bir şekilde düzenlenmektedir. Pestisit ürünlerinin piyasaya sürülmesi için ruhsatlı olması ve aktif maddelerin sağlık ve çevresel risk değerlendirmelerini de içeren yoğun bir değerlendirme yoluyla onaylanması gereklidir. Bu amaçla Avrupa Komisyonu (EC), 1107/2009 sayılı yönetmeliği kabul etmiş olup, belirli gıdalarda yasal olarak izin verilen pestisit kalıntılarının maksimum konsantrasyonları (MRL) 396/2005 sayılı Yönetmelik kapsamında belirlenmiştir [1], [4]. Ülkemizde bitkisel ve hayvansal ürünler ile bu ürünlerden elde edilen ürünlerde pestisit kalıntılarının maksimum limitlerine ilişkin usul ve esaslar ise Türk Gıda Kodeksi (TGK) Pestisitlerin Maksimum Kalıntı Yönetmeliği 25 Kasım 2016 yılında yayınlanarak yürürlüğe girmiştir [5].

Ülkemizde pestisit kullanım miktarları ile ilgili gerçekleştirilen derleme çalışmasında 2020 yılına ait TÜİK pestisit kullanım verileri kullanılarak değerlendirmelerde bulunulmuştur. 2020 yılı TÜİK verilerine göre ülkemizde 53000 ton pestisit kullanılmaktadır. Bunun yaklaşık %38'i fungisit, %25'i herbisit, %23'ü insektisit, %4'ü akarisit, kalanı ise diğer pestisitlerdir. Ülkemizde en çok pestisit kullanımının Akdeniz Bölgesinde ve Antalya ilinde en az ise Karadeniz Bölgesinde Ardahan ilinde gerçekleştiği tespit edilmiştir. En çok kullanılan pestisit grubunun ise fungisit, herbisit ve insektisit grubu pestisitler oluşturmuştur. Konya'da en yoğun pestisit kullanılan ilk on il arasında yer alıp, Konya ilinde ise en yoğun kullanılan pestisit grubunun herbisitler %42.3) olduğu bunun sebebinin ise yoğun hububat üretimi olduğu düşünülmektedir. Sebze ve meyve üretiminin yoğun gerçekleştiği Antalya, Manisa, Mersin, Aydın, Malatya ve Çanakkale illerinde ise en yüksek pestisit kullanımı fungisit grubunda görülmektedir [6].

Tözün ve Akar [7] tarafından 2010 yılı sonrasında ülkemizdeki gıda numunelerinde tespit edilen pestisit kalıntıları ile ilgili çalışmalar derlenmiştir. Toplamda 35 çalışma gerçekleştirildiği, 16 çalışmada pestisit kalıntısı tespit edildiği ve tespit edilen değerlerin TGK Pestisitlerin Maksimum Kalıntı Yönetmeliği'nde belirtilen MRL değerini aştığı; 10 çalışmada pestisit kalıntısı bulunduğu ancak MRL değerlerinin aşılmadığı tespit edilmiştir. Çalışmada üzüm, çilek, turunçgiller ve sık tüketilen bazı sebzelerde pestisit kalıntısı fazlaca çalışılmıştır ve pestisit kalıntısına rastlanmıştır. Şeftaliden elde edilen meyve sularında bazı organik fosforlu pestisitlerin araştırıldığı çalışmada deterjanla meyvelerin kısa ve uzun süre yıkama işleminin kalıntı azalması sağladığı, haşlama işleminin ise %22-90 arasında kalıntı azaltımı sağladığı, gushation, malathion, malaoxon, dipterex pestisitlerinin içtiğimiz meyve sularında tolerans değerlerinin altındaki miktarlarda tespit edildiği rapor edilmiştir [8]. Ege Bölgesinde yetiştirilen çilek, kiraz, şeftali, üzüm meyvelerinde en az bir pestisit tespit edilmiştir [9]. Konya'da market ve pazarlardan toplanan üzüm, çilek, elma, armut, ayva, portakal, mandarin, altın top, muz, kivi, incir, nar, altın çilek, pepino, pasifulora meyvelerinde pestisit kalıntısı araştırılmış ve kullanımı yasak olan chlopyrifos'un portakal, mandarin, altın topun birer örneklerinde tespit edilmiştir. Aynı altın top örneğinde kullanımı yasaklanmış diazinon, pyrimippos ethylin'in tespit edildiği, mandarin örneklerinden birinde kullanımı yasak olan chlorpyriphose, diazinon ve primiphos ethyl'in olduğu tespit edilmiştir. Muz örneklerinin üç tanesinde kullanımı yasaklanmış thiabendazol'ün olduğu tespit edilmiştir. Elma, armut ve ayva örneklerinde kullanımı yasak olan thiabendazol, chlorpyrifos, amitraz kalıntısı tespit edilmiştir. Yaş üzüm örneklerinde ülkemizde kullanımı yasak olan acetamiprid, çilek örneklerinde chlorpyrifos, kirazda monocrotophos, şeftalide chlorpyrifos kalıntısı tespit edilmiştir [10], [11], [12] – [13].

Gıdalarda pestisit kalıntısının sağlık riski oluşturması sebebiyle Sırbistan'da satışa sunulan 139 meyve suyu örneğinde araştırılan 69 pestisit türünden 19 aktif madde tespit edilmiştir. Carbendazim, acetamiprid ve pyrimethanil pestisitleri sıklıkla tespit edilmiştir. Numunelerin yaklaşık %3'ünde onaylanmamış pestisit kalıntısı tespit edilirken, izin verilen maksimum limit değerine uymayan numune yüzdesi yaklaşık %2'dir. Meyve suyunda kanserojenik pestisitlerden kaynaklanan yaşam boyu kanser riski tahmini yılda toplam 0.0.13 ek kanser vakasına karşılık gelmektedir [14].

Ülkemiz önemli miktarda meyve ve sebze üretiminin yapıldığı bir tarım bölgesidir. TÜİK verilerine göre 2023 yılında Türkiye yaş meyve üretiminde 24 milyon ton ile dünyada meyve üretiminde dördüncü sırada yer almıştır. Üzüm, muz, incir, kivi, avakado, portakal, mandalina, limon, turunçgil, armut, erik, kiraz, çilek, nar bu üretimde önemli miktarda yer almaktadır [15]. Ülkemizde elma, kayısı, vişne, kayısı/şeftali, narenciye, üzüm, nar ve havuç meyvelerinden meyve suyu üretilmektedir. Bunlar %100 meyve suyu, meyve nektarı, meyveli ve aromalı içecekler olarak satışa sunulmaktadır. 2010 yılı verilerine göre kişi başına ülkemizde meyve suyu ve benzeri ürün tüketimi 12 litre civarında olup bunun yaklaşık 9 litresini %100 meyve suyu ve nektarı oluşturmaktadır [16]. Özellikle çocukların meyve suyu tüketim oranının yetişkinlere göre daha yüksek olduğu tahmin edilmektedir. Bu çalışmanın amacı ülkemizde marketlerde karışık meyve suyu adı altında satışa sunulan meyve sularında farklı pestisit türlerinin kalıntı düzeyini araştırmak, tespit edilen miktarlar için TGK Pestisitlerin Maksimum Kalıntı Yönetmeliği'ne göre değerlendirmelerde bulunmak ve elde edilen sonuçların yetişkin ve çocuk için risk değerlendirmesini gerçekleştirmektir.

II. MATERYAL VE YÖNTEM

A. Meyve Suyu Örneklerinin Temini

Ülkemizde meyve suyu üretimi TGK Meyve Suyu ve Benzeri ürünler Tebliği'ne göre üretilmektedir [17]. Tebliğ kapsamında yer alan ürünlerdeki pestisit kalıntıları miktarları ile ilgili TGK Pestisitlerin Maksimum Kalıntı Limitleri Yönetmeliğinde yer alan hükümlere uygun olmalıdır şartı vardır. Çalışmada incelenmek üzere marketlerden karışık meyve suyu olarak satışa sunulan 13 farklı meyve suyu örneği temin edilmiştir.

B. Pestisit Kalıntı Analizi

Meyve sularının ekstraksiyonu QuEChERS (Quick, Easy, Cheap, Effective, Rugged, and Safe) metoduna göre gerçekleştirilmiştir. QuEChERS metodu çoklu kalıntı pestisit analizi için kullanılan bir numune hazırlama tekniğidir. Numunede doğal olarak bulunan pigment, yağ ve diğer istenmeyen maddelerin numune matriksinden uzaklaştırılması ve pestisitler için daha düşük dedeksiyon limitlerine ulaşılmasını sağlar. Meyve suyu örneklerinden 5 g alınarak 7.5 g su ile homejen hale getirildikten 15 mL %1 asetik asit ihtiva eden asetonitril ilave edilerek ve 1 dk süresince kuvvetlice çalkalanmıştır. Böylece numunenin asetonitril içinde %1 asetik asit içeren bir çözücü ile çekilmesi sağlanmıştır. Karışım üzerine 6 g magnezyum sülfat ve 1,5 g sodyum asetat ilave edilerek, 1 dk süresince çalkalanmıştır ve 4000 rpm'de 5 dk santrifüjlenmiştir. Daha sonra, örneklerin üst fazından 4'er ml alınarak, magnezyum sülfat ve sodyum asetat eklenmesi ile oluşturulan sıvı-sıvı partisyon ile temizleme işlemi gerçekleştirilmiştir. Bunun için alınan kısım 15 ml'lik falkon tüplerine aktarılarak, üzerine 0.6 g magnezyum sülfat, 0,2 g primer sekonder amin ilave edilerek 1 dk süresince kuvvetlice çalkalama işlemi sonrasında 4000 rpm'de 5 dk santrifüjlenmiştir. Daha sonra üst faz viallere aktarılarak 325 pestisit kalıntısı için LC-MS/MS ve GC-MS/MS cihazları ile pestisit okumaları gerçekleştirilmiştir [18].

C. Risk Değerlendirmesi

Meyve sularında buluna pestisit kalıntılarının potansiyel tehlikenin belirlenmesi amacıyla risk değerlendirmesi gerçekleştirilmiştir. Bu amaçla tespit edilen pestisit kalıntıları için uzun süreli/kronik tüketici sağlık riski (Hazard Quotient, HQ) ve kısa süreli/akut tüketici sağlık riski (aHI) değerleri hesaplanmıştır. HQ değeri tahmini günlük alım (estimated daily intake, EDI) ve kabul edilebilir günlük alım (acceptable daily intake, ADI) kullanılarak hesaplanmıştır. EDI değeri ise günlük meyve suyu

tüketim miktarı, pestisit kalıntı miktarı ve tüketici ortalama vücut ağırlığı kullanılarak hesaplanmıştır [18].

EDI = (Pestisit kalıntı seviyesi x Meyve suyu tüketim miktarı) / (Tüketici vücut ağırlığı)
HQ = (EDI / ADI) x 100

aHI tahmini kısa vadeli alım (estimated short term intake, ESTI) ve akut referans doz (ARfD) değerleri kullanılarak bulunuştur. ESTI değeri ise günlük meyve suyu tüketim miktarı, pestisit kalıntı miktarı ve tüketici ortalama vücut ağırlığı kullanılarak hesaplanmıştır [18].

ESTI = (Pestisit kalıntı seviyesi x Meyve suyu tüketim miktarı) / (Tüketici vücut ağırlığı)
aHI = (ESTI / ARfD) x 100

Tespit edilen pestisitler için ARfD ve ADI değerleri Tablo 1'de verilmiştir.

Tablo 1. Pestisitler için ARfD ve ADI değerleri

Pestisit ismi	**ARfD**	**ADI**
Cypermethrin	0.04	0.02
Carbendazim	0.02	0.02
Chlorpyrifos	0.005	0.001
Imidacloprid	0.4	0.06
Pyriproxyfen	0.04	0.1

Hesaplamalarda ortalama yetişkin ağırlığı 73 kg, çocuk ağırlığı ise 32.7 kg alınmıştır. Günlük meyve suyu tüketim miktarı ise 0.345 kg alınmıştır [18].

Kanserojen olmayan risk (target hazardous quotient, THQ) EDI ve ADI değerlerinin oranıyla hesaplanmaktadır. THQ'nun toplamı toplam pestisit kirliliğinin karışımı tehlike indeksi (hazard indeks, HI) olarak tanımlanmaktadır.

THQ = EDI / ADI

$$HI = \sum_{k=1}^{i} THQ_n$$

THQ ve HI değerlerinin 1'den büyük olması riskin kabul edilemez olduğu göstermektedir.

III. BULGULAR

Tablo 2'de karışık meyve suyu örneklerinde tespit edilen pestisitlerin kalıntı miktarları, pestisit ismi ve türü verilmiştir. 7 numunede pestisit kalıntısı tespit edilmez iken 6 numune de ise insektisit ve fungisit sınıfında 5 farklı türde pestisit tespit edilmiştir. Tespit edilen pestisitler ile ilgili TGK Pestisitlerin Maksimum Kalıntı Limitleri Yönetmeliğinde MRL değeri bulunmamaktadır. Tespit edilen Cypermethrin değerleri 0,010±0,005 mg/kg ile 0,013±0,007 mg/kg aralığında tespit edilirken, Chlorpyrifos 0,010±0,005 mg/kg, Imidacloprid 0,043±0,022 mg/kg, Pyriproxyfen 0,010±0,005 mg/kg, Carbendazim 0,017±0,009 mg/kg olarak tespit edilmiştir. 10 nolu meyve suyu örneğinde tespit edilen toplam pestisit miktarı 0.0.93 mg/kg'dır [18].

Cypermethrin, Chlorpyrifos, Imidacloprid, Pyriproxyfen pestisitleri insektisit iken Carbendazim ise fungisit sınıfındadır. Cypermethrin tüm numunelerde tespit edilmiştir. Cypermethrin piretroid insektisit sınıfında bir insektisit olup böcek ve haşereleri öldürmek veya kontrol etmek amacıyla kullanılmaktadır. Ayrıca veterinerlik alanında da kullanımı vardır. Tarım ilaçlarında farklı konsantrasyonlarda etken madde olarak kullanılmaktadır.

Tablo 2. Karışık meyve sularında tespit edilen pestisit miktarları, pestisit ismi ve pestisit türü

Numune ismi	Kalıntı miktarı (mg/kg)	Pestisit ismi	Pestisit türü
Meyve suyu 1	0,010±0,005	Cypermethrin	İnsektisit
Meyve suyu 2	-	-	-
Meyve suyu 3	0,010±0,005	Cypermethrin	İnsektisit
Meyve suyu 4	-	-	-
Meyve suyu 5	-	-	-
Meyve suyu 6	0,011±0,006	Cypermethrin	İnsektisit
Meyve suyu 7	0,010±0,005	Cypermethrin	İnsektisit
Meyve suyu 8	-	-	-
Meyve suyu 9	-	-	-
Meyve suyu 10	0,017±0,009 0,010±0,005 0,013±0,007 0,043±0,022 0,010±0,005	Carbendazim Chlorpyrifos Cypermethrin Imidacloprid Pyriproxyfen	Fungisit İnsektisit İnsektisit İnsektisit İnsektisit
Meyve suyu 11	-	-	-
Meyve suyu 12	0,010±0,005	Cypermethrin	İnsektisit
Meyve suyu 13	-	-	-

- Dedeksiyon limitinin altında

Chlorpyrifos tarım ilaçlarında etken madde olarak kullanılan bir insektisit türü olup yaygın kullanılmaktadır. Avrupa Birliği tarafından ihraç edilen yaş ve kuru üzümlerde sağlık riski içerdiği için kalıntı limiti 50 kat daha düşürülmüştür. Imidacloprid haşerenin sinir sistemine zarar veren nitrometilen bazlı bir insektisit olup, bahçelerde ve hayvanlarda zararlıların kontrolünde kullanılmaktadır. Pyriproxyfen özellikle sivrisinek larvalarının kontrolünde kullanılan geniş spektrumlu bir insektisittir. Carbendazim pekçok bitki hastalığını kontrol için özellikle de külleme, yaprak lekeleri gibi mantar hastalıkları ile mücadelede kullanılan bir fungisittir. Meyve, sebze ve hububat üretiminde yaygın kullanılır. Hayvancılıkta bazı enfeksiyonların tedavisinde de kullanılmaktadır.

Tablo 3'de risk hesaplamaları sonucunda çocuk ve yetişkin için tespit edilen ESTI, EDI, aHI, HQ ve THQ değerleri verilmiştir. Tablo 3 incelendiğinde yetişkin için aHI ve HQ değerlerinin 1'den küçük çıktığı ve akut ve kronik risk içermediği görülmektedir. Çocuk için yapılan hesaplamalarda ise Chlorpyrifos pestisit için aHI değerinin 2.1101 HQ değerinin ise 1.0550 olduğu görülmektedir. Bu durumda tüketilen meyve sularında bulunan bu pestisitin çocuklar için hem akut hem de kronik risk sergilediği görülmektedir [18].

Tablo 3. Karışık meyve sularında çocuk ve yetişkin için risk değerlendirme sonuçları

Pestisit türü	Çocuk					Yetişkin				
	ESTI	EDI	aHI	HQ	THQ	ESTI	EDI	aHI	HQ	THQ
Cypermethrin	1,37E-04	6,75E-05	0,3429	0,3376	0,0034	6,14E-05	3,03E-05	0,1536	0,1512	0,0015
Carbendazim	1,79E-04	1,79E-05	0,8968	0,0897	0,0009	8,03E-05	8,03E-06	0,4017	0,0402	0,0004
Chlorpyrifos	1,06E-04	1,06E-05	**2,1101**	**1,0550**	0,0106	4,73E-05	4,73E-06	0,9452	0,4726	0,0047
Imidacloprid	4,54E-04	4,54E-05	0,1134	0,0756	0,0008	2,03E-04	2,03E-05	0,0508	0,0339	0,0003
Pyriproxyfen	1,06E-04	1,06E-05	0,2638	0,0106	0,0001	4,73E-05	4,73E-06	0,1182	0,0047	0,0001

IV. TARTIŞMA VE SONUÇLAR

Ülkemizde ve uluslararası alanda gerçekleştirilen birçok çalışmada meyvelerde pestisit kalıntıları tespit edilmiştir. Ayrıca sınırlı sayıda gerçekleştirilen araştırmada da meyve suyunda pestisit kalıntıları tespit edilmiştir. Güney Kore'de üretilen taze omija meyveleri ve omija sularında 33 farklı pestisit kalıntı analizi yapılmış ve EDI ve ADI değerleri hesaplanarak pestisitlerin risk değerlendirmesi gerçekleştirilmiştir. Ethoprophos, pendimethalin ve hexaconazole pestisitleri sıklıkla tespit edilmiş olup tespit edilen miktarların insan sağlığına zarar vermediği sonucuna varılmıştır. Bu çalışmada taranan pestisit sayısı bizim çalışmamıza göre düşük olup ayrıca çocuklar için risk değerlendirmesi sonuçları

yetişkinlere göre daha hassas olduklarından daha yüksek çıkabilir [19]. Berrak ve bulanık elma suyu üretimi ve depolama sırasında carbendazim, thiamethoxam, imidacloprid, acetamiprid, prochloraz ve difenoconazole pestisitlerinin kalıntı davranışları değerlendirilmiştir. Bulanık ve berrak elma meyve suyu üretiminde farklı proseslerin farklı etkilere sahip olduğu tespit edilmiştir. Yıkama ve presleme işlemlerinin pestisit kalıntısını %36 ile %89 arasında azalttığı tespit edilmiştir. Berrak meyve suyu üretiminde enzim, pastörizasyon, süzme işlemleri de kısmen pestisit kalıntısını azaltmıştır [20].

Konya da pazarlar ve marketlerden toplanan domates, biber, patlıcan örneklerinde 203 adet pestisit kalıntı düzeyinin belirlenmesine yönelik yapılan çalışmada patlıcan ve domates örneklerinde yasaklanmış oxamyl, 3 farklı patlıcan örneğinde inidiacloprid, biber örneğinde üç farklı pestisit türünün bulunduğu, 120 ug/kg benomyl-carbendazim'in TGK'nın tolerans değeri olan 100 ug/kg değerinin üzerinde olduğu tespit edilmiştir [21]. Konya bölgesinde yetiştirilen buğdaylarda klorlu ve fosforlu pestisit bulaşmış buğdaylarda tüketimin neden olduğu sağlık riski değerlendirilmiş, buğday örneklerinde yasaklanmış pestisitler tespit edilmiş ve buğday tüketimi nedeniyle akut ve kronik insan sağlığını etkileyici risk bulunduğu görülmüştür [22]. Konya bölgesindeki ticari sütlerde bulunan organoklorlu pestisit kalıntılarının incelendiği araştırmada 24 örneğin hemen hepsinde dieldrin, BHC bileşikleri, endosülfan bileşikleri, DDT bileşikleri ve aldrin olduğu tespit edilmiştir [23]. Konya da market ve pazarlardan toplanan kuruyemiş örneklerinde 227 adet pestisitin kalıntı düzeyleri araştırılmıştır. 162 numunenin 47'sinde en az 1 adet pestisit kalıntısına rastlanılmıştır. Pestisitlerin %25'inin yetişkinler için hem akut hem de kronik risk oluşturduğu görülmüştür. %35'inin çocuklar için hem akut hem de kronik risk oluşturduğu belirtilmiştir [24].

Tüm araştırma sonuçları gösteriyor ki biz pek çok gıda ile pestisit kalıntısını vücudumuza almaktayız. Bu nedenle sadece bir gıdada alınan miktar üzerinden yapılan değerlendirmeler yetersizdir. Tüm tüketilen gıdalar ile alınan pestisit kalıntısının kümülatifi üzerinden risk değerlendirilmesi yapıldığında daha pestisitlere karşı daha yüksek risk altında olduğumuz söylenebilir. Ülkemizde geçerli olan mevzuat kapsamında bazı meyve ve meyve suları ile ilgili TGK Pestisitlerin Maksimum Kalıntı Limitleri Yönetmeliğinde limit değerler tanımlanmıştır. Ancak günümüzde özellikle çocuklar tarafından sıklıkla tüketin karışık meyve suyu ile ilgili de yasal düzenlemelerin yapılması uygun olacaktır.

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Mathematical Modeling and Thin-Layer Drying Characteristics of Pre-Treated Breadfruit (*Artocarpus Altilis*) Chips

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Abstract – Drying operations reduce moisture content of food materials for avoidance of microbial growth and deterioration, for shelf life elongation, to minimize packaging and improving storage for easy transportation. Researches have shown that sole reliance on experimental drying practices without mathematical considerations for the drying kinetics, can significantly affect the efficiency of dryers, increase the cost of production, and reduce the quality of the dried product. The understanding of drying characteristics of food materials is very important for processing and adding value, and a thin layer drying study is a proven method for achieving this. In this study, changes in moisture content, moisture ratio, drying rate, effective diffusivity and shrinkage of pretreated breadfruit chips were investigated at three drying temperatures: 50, 60 and 70 °C following standard procedures. Five thin layer drying models suitable for predicting drying equation of high carbohydrate foods were selected for the study. Non-linear regression was used to establish the coefficient of determination (R^2), sum of square error (SSE) and root mean square error (RMSE) for each model to determine the model of the best fit. The logarithmic model was best suited in predicting the drying behaviour of pretreated breadfruit chips. The effective diffusivity and activation energy of pretreated breadfruit chips ranged from 0.106 x 10^{-6} to 9.910 x 10^{-6} m^2s^{-1} and 29.71 to 36.06 $kJmol^{-1}$, respectively. Thus, this study therefore provide information necessary for improved drying, processing and handling of breadfruit chips, thereby boosting the obtainable income from the value chain.

Keywords – Mathematical modeling; thin-layer drying; pre-treatment; breadfruit; chips

I. INTRODUCTION

Breadfruit, (*Artocarpus altilis*), belongs to the tree of the mulberry family (*Moraceae*) and bear an edible large fruit which serves as a staple food to the South Asia (Philippines, Malaysia, Singapore, Thailand and Vietnam) and the Pacific region [1]. Major producers of breadfruit are Canada, Peru, United States, Chiles, Netherlands and Mexico [2]. In Africa, its cultivation is mainly in West and Central Africa countries such as Tanzania, Zambia, Nigeria and Uganda [3]. However, the seedless and seeded plants (*Artocarpus communis and Artocarpus altilis*) are widely cultivated in the Southern Nigeria comprises of Lagos, Osun, Oyo, Ogun, Benin, Anambra, Abia and Cross River states for their seeds and fruits. In Nigeria, seedless breadfruit is regarded as the poor man's substitute for yam [4]. Breadfruits may be eaten ripe as fruit, fried, baked, steamed, boiled and made into pudding. It is a carbohydrate-rich staple food for centuries to many Islanders around the Oceania. It also contains other nutrients such as protein, minerals (calcium, phosphorus, iron, potassium) and vitamins though its nutritional composition changes with stages of ripening. Furthermore, breadfruit is gluten free and can be utilized in a variety of products to substitute or partially replace for wheat. Breadfruit yields in term of food have found to be superior to other starchy staples such as cassava and yam [5]. Despite the various uses of breadfruits, it is still regarded as

underutilized or neglected food due to social stigmatization (people believe it is food for slaves and the poor) [6]. Breadfruit deteriorates rapidly once harvested due to physiological changes, high moisture content and mechanical damage during its harvesting, transportation and handling. The very short storage life after harvest has been recognized as a great limitation to its cultivation. Due to its high level of perishability, growers prefer to convert the fruit into value-added products such as chips and flour so as to prolong the shelf life. Drying is one of the oldest means of food preservation. Recent advances in technology and competition among food processors have led to pre-treating of foods in order to conserve its nutrients during processing – blanching helps to inactivate enzymes that may lead to quality degradation and to improve the acceptability of the final product [7]. Blanching also leads to structural softening and hence facilitates moisture removal. Hot water blanching and the use of chemicals such as sulphur, methyl and ethyl ester emulsions or alkaline pre-treatment in aqueous solutions of sodium hydroxide, sodium chloride, potassium and sodium carbonate, calcium chloride have been applied to overcome the waxy or fibrous barrier on roots, fruits and vegetables [8]. Food is usually dried after being subjected to pre-treatment by cutting the fruit into slices and drying them in the open sun or in an air-dryer. Knowledge of the drying kinetics of biological materials is essential to the design, optimization and control of drying processes. Drying characteristics of some agricultural and food products such as tomato, yam, carrot, banana have been documented by many authors [9] In addition, several thin layer models have been proposed to explain the drying behavior of these agricultural and food products. These equations allow the prediction of the process parameter as a function of time at any point in the drying process based on the initial condition. Since industrial production of food products normally depend on artificial dryers, there is a need to investigate the drying kinetic of breadfruit slices under artificial dryer conditions. Therefore, this work focuses on drying kinetic of pretreated breadfruit slices under artificial dryer conditions in order to provide engineering data that will help in promoting its usage beyond present status.

II. Materials and Method

A. *Material Preparation*

Fresh and mature breadfruit used for this study was be obtained from *Iyanfoworogi* market, Ife East Local Government Area of Osun State and botanical classification was investigated at Herbarium Laboratory of Botany Department, Obafemi Awolowo University, Ile-Ife. The sample was washed in a plastic bowl to remove the sticky latex and dirt afterward; and peeled with the aid of stainless steel knife. Pulp obtained was sliced across its vertical dimension with thickness of about 5.0 mm using digital vennier caliper. The samples were divided into three portions: two of the samples were pretreated (blanching and dipping in sodium metabisulphite) before drying, while the third portion was used as the control (unpretreated sample).

B. *Sample Pretreatment*

The first portion of the sample was dipped in sodium metabisulphite ($Na_2S_2O_5$) solution (10g/1000ml) for 1 min. [10]; the second portion was steam-blanched for 1 min [11]; while the third portion was left untreated and serve as the control. After pretreatment, the samples were drained and spread in a thin layer form to dry the surface water at room temperature before drying. Afterward, the three samples were transferred into a dryer already set at different temperatures (50, 60, and 70 ºC) and the drying was monitored by gravity at an interval of 30 min till sample weight remained constant. Figure 1 shows the flow chart of breadfruit chips production.

Figure 1: Flow chart for production of breadfruit chips

C. *Thin Layer Drying*

The thin layer drying experiments were carried out at 50, 60 and 70 °C air temperature. Samples were spread in a thin layer form on a stainless steel drying trays and placed in the drying chamber. About 200 g of the sample on each tray was dried in a laboratory oven (SM 9023 Surgifriend Uniscope Laboratory digital oven). The dryer was allowed to run for 30 min. to reach the set drying air temperature. Prior to drying of sample, initial weights of the samples were measured by means of digital weighing balance (Mettler Toledo PB153 with an accuracy of $\pm$ 0.0001 g). Subsequently, the weight was monitored at interval of 30 min. until the sample weight remained constant. At this point, the sample was considered to have attained its equilibrium moisture content (EMC).

Moisture content determination: Moisture content of the sample was determined using [12]. Ground sample (10 g) was weighed using an electronic weighing balance (Mettler Toledo PB153 with an accuracy of $\pm$ 0.0001 g) and oven dry in a laboratory oven (SM 9023 Surgifriend Uniscope Laboratory digital oven) at 106 ºC for 6 h. and afterwards, allow to cool in a desiccator. The moisture content was determined using equation (1) and this was done in triplicate.

$$M.C_{(db)} = \frac{w_i - w_f}{w_f} \times 100 \qquad (1)$$

Where: $M.C\ (d.b)$ = Moisture content, %; w_i = initial sample weight before drying, g; w_f = final sample weight after drying, g.

D. *Determination of Drying Parameters:*

The drying parameters such as moisture loss at time t (%), moisture ratio, and drying rate (g/min) of the dried breadfruit chip were determined using standard procedures:

Moisture loss: Moisture loss at time t (%) of the breadfruit slices was determined from the weight loss data using equation 2 [13]:

$$M_t = \frac{W_i - W_f}{W_f} \quad (2)$$

Where: M_t (d.b) = moisture content at time t, (%); W_i = initial weight of sample, g; W_f = final weight of sample, g.

Moisture ratio: Moisture ratio (MR) of the breadfruit chips during the thin layer drying experiment was calculated using equation (3):

$$MR = \frac{M - M_e}{M_i - M_e} \quad (3)$$

Where: MR = Moisture ratio, dimensionless; M = moisture content of the sample, decimal d.b; M_i = initial moisture content of the sample, decimal d.b; M_e = equilibrium moisture content of the sample, decimal d.b

Drying rate: The drying rate which is the moisture loss in the breadfruit slices per the drying time was calculated by using equation 4 [13]:

$$DR = \frac{M_{t+dt} - M_t}{dt} \quad (4)$$

Where: DR = drying rate; M_t = mass at time t, M_{t+dt} = successive mass; dt = time interval.

The drying curves from the moisture ratio variation with drying time and drying rate curves from the drying rate variation with drying time of the different samples was obtained and used to explain the thin layer drying characteristics of the breadfruit slices.

E. *Model Fitting*

Five thin layer drying models (Table 1) suitable for predicting drying equation of high carbohydrate foods were selected.

Table 1: Mathematical models used for drying characteristic of pretreated breadfruit chips

Model name	Model equation	Reference
Newton	$MR = e^{-kt}$	Tongrul and Pehlivan, 2004
Page	MR = e^{-ktn}	Salau *et al.*, 2023
Logarithmic	MR = ae^{-kt} + c	Salau *et al.*, 2023
Henderson and Pabis	MR = ae^{-ktn}	Salau *et al.*, 2023
Modified page	MR = ne^{-kt}	Salau *et al.*, 2023

Modeling was exhibited through the regression wizard in the nonlinear regression drop down menu of the statistics tab of SigmaPlot for Windows Software Version 12.0 (Systat Software Inc., Chicago, IL, USA). The model which has the highest coefficient of determination (R^2) and the lowest root mean square error (RMSE) and sum of square error (SSE) values were selected as the best model for the prediction [14]. These criteria parameters were determined using equations 4 and 5:

$$\mathrm{SSE} = \frac{1}{N}\sum\left(\mathrm{MR}_{\mathrm{exp},i} - \mathrm{MR}_{\mathrm{pre},i}\right)^2 \quad (4)$$

$$RMSE = \left[\frac{1}{N}\sum_{i=1}^{N}(MR_{pre,i} - MR_{exp,i})^2\right]^{1/2} \quad (5)$$

Where $MR_{exp,i}$ is the ith moisture ratio observed experimentally; $MR_{pre,i}$ is the ith predicted moisture ratio; N and n represent the number of observations and constants, respectively. Multiple linear regression analyses were also performed on the constants and coefficients of the best model chosen to determine their effect on the drying temperature.

F. *Calculation of effective moisture diffusivity and activation energy*

The simplified Frick's law equation of moisture diffusion was adapted to determine the effective moisture diffusion from the samples during drying [15] which was represented by equation 6:

$$MR = \frac{M}{M_o} = \frac{8}{\pi^2}\sum_{n=0}^{n-1}\frac{1}{(2n-1)^2}exp\left(-\frac{(2n-1)^2\pi^2 D_{eff}\,t}{4L^2}\right) \quad (6)$$

Where: MR = moisture ratio; M = moisture content at any time (g water/g dry mater); M_o = initial moisture content (g water/g dry mater); t = time of drying (s); D_{eff} = effective moisture diffusivity (m^2/s); L = thickness of the chips (m).

For long drying periods as in the case of breadfruit chips, Equation (6) can be further simplified to only the first term of the series [15]. Thus equation (7) can be written in the logarithmic form as:

$$\ln(MR) = ln\left(\frac{8}{\pi^2}\right) - \left(\frac{\pi^2 D_{eff} t}{4l^2}\right) \quad (7)$$

The effective moisture diffusivity (D_{eff}) was calculated using the method of slope. The effective moisture diffusivity was determined by plotting experimental drying data in terms of ln (MR) versus drying time (t). The plot yields a straight line with a slope k as in equation (8), from which the effective diffusivity was computed.

$$k = \frac{\pi^2 D_{eff}}{4l^2} \quad (8)$$

Where: k = slope; D_{eff} = effective moisture diffusivity (m^2/s); L = thickness of the slice (m)

The activation energy was calculated using an Arrhenius type equation [16]:

$$D_{eff} = D_o \exp\left(-\frac{E_a}{RT_a}\right) \quad (9)$$

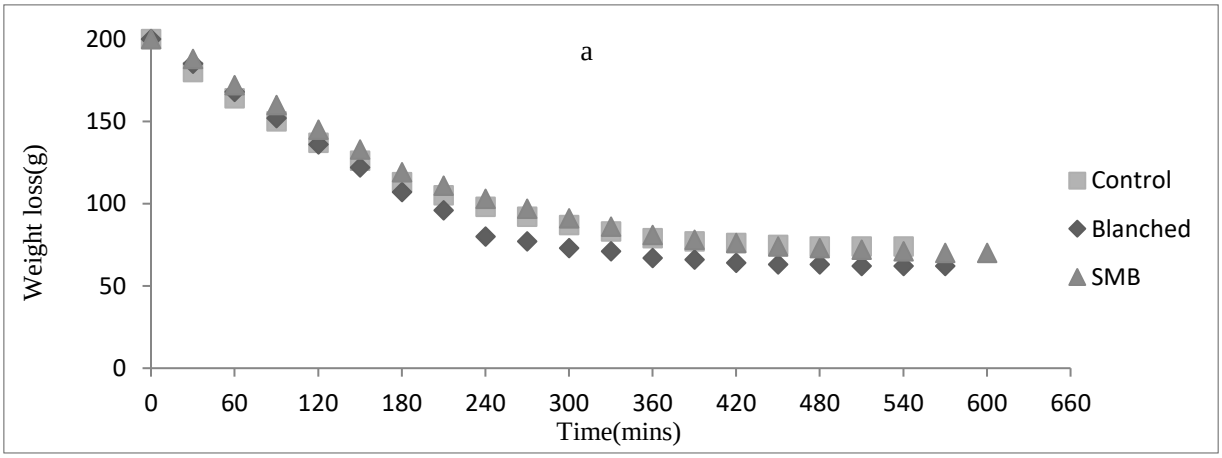
Where: E_a = energy of activation (kJ/mol) R = universal gas constant (8.3143kJ/mol K); T_a = absolute air temperature (K)**;** D_o = pre-exponential factor of the Arrhenius equation (m^2/s)

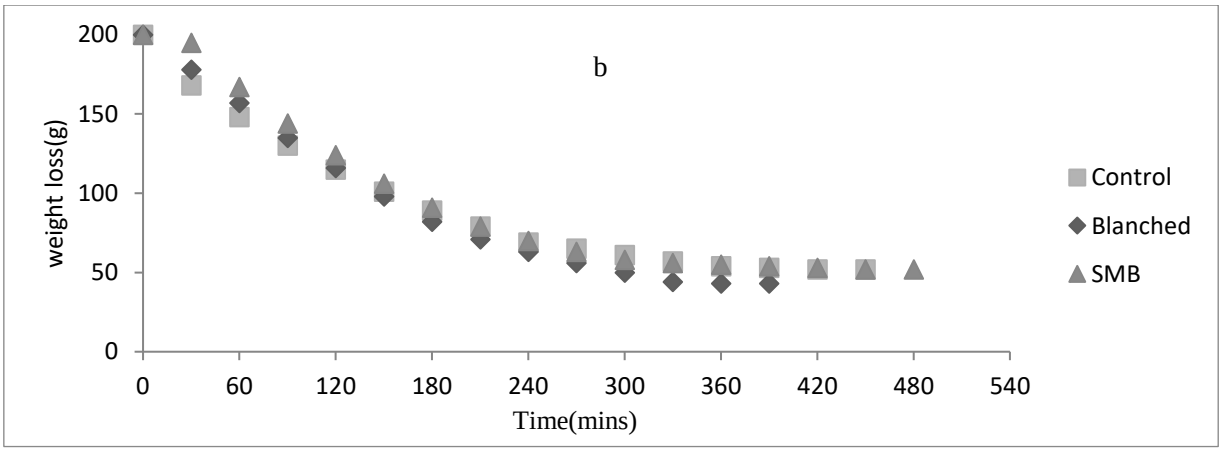
From Equation (9), the plot of natural logarithm of D_{eff} against inverse of the absolute temperature gives a straight slope of K_1 from which E_a was computed using equation 10.

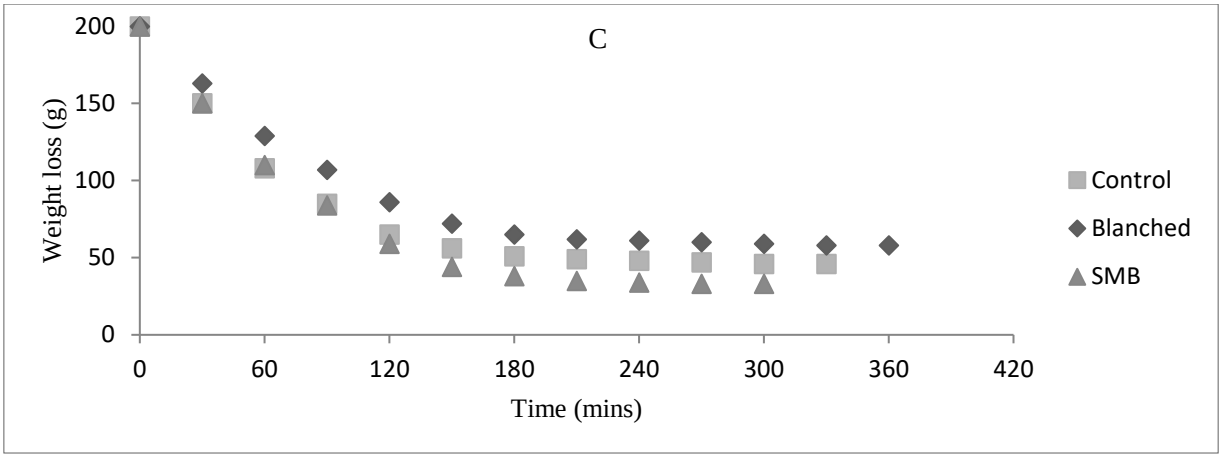
$$K_1 = \frac{E_a}{R} \quad (10)$$

III. RESULTS AND DISCUSSION

The pretreatment effect on thin layer drying of breadfruit slices is presented in Figure 2. The blanched sample exhibited greatest drying rate in comparison to metabisulphite treated and control samples (Figure 2). Furthermore, all the three samples exhibited non-linear relationship between instantaneous drying weight and drying time. The figure also showed that as drying time increases, there is corresponding decrease in drying weight. Similar trends were reported for sweet potato slices [17]. However, during the initial stages of drying, there was a rapid decrease in drying weight of the samples, which later reduced as drying time progressed. The sample thereafter exhibited falling rate period as a result of prevalence of diffusion mechanisms [18]. The rapid drying in the falling rate period could be associated with the material surface which was no longer saturated with water and drying rate being controlled by moisture diffusion from the sample interior to its surface. Thereafter, drying became slower as there was substantial reduction in the sample moisture content [17].

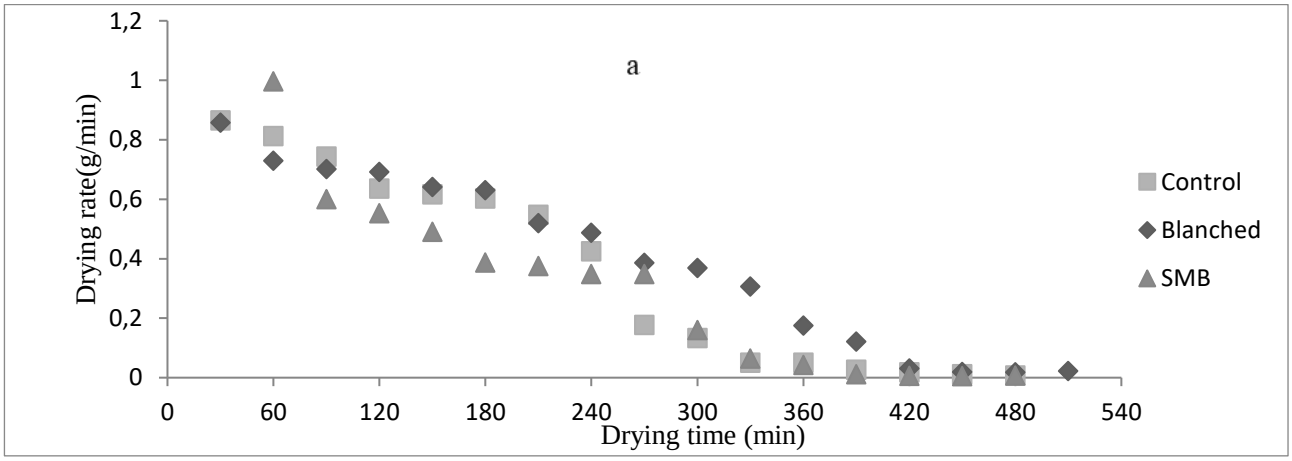


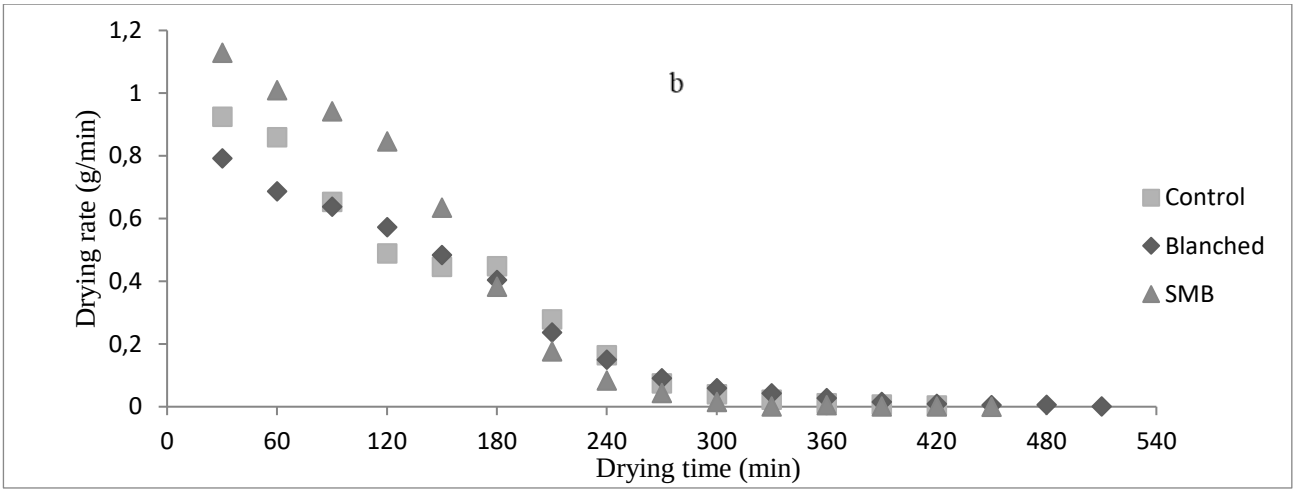


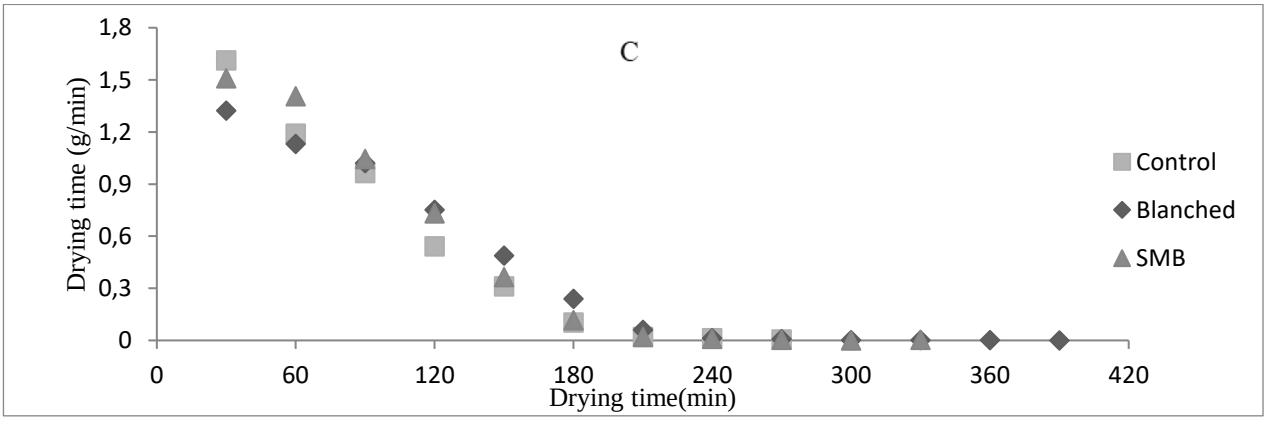


(a) weight loss against time at 50 ºC; (b) weight loss against time at 60 ºC; (c) weight loss against time at 70 ºC
Figure 2: Curve of Weight loss against time of breadfruit slices at different temperatures

Effect of pretreatment on drying time of thin layer breadfruit slices is presented in Figure 3. The Figure showed that as temperature increased from 50 to 70 ℃, drying time for metabisulphite-treated sample decreased from 480 to 330 min., likewise blanched and control samples. This showed that as temperature increased, drying time rate decreases. A slightly different trend was documented for sweet potato slices [17]. This may be due to longer blanching time for the yam samples as blanching disrupt cells and softening tissues thereby facilitating the transport of water to the surface of the sample where it is being evaporated this in turn led increase in moisture content.



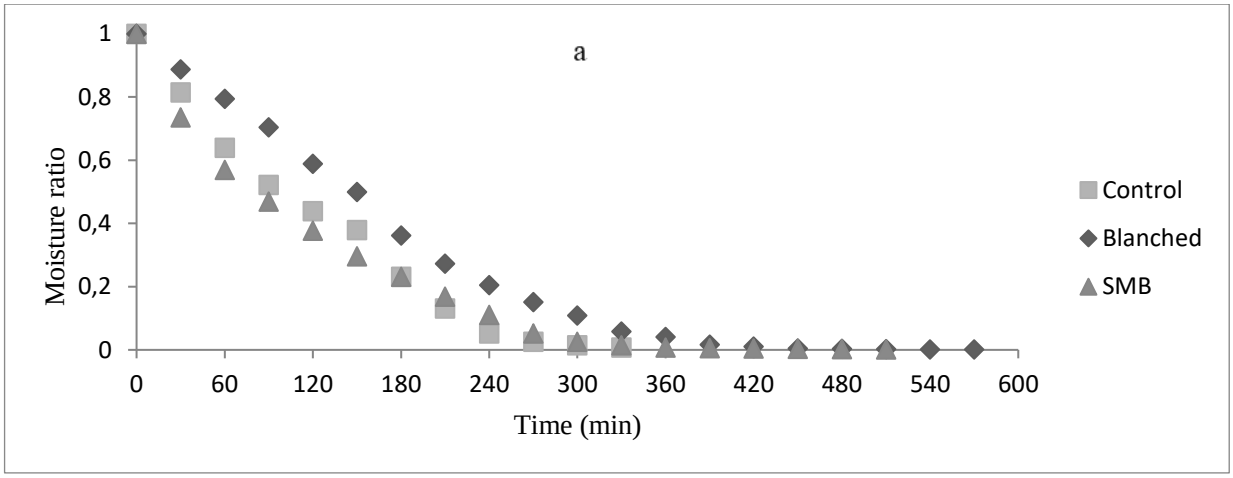


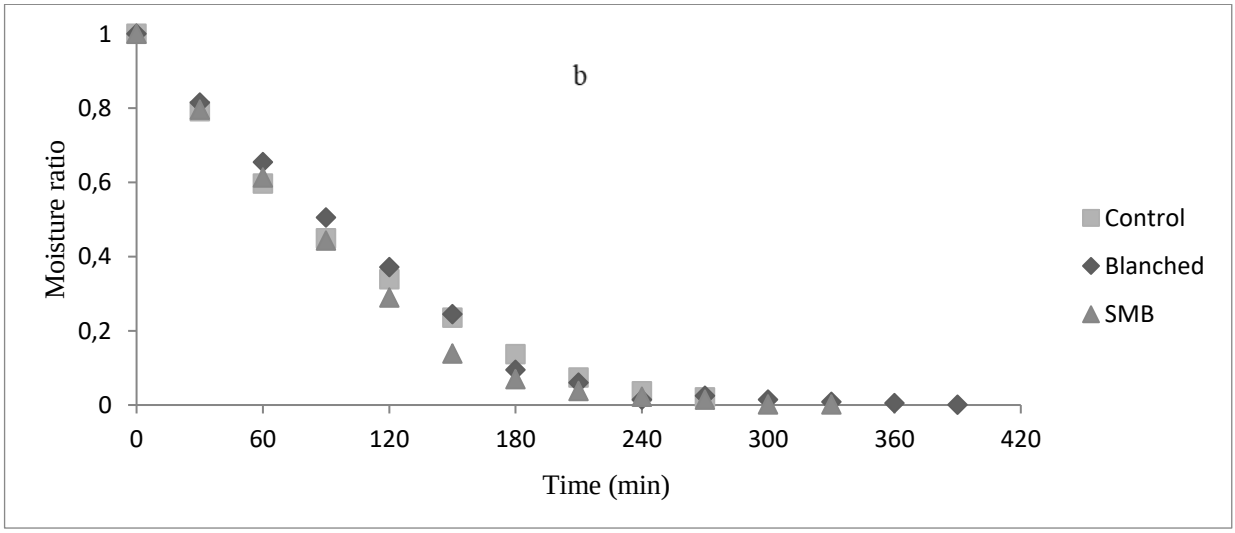


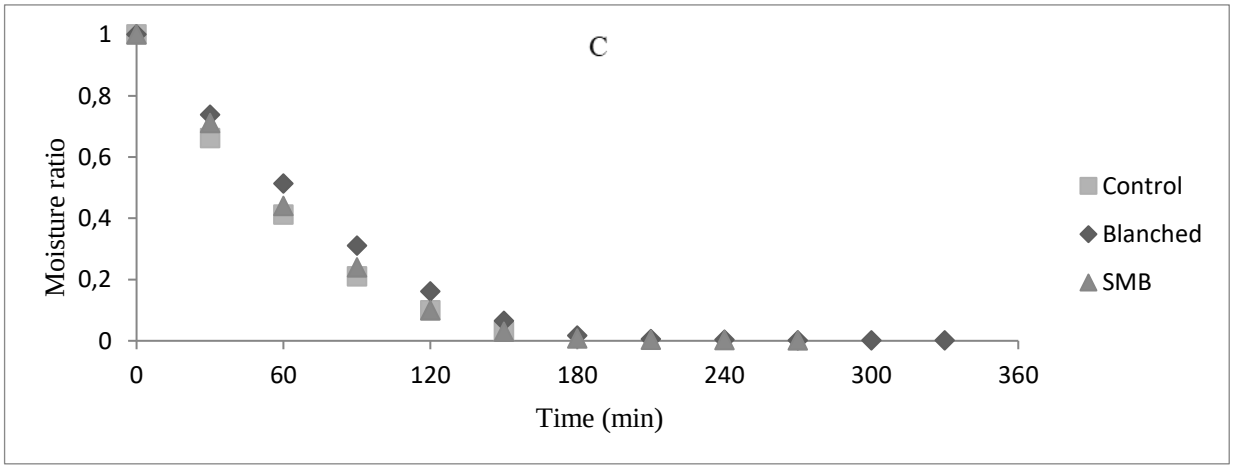
(a): Drying rate curve at 50 °C, (b) Drying rate curve at 60 °C, (c) Drying rate curve at 60 °C

Figure 3: Drying rate against time of breadfruit chips at different temperatures

Effect of drying temperature on moisture ratio of thin layer breadfruit chips is presented in Figure 4. The figure showed that moisture ratio decreases as temperature progressed from 50 to 70 °C. Furthermore, all the three samples exhibited non-linear relationship between moisture ratio and drying time. As seen from Figure 4, it indicated that the drying behavior of the breadfruit slices was governed by diffusion process as there was no constant rate period, but a long falling rate period in all drying air temperature [17]. Afterwards, with less free water available on the surface of the breadfruit slices, the drying rate started to decrease. The drying process occurred mainly in the falling rate period, during which most of the water was removed. Similar results were obtained for sweet potato slices [17].







(a) Moisture ratio against time at 50 ºC; (b) Moisture ratio against time at 60 ºC; (c) Moisture ratio against time at 70 ºC

Figure 5: Curve of moisture ratio against time of breadfruit chips at different temperatures

Effect of drying air temperature on shrinkage of breadfruit slices is presented in Figure 5. The shrinkage values ranged from 3.109 to 2.73 mm; 3.194 to 2.790 mm and 3.556 to 2.830 mm for control, blanched and metabisulphite treated samples respectively as drying air temperature progressed from 50 to 70 °C. The result showed that as drying air temperature increases, there is corresponding decrease in shrinkage. The results further showed that pretreatments influenced shrinkage as blanching caused greater damage to cell

structure, resulting in more moisture removal and increased contraction stresses in the material [18]. Also, the soaking of breadfruit slices in sodium metabisulphite caused a high intake of water before drying.

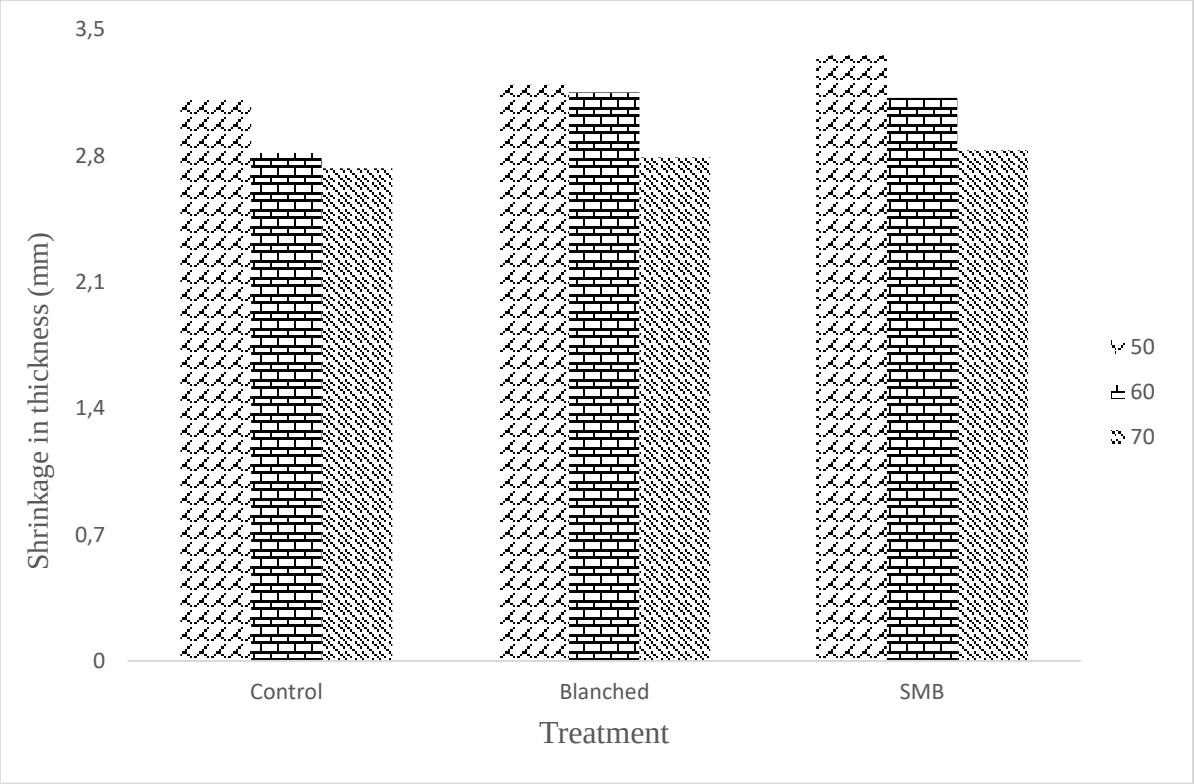


Figure 5: Shrinkage in pre-treated and untreated breadfruit chips thickness dried at different temperature

Fitting of thin layer drying data to models

A non-linear regression analysis was carried out and the acceptability of the model as the best describing the thin layer dry characteristics of breadfruit slices based on the coefficient of determination (R^2), sum of square error (SSE) and root mean square error (RMSE) is presented in the Table 2. Page model best described the thin layer drying characteristics of untreated breadfruit slices at 50 ℃ based on its highest COD value of 0.9939; lowest SSE value of 0.00073 and RMSE value of 0.0270. Although, logarithmic model best described the thin layer drying characteristics of the sample based on its highest COD values of 0.9960 and 0.9915, lowest SSE value of 0.00026 and 0.00054 and RMSE value 0.0162 and 0.0235 at temperature 60 and 70 ℃, respectively. Page model best described the thin layer drying characteristics of blanched breadfruit slices based on its highest COD values of 0.9970 and 0.9763, lowest SSE value of 0.00016 and 0.00269 and RMSE value 0.0126 and 0.0519 at temperature 50 and 70 ℃, respectively. Although, logarithmic model best described the thin layer drying characteristics of the sample based on its highest COD values of 0.9971, lowest SSE value of 0.00021 and RMSE value 0.0145 respectively at temperature 60 ℃. Logarithmic model best described the thin layer drying characteristics of sodium metabisulphite treated breadfruit slices based on its highest COD values of 0.9960, 0.9970, and 0.9922, lowest SSE value of 0.00044, 0.00026 and 0.00049 and RMSE value 0.0209, 0.0161 and 0.0223 at temperature 50, 60 and 70 ℃, respectively.

Table 2: Description of models in terms of temperatures for breadfruit chips

Model Name	Treatment	Temp (°C)	Coefficients	R^2	SSE	RMSE
		50	K = 0.0034	0.9656	0.00271	0.0521
	UNT	60	K = 0.0025	0.9835	0.00109	0.0331
		70	k = 0.0032	0.9906	0.00600	0.0245
		50	k = 0.0060	0.9890	0.00065	0.0254
Newton	BLN	60	k = 0.0092	0.9910	0.00059	0.0243
MR = exp(-kt)		70	k = 0.0138	0.8551	0.01658	0.1288
		50	k = 0.0084	0.9211	0.00930	0.0964
	SMB	60	k = 0.0106	0.9951	0.00034	0.0184
		70	k = 0.0138	0.9390	0.00535	0.0731
		50	n = 1.3011, k = 0.0059	0.9939	0.00073	0.0270
Page	UNT	60	n = 1.1691, k = 0.0093	0.9925	0.00050	0.0224
MR = exp(-kt^n)		70	n = 0.9309, k =0.0485	0.9893	0.00050	0.0224
		50	n = 1.4328, k = 0.0015	0.9970	0.00016	0.0126
	BLN	60	n =1.3562, k = 0.0027	0.9911	0.00059	0.0243
		70	n = 1.3684, k = 0.0023	0.9763	0.00269	0.0519
		50	n = 1.0468, k = 0.0085	0.9840	0.00188	0.0403
	SMB	60	n = 1.0236, k = 0.0087	0.9950	0.00032	0.0178
		70	n = 1.0375, k = 0.0076	0.9860	0.00121	0.0348
Logarithmic		50	c = -0.0979,			

MR=Aexp(-kt) +c	UNT		a = 1.1687, k= 0.0030	0.9851	0.00132	0.0364
			c = -0.4109,			
		60	a = 1.4060,			
			k = 0.0015	0.9960	0.00026	0.0162
			c = 0.0243,			
		70	a = 0.9632,			
			k = 0.0034	0.9915	0.00054	0.0232
			c = -0.0772,			
	BLN	50	a = 1.1488,			
			k = 0.0054	0.9970	0.00019	0.0138
			c = 0.0573			
		60	a = 1.0658,			
			k = 0.0165	0.9971	0.00021	0.0145

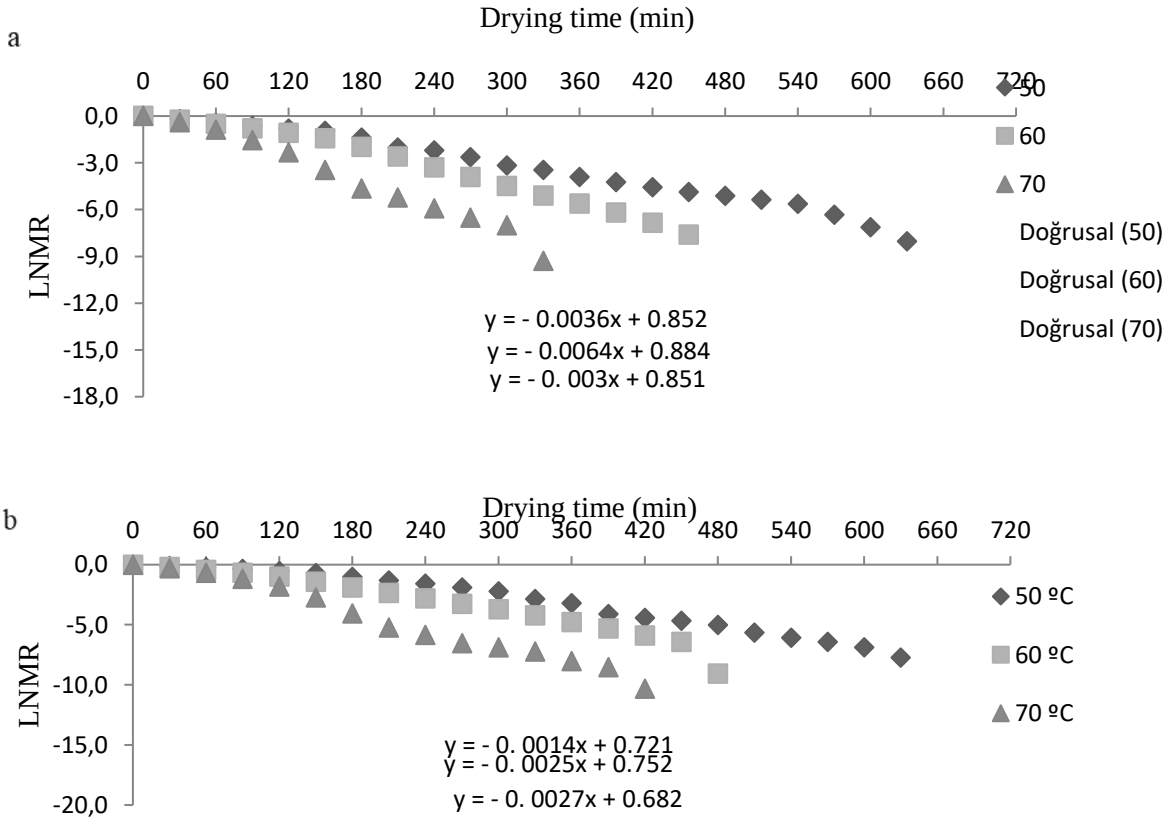
Table 2: Description of models in terms of temperatures for breadfruit slices (cont'd)

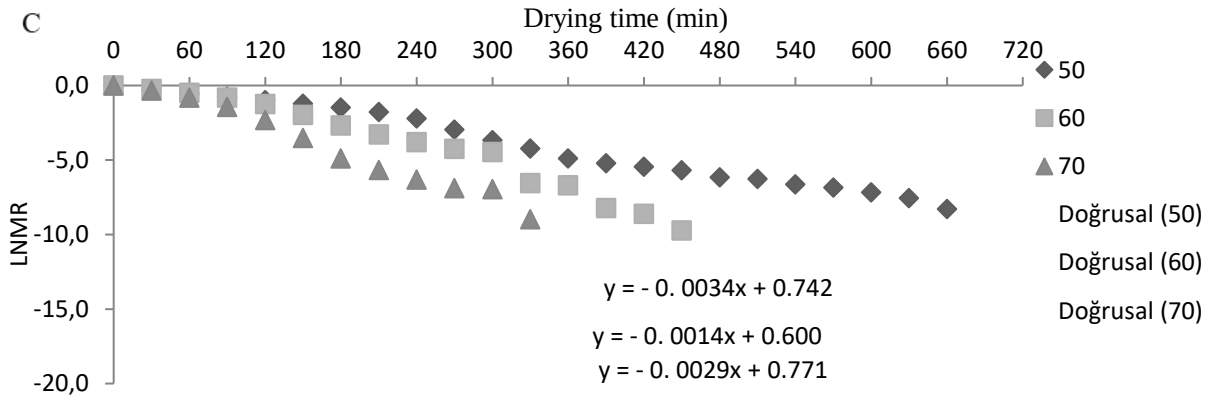
			c = -0.0302,			
		70	a = 1.0322,	0.9669		
			k =0.0117		0.00496	0.0704
	SMB		c = 0.0181,			
		50	a = 1.0056,			
			k =0.0084	0.9960	0.00044	0.0209
			c = 0.0164,			
		60	a = 1.0786,			
			k =0.0141	0.9970	0.00026	0.0161
			c = 0.0307,			
		70	a = 1.0686,			
			k =0.0170	0.9922	0.00049	0.0223
Henderson	UNT		a = 1.0935,			
		50				
$MR = a \exp(-kt^n)$			k = 0.0037	0.9819	0.00160	0.0400
			a = 1.0358,			
		60				
			k = 0.0027	0.9864	0.00091	0.0302
		70	a = 0.9809,			

			k = 0.0032	0.9913	0.00055	0.0235
	BLN	50	a = 0.9630, k = 0.0002	0.9980	0.00112	0.0334
		60	a = 0.9841, k = 0.1252	0.9888	0.00212	0.0460
		70	a = 1.0000, k = 0.2661	0.9721	0.00145	0.0380
	SMB	50	a = 1.9039, k = 0.0051	0.9926	0.00066	0.0257
		60	a = 1.6915, k = 0.0035	0.9925	0.00051	0.0224
		70	a = 0.4546, k = 0.0051	0.9790	0.00181	0.0425
Modified page $MR = \exp(-(kt)^n$	UNT	50	n = 0.8454, k = 0.0077	0.9910	0.00080	0.0283
		60	n= 1.0451, k = 0.0182	0.9821	0.00052	0.0229
		70	n= 1.2494, k = 0.0298	0.9864	0.00047	0.0216
	BLN	50	n = 1.7211, k = 0.0226	0.9943	0.00034	0.0184
		60	n = 1.1850, k = 0.0261	0.9910	0.00056	0.0236
		70	n = 1.0000, k = 0.2661	0.9571	0.00487	0.0697
	SMB	50	n = 1.0470, k = 0.1146	0.9852	0.00175	0.0418
		60	n = 1.1725, k = 0.0545	0.9850	0.00029	0.0170
		70	n = 1.1319, k = 0.0076	0.9825	0.00159	0.0398

Effective moisture diffusivity and activation energy of thin layer breadfruit chips

The graph of effective diffusivity of breadfruit slices for thin layer breadfruit slices is shown in Figure 6. From the figure, it showed at high temperature the water molecules were loosely bound to the breadfruit slices, thus requiring less energy to remove than at lower temperature. The drying rate curves shown in Figure 6 indicated that the drying of breadfruit slices took place predominantly in the falling rate period and as such liquid diffusion controls the process. During the falling rate period, the internal resistance governs the mass transfer; hence, Fick's second law can be used to estimate the effective diffusivity using equation 9. Table 2 shows the effective diffusivity ranges from 0.106 x 10^{-6} to 9.910 x 10^{-6} m^2/s and are found to be within the general range of 10^{-12} to 10^{-6} m^2/s for food materials and agricultural crops [18]. Moisture diffusivity, which is related to the quantity of heat passing normally through a unit area per unit time is also affected by drying temperatures, as increasing in drying air temperature resulted in higher effective moisture diffusivity as shown in Table 3. This result is similar to the findings for finger millet [19]. Figure 7 showed effect of influence of temperature on the effective diffusivity against reciprocal of temperature.1/T for control, blanched and pre-treated samples. From the slope of the graph, the activation energy was observed to be 36.06 kJ/mol, 29.71 kJ/mol and 33.24 kJ/mol for control, blanched and pre-treated samples respectively. From the result, it was clearly observed that there was lower activation energy for the sodiummetabisulphite treated and blanched samples than for the untreated sample. This indicates that it was easier to induce the water release process in the blanched and sodiummetabisulphite treated samples compared to the untreated sample.





(a) Variation of ln MR with drying time for untreated breadfruit slices, (b) Variation of ln MR with drying time for blanched breadfruit slices, (c): Variation of ln MR with drying time for sodium metabisulphite treated breadfruit chips

Figure 6: Variation of ln MR with drying time for breadfruit slices

Table 3: Effective diffusivity of breadfruit slices at different drying temperatures

Treatment	Temperature	D_{eff} x 10^{-6}(m^2/s)	Linear Equation	R^2
UNT	50	7.356	y = - 0. 003x + 0.851	0.9365
BLN	50	7.660	y = - 0. 0014x + 0.721	0.9868
SMB	50	7.964	y = - 0. 0014x + 0.600	0.9822
UNT	60	0.106	y = - 0.0036x + 0.852	0.9306
BLN	60	9.910	y = - 0. 0025x + 0.752	0.9163
SMB	60	0.133	y = - 0. 0029x + 0.771	0.9712
UNT	70	0.165	y = - 0.0064x + 0.884	0.9373
BLN	70	0.150	y = - 0. 0027x + 0.682	0.9426
SMB	70	0.168	y = - 0. 0034x + 0.742	0.9796

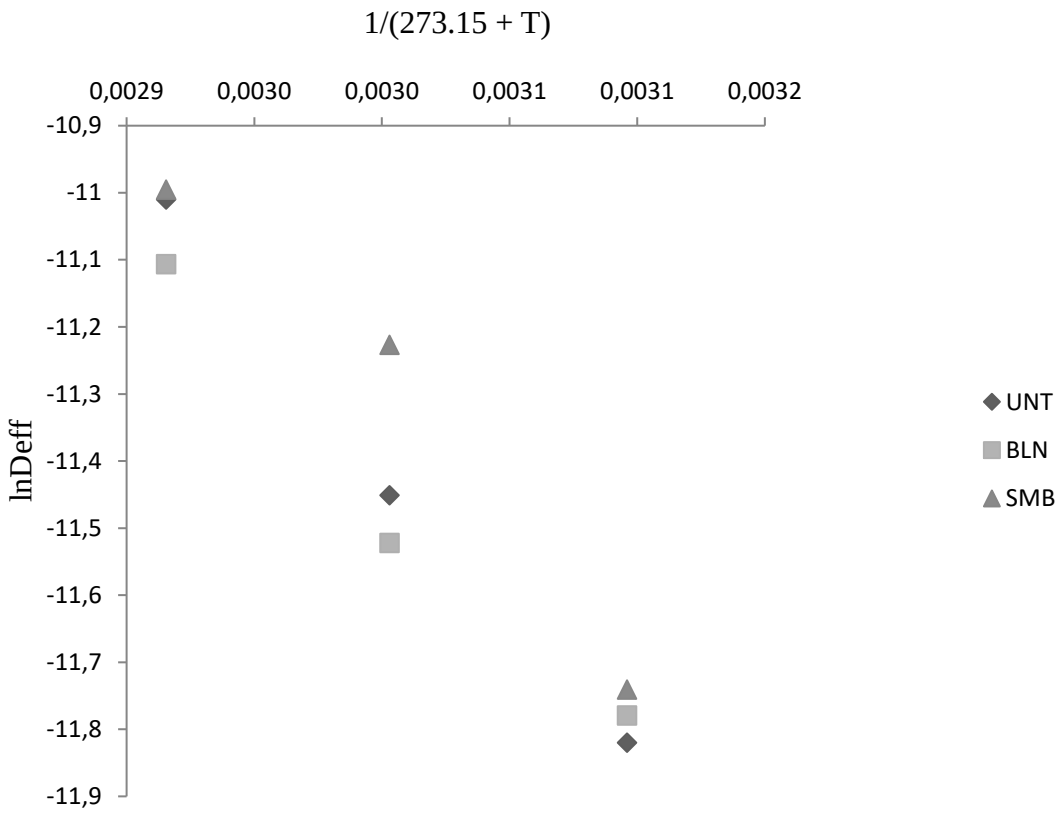


Figure 7: Influence of drying air temperature on effective diffusivity of breadfruit slices

IV. CONCLUSION

This research work generated engineering data needed for understanding thin layer drying characteristics of breadfruit slices. Therefore, the following conclusion can be drawn from the results obtained:

a) drying air temperature increased significantly the drying rate of breadfruit slices;
b) Logarithmic model was judged to have performed best in describing the drying curves of treated and untreated breadfruit slices, respectively;
c) The effective moisture diffusivity values of pre-treated, blanched and controlled breadfruit slices the ranged from 0.106×10^{-6} to 9.910×10^{-6} m^2/s; and
d) There was lower activation energy for the pre-treated and blanched than for the control sample. The result of the activation energy was found to be 36.06kJ/mol, 29.71kJ/mol and 33.24kJ/mol for control, blanched and pre-treated samples respectively. This indicates that it was easier to induce the water release process in the blanched and pre-treated samples compared to the untreated samples.

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Yapay Zekâ ve Dijital Materyallerle Desteklenmiş Çevre Eğitimi Dersinin Çevre Öz Yeterliklerine Etkisi

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Özet – Çevre eğitimi, günümüzde önemli bir konu haline gelmiştir. Bu konu alanında eğitim sağlayacak olan öğretmen adaylarının öz yeterliklerinin yüksek olması, öğrencilere çevre konularını doğru ve etkili bir şekilde aktarabilmeleri açısından son derece önem arz etmektedir. Eğitim sürecinde yapay zekâ ve dijital materyallerin kullanımı büyük bir avantaj sağlamaktadır. Özellikle öğretmen adaylarının çevre eğitimini daha ilgi çekici ve etkili bir şekilde aktarabilmeleri için yapay zekâ destekli dijital materyallerden yararlanabilirler. Bu bağlamda araştırmanın amacı, 4.sınıf fen bilgisi öğretmen adaylarının yapay zekâ ve dijital materyaller ile desteklenmiş çevre eğitimi dersinin fen bilgisi öğretmen adaylarını çevre eğitimi öz yeterliliklerine etkisinin incelenmesidir. Araştırma, 2022-2023 eğitim öğretim yılının güz döneminde İç Anadolu bölgesinde bulunan bir devlet üniversitesinin fen bilgisi öğretmenliği programında 4. Sınıf çevre eğitimi dersini alan 20 fen bilgisi öğretmen adayı ile gerçekleştirilmiştir. Araştırmada, fen bilgisi öğretmen adaylarının çevre eğitimi öz yeterliklerini belirlemek için "Çevre Eğitimi Öz-Yeterlik Ölçeği" kullanılmıştır. Elde edilen veriler, SPSS.26 paket programı kullanılarak Wilcoxon İşaretli Sıralar Test ile analiz edilmiştir. Araştırmada elde edilen verilerin sonuçlarına göre, yapay zekâ ve dijital materyaller desteklenen çevre eğitimi dersinin fen bilgisi öğretmen adaylarının çevre eğitimi öz yeterliklerini olumlu etkilediği görülmektedir. Bu sonuçlar doğrultusunda, çevre eğitimi alanında yapay zekâ uygulamalarının ve dijital materyallerin kullanımının yaygınlaştırılması büyük önem taşımaktadır.

Anahtar Kelimeler –Çevre eğitimi, öz yeterlilik, yapay zekâ, dijital material.

I. GİRİŞ

İnsanlar doğumundan ölümüne kadar doğa, kültür ve yaşadığı çevre ile etkileşim içindedir. Bu etkileşim, insanın yaşamı boyunca önem arz etmektedir [1]. İnsan yaşamının hızla değişmesi ve gelişmesi sonucunda çevreye karşı olumsuz etkiler ortaya çıkmaktadır [2]. Bu olumsuz etkiler çevre sorunlarına sebep olmaktadır. Yaşanan çevre sorunlarının çözülebilmesi ve önlenmesi için; bireylerin çevre sorunlarına dair bilinç sahibi olup, çözümler bulmaya ve yeni fikirler üretmeye yönelmeleri gerekmektedir [3]. Çevre bilincinin kazanılması çevre eğitimi ile mümkündür. Çevre eğitimi, bireylerin çevre sorunlarına karşı daha duyarlı olmalarına, çevre bilinci geliştirmelerine katkı sağlayacaktır [4,5]. Çevre bilinci sayesinde bireyler, çevrelerini daha iyi anlayabilir, çevre sorunlarına karşı bilinçli yaklaşabilir ve çevreyi korumaya yönelik yaklaşımlarda bulunabilirler [6]. Çevreye karşı duyarlı, çevre bilincine sahip bireyler yetiştirecek olan öğretmenler ve öğretmen adaylarına önemli bir rol düşmektedir. Öğretmenler ve öğretmen adayları, çeşitli öğretim materyalleri ve yöntemleri kullanarak çevre eğitimi derslerini işleyerek bireylerin çevreyi korumaya ve çevre bilincine sahip olmalarını sağlayacak nitelikte kişilerdir. Bu açıdan bakıldığında ilk olarak öğretmen ve öğretmen adaylarının çevre bilincine sahip, çevreyi koruyabilen bireyler olması gerekmektedir.

Kılıçoğlu [7] sosyal bilgiler öğretmen adaylarının çevre eğitimi konusundaki öz-yeterlilik algılarının farklı değişkenler tarafından etkisini [7], Fradila ve arkadaşları [8] biyoloji eğitiminde yüksek lisans yapan öğrencilerin Problem Bazlı Öğrenme (PBL) temelli E-modül yöntemi ile işlenen ekoloji ve çevre eğitimi derslerinin öğrencilerin duyusal ve psikomotor öğrenme becerileri üzerine etkisini [8], Monus [9] okulların çevre eğitimi ve sürdürülebilirlik eğitiminin ortaokul öğrencilerinin çevresel tutumlarına etkisini [9], Karakoyun ve Uzun [10] 2011-2022 yılları arasında yayımlanan çevre eğitimi ile ilgili olan lisansüstü tez çalışmalarının incelemesini [10], Kayaer ve Çiftçi [11] siyaset bilimi ve kamu yöntemi dördüncü sınıf öğrencilerin aldığı çevre eğitiminin öğrencilerin çevre bilincine etkisini [11], Yalçın Çelik ve arkadaşları [12] çevre eğitimi derslerinin üniversite öğrencilerinin çevre ile ilgili değer, davranış ve etik görüşlerine etkisini incelemiştir [12]. Akay ve Cakir [13] çalışmasında Web 2.0 araçlarından Powtoon 'u video oluşturmak ve Wordwall'u eğitsel oyun tasarlamak amacıyla kullanarak, okul öncesi öğrencilerin çevreye karşı tutumlarını incelemiştir [13].

Bu çalışmanın amacı 4.sınıf fen bilgisi öğretmen adaylarının yapay zekâ ve dijital materyaller ile desteklenmiş çevre eğitimi dersinin fen bilgisi öğretmen adaylarını çevre eğitimi öz yeterliliklerine etkisinin incelenmesidir.

II. MATERYAL VE YÖNTEM

Araştırmada, nicel araştırma yöntemlerinden tek gruplu öntest-sontest deneysel desen tercih edilmiştir. Bu desende, araştırmanın uygulama sürecinden önce ön test, uygulama sürecinin sonrasında ise son test uygulanarak veriler toplanmıştır. Elde edilen veriler incelenerek sonuç çıkarılmaktadır [14].

III. BULGULAR

Yapılan araştırma 2023-2024 eğitim öğretim yılında İç Anadolu bölgesinde bulunan bir devlet üniversitesinin fen bilgisi öğretmenliği programında 4. Sınıf çevre eğitimi dersini alan 20 fen bilgisi öğretmen adayı ile yürütülmüştür. Araştırmada fen bilgisi öğretmen adaylarının çevre eğitimi öz yeterliklerini belirlemek için Özlü ve arkadaşları [15] tarafından geliştirilen "Çevre Eğitimi Öz-Yeterlik Ölçeği" kullanılmıştır. Ölçek, 2 alt boyut içermekte olup, toplamda 24 maddeden oluşmaktadır. Ölçeğin ölçeklendirilmesinde 10 birimlik değişim olacak şekilde 0-100'lük ölçeklendirme tercih edilmiştir. Ölçeğin güvenilirliği, Cronbach Alpha katsayısı ile değerlendirilmiş ve güvenirliği 0,97 olarak hesaplanmıştır [15].

Araştırmanın uygulaması, fen bilgisi öğretmen adaylarının çevre eğitimi dersinin 12 haftasında gerçekleştirilmiştir. Uygulama sürecinde her hafta fen bilgisi öğretmen adayları ile birlikte Magicschool.ai, Tome.app, WEKA, Diffit.me, Canva.ai, ChatGPT, Conker.ai, Gamma.app gibi yapay zeka araçlarını ve Canva, Google Classroom, Learning Apps, Animaker, Padlet, Edpuzzle, Mentimeter, Mindomo, Socrative gibi Web 2.0 uygulamalarını kullanarak çevre konuları ile ilgili poster, soru oluşturma, sunum hazırlama, ders planı hazırlama, kavram ağı hazırlama, animasyon hazırlama, eğitici oyunlar geliştirme, araştırma yapma gibi çalışmalar yapılmıştır.

Araştırmada elde edilen veriler SPSS.26 paket programı kullanılarak Wilcoxon İşaretli Sıralar Test ile analizi sağlanmıştır. Araştırmaya katılan fen bilgisi öğretmen adaylarının "Çevre Eğitimi Öz-Yeterlik Ölçeği" anketine vermiş oldukları cevaplara ilişkin Wilcoxon İşaretli Sıralar Test analizi Tablo 1'de görülmektedir.

Tablo 1.Fen Bilgisi Öğretmen Adaylarının Ön Test-Son Test Wilcoxon İşaretli Sıralar Test Sonuçları

Ön Test- Son Test	n	Sıra Ort.	Sıra Top.	z	p
Negatif Sıralar	2	2,50	5,00	3,73	,000
Pozitif Sıralar	18	11,39	205,00		
Eşit	0				

*p< .05

Tablo 1 incelendiğinde fen bilgisi öğretmen adaylarının yapay zekâ ve dijital materyaller ile desteklenmiş çevre eğitimi dersi öncesi ve sonrası fen bilgisi öğretmen adaylarının çevre eğitimi öz-yeterlikleri arasında istatistikî açıdan bir fark olup olmadığını ortaya koymak için Wilcoxon İşaretli Sıralar testi ile analiz edilmiştir. Analiz sonucuna göre, fen bilgisi öğretmen adaylarının yapay zekâ ve dijital materyaller ile desteklenmiş çevre eğitimi öncesi ve sonrası çevre eğitimi öz-yeterlikleri arasında istatistiksel olarak anlamlı bir fark görülmüştür. (z=-3,73; p<,00). Elde edilen sonuca göre, yapay zekâ ve dijital materyaller ile desteklenmiş çevre eğitimin fen bilgisi öğretmen adaylarının çevre eğitimi öz-yeterlik düzeylerinde etkili olduğunu göstermektedir.

IV. SONUÇ

"Çevre Eğitimi Öz-Yeterlik Ölçeği" ile elde edilen verilere dayanarak, yapay zekâ ve dijital materyaller desteklenen çevre eğitimi dersinin fen bilgisi öğretmen adaylarının çevre eğitimi öz yeterliklerini olumlu etkilediği görülmektedir. Bu açıdan bakıldığında, teknolojinin eğitim süreçlerinde aktif kullanılmasının fen bilgisi öğretmen adaylarının öz-yeterliklerini artırabileceği görülebilir. Özellikle çevre eğitimi derslerde, bu teknolojilerin kullanımı öğrencilerin konuya olan ilgisini artırarak, öğrenme motivasyonlarını yükseltmesini sağlayabilir. Ayrıca gelecek nesillere çevre bilincini aktaracak olan öğretmen adaylarının çevre eğitimi konusundaki bilgi ve becerilerin geliştirilmesinde yapay zekâ ve dijital materyallerin kullanımı çevre eğitimi öz-yeterliklerine katkı sağlayabilir. Bu sayede, gelecek nesiller çevreye daha duyarlı ve sorumlu bireyler olarak yetiştirilebilecektir.

Sonuç olarak, çevre eğitimde yapay zekâ ve dijital materyallerin kullanımı ve yenilikçi yöntemlerin benimsenmesi, öğretmen adaylarının çevre eğitimi öz-yeterliklerini artırmak açısından önem taşımaktadır.

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Fen Eğitiminde Yapay Zekâ Kullanımı

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Özet – Fen eğitimi, öğrencilere doğa bilimleri konularında temel bilgileri öğretmeye, öğrencilerin bilimsel düşünme becerilerini geliştirmelerine ve çevrelerindeki dünyayı daha iyi anlamalarına olanak sağlamaktadır. Yapay zekâ, insan zihninin işlevlerini taklit eden bilgisayar sistemlerini oluşturan bir bilim dalıdır. Yapay zekâ, makine öğrenmesi ve yapay sinir ağları gibi teknikler kullanılarak geliştirilmektedir. Bu yapay zekâ teknolojileri, birçok alanda insanlara yardımcı olmak için kullanılmaktadır. Fen eğitimi ve yapay zekâ, birbirinden farklı alanlarda olsalar da fen eğitiminde yapay zekâ teknolojisinin kullanımı eğitim ortamlarına önemli fırsatlar sağlayabilmektedir. Yapay zekâ, fen eğitiminde öğrencilere interaktif ve kişiselleştirilmiş bir öğrenme deneyimi sunarak öğrencilerin konuları daha iyi anlamalarına yardımcı olmakta, öğrencilerin performansını değerlendirmede ve öğrencilerin zayıf ve güçlü yönlerini belirlemede kullanılabilmektedir. Gelecekte yapay zekâ teknolojisinin fen eğitiminde daha yaygın bir şekilde kullanılması ve farklı eğitim alanlarına uygun uygulamaların geliştirilmesi beklenmektedir. Bu araştırmada, fizik, kimya ve biyoloji gibi fen eğitimi alanlarında yapay zekânın rolü ve fen eğitiminde yapay zekânın kullanımı incelenmiştir. Araştırma, yapay zekânın fen eğitiminde nasıl etkili olduğunu ve fen eğitiminde kullanılabilecek bazı yapay zekâ araçlarından bahsedilmiştir.

Anahtar Kelimeler – Fen eğitimi, yapay zekâ, teknoloji, yapay zekâ uygulamaları

I. GİRİŞ

Fen bilimi, insanlık tarihi boyunca doğa olaylarını anlamaya ve açıklamaya yönelik önemli bir role sahip olmuştur. Fizik, kimya, biyoloji gibi alanları kapsayan fen bilimi; doğanın işleyişini anlamamızı, bu bilgiyi kullanarak çeşitli sonuçlara ulaşmamızı, gelecekteki keşifler için temel oluşturmamızı sağlamaktadır [1]. Fen bilimi, gözlem yapma, deney yapma, hipotez oluşturma ve teori geliştirme gibi yöntemlerle doğal dünyayı anlamaya çalışır. Fen eğitimi ise gözlem yapma, deney yapma, hipotez kurma gibi bilimsel süreç becerilerini kullanarak bireye yaşadığı çevreyi anlamak, bilimsel düşünme ve problem çözme becerileri kazanmak konularında yardımcı olmaktadır [2]. Ancak hayatımızda teknoloji kullanımının hızlı entegrasyonuyla birlikte, fen eğitiminde yapay zekâ gibi yeni teknolojilerin kullanımı da önem kazanmaya başlamıştır.

Yapay zekâ; insanlar tarafından geliştirilen bilgisayar sistemlerinin veri analizi, öğrenme ve karar verme gibi süreçleri otomatikleştirmesi ile insanlara daha hızlı ve etkili karar verme imkânı sunan bir teknolojidir [3, 4]. Derin öğrenme, makine öğrenmesi ve doğal dil işleme gibi çeşitli çalışma alanlarında yaşanan teknolojik gelişmeler, günümüzde yapay zekâ uygulamalarının etkili bir şekilde kullanılmasına olanak sağlamaktadır [5].

Eğitim alanında yapay zekâ ile ilgili yapılan araştırmalar, son yıllarda giderek artmaktadır. Bu çalışmalar, yapay zekânın eğitimdeki avantajları ve dezavantajlarıyla birlikte, eğitim süreçlerindeki potansiyel kullanım alanlarını da incelemektedir [6-14]. Ancak bu çalışmaların konu başlıkları incelendiğinde, fen eğitiminde yapay zekâ kullanımı alanında yoğunlaşılmadığı görülmektedir. Bu bağlamda bu araştırmanın amacı; fizik, kimya ve biyoloji gibi fen eğitimi alanlarında yapay zekânın etkisi ve fen eğitiminde yapay zekâ kullanımının incelenmesidir.

II. MATERYAL VE YÖNTEM

Araştırma modeli olarak literatür taraması tercih edilmiştir. Araştırmada literatür taraması sonucunda elde edilen kaynaklar kullanılmıştır.

III. BULGULAR VE TARTIŞMA

A. Yapay Zekâ

Yapay zekâ, insan zihninin işlevlerini taklit edebilen bilgisayar sistemlerini oluşturan bilim dalıdır [15]. Bu bilgisayar sistemleri, insan zihninde olduğu gibi öğrenme, problem çözme, muhakeme yapma ve karar verme gibi bilişsel işlevleri yapabilmektedir [16].

Yapay zekânın tarihi eski zamanlara dayanmakta olup, 1956 yılında ilk kez yapay zekâ kavramı, McCarty tarafından ortaya çıkmıştır. McCarty yapay zekâyı "insana benzeyen zeki makineler ve bilgisayar programları geliştirebilen bir disiplin" olarak ifade etmiştir [17]. Bu tanımdan yola çıkarak yapay zekâyı bilgisayarların öğrenme, karar verme, dil işleme ve algılama gibi insan benzeri yeteneklere sahip olması olarak açıklayabiliriz. Yapay zekâ ile bilgisayarlar karmaşık verilerin analizini sağlayabilir, bir durum hakkında öngörülerde bulunabilir ve insanlar için yapması zor ve riskli görevleri yapabilmektedir [15].

Yapay zekâ, günümüzde pek çok alanda kullanılmaya başlamasıyla birlikte günümüz teknolojisinin en önemli ve etkileyici alanlarından biri haline gelmiştir [18]. Örneğin, sağlık sektöründe yapay zekâ, hastalıkları teşhis etmek ve tedavi planları oluşturmak için kullanılmaktadır. Otomotiv endüstrisinde ise sürücüsüz araçlar yapay zekâ sayesinde güvenli ve etkili bir şekilde hareket edebilmektedir. Güvenlik sektöründe, suç analizi ve terörle mücadele için yapay zekâ teknolojileri kullanılmaktadır.

Ünlü ve arkadaşları [19] tarafından gerçekleştirilen çalışmada, yapay zekâ teknikleri kullanarak Cleveland ve Z-Alizadehsani veri kümelerinin, kalp hastalığının teşhisindeki etkisini, Chai ve Nizam [20] otomotiv endüstrisindeki otonom araçlar ve akıllı fabrikalar gibi alanlarda yapay zekâ kullanımının etkisini, Ak [21] ise çalışmasında güvenlik ve kolluk kuvvetinin suç önleme faaliyetlerinde yapay zekâ kullanımının etkisini incelemiştir.

Yapay zekâ alanındaki bu gelişmelerin hızlanması ve yaygınlaşması, son yıllarda yapılan çalışmalar ile gerçekleşmektedir. Özellikle uzman sistemler, bulanık mantık, algoritmalar, yapay sinir ağları ve makine öğrenmesi gibi tekniklerin gelişmesi, yapay zekânın önemini artırmaktadır [22].

Yapay zekâ alanının bir parçası olan uzman sistemler, belirli bir alandaki uzman kişilerin bilgi ve deneyimlerini kullanarak karşılaşılan karmaşık problemleri çözmek için tasarlanmış uzman kişiler olmadan kararlar alabilen bilgisayar sistemleridir [23]. Uzman sistemler, genellikle tıp, mühendislik ve finans gibi pek çok alanlarda kullanılabilen ve karar verme süreçlerini optimize etmeye yardımcı olan yapılardır [19].

Bulanık mantık, geleneksel mantık kurallarının dışında kalan bir kavram olup, kesin sınırların bulunmadığı durumların analiz edilmesi için kullanılan matematiksel modelleme yönetimidir. Bu yöntem, belirsiz ve karmaşıklık içeren sistemlerde kullanılarak daha gerçeğe yakın sonuçlar elde etmeyi amaçlamaktadır [24].

Algoritma, kısaca belirli bir problemi çözmeye giden yoldaki basamakların belirlendiği bir süreç olarak tanımlanmaktadır. Algoritmalar bilgisayar biliminde genellikle veri işleme, sıralama veya arama gibi işlemleri gerçekleştirmek için kullanılmaktadır [25].

İnsan beyninin sinir hücrelerinden esinlenilerek geliştirilen yapay sinir ağları, veri setlerini işleyerek öğrenme, karmaşık problemi çözebilme ve tahmin yapma gibi yeteneklere sahip olup geniş veri setleri üzerinde kullanılmaktadır [26,27].

Makine öğrenimi, veri analizi ile bilgisayar sistemlerinin öğrenme becerisine sahip olmasına olanak sağlamaktadır [23]. Bu teknoloji sayesinde bilgisayar sistemleri, algoritmaların karmaşık veri setlerinin analizini sağlayarak örüntüler belirlenmektedir [25]. Makine öğrenmesi, çeşitli endüstrilerde kullanılarak hem verimliliği artırabilir hem de karar alma süreçlerini optimize edebilmektedir[28].

B. Fen Eğitiminde Yapay Zekâ

Yapay zekâ, son yıllarda farklı birçok alanın gelişimine katkı sağladığı gibi eğitim alanında da kullanılması ile öğrencilerin daha etkili ve verimli bir şekilde öğrenmelerine, yapay zekâya dayalı değerlendirme sistemlerine, otomatik test oluşturma gibi pek çok eğitim ortamına katkı sağlamıştır [6, 25]. Bu eğitim alanlarından biri olan fen eğitimi de yapay zekâ teknolojisi ile derslerinin daha ilgi çekici hale gelmesine ve öğrencilerin konuları daha iyi anlamalarına yardımcı olmaktadır. Yapay zekâ teknolojileri, fen eğitiminde öğrencilere interaktif ve kişiselleştirilmiş bir öğrenme deneyimi, öğrencilerin ilgi ve yetenekleri doğrultusunda özel olarak tasarlanmış eğitim materyalleri, öğrencilerin konuları daha kolay anlamaları ve öğrenmeleri gibi eğitim sürecine katkı sağlanmaktadır. Yazıcı ve Erkoç [29] tarafından yürütülen araştırmada, 44 fen grubu (fizik, kimya, biyoloji, fen bilimleri) öğretmenlerinin yapay zekâ kullanım durumlarını incelemiştir. Araştırma, öğretmenlerin yapay zekâ araçlarını tercih etme nedenlerinin kişiselleştirilmiş öğrenme, öğrencilerin ilgisini çekme ve derse daha aktif katılımlarını sağlama gibi eğitim sürecinin önemli unsurlarında etkili olduğunu ortaya çıkarmıştır. Ek olarak Darayseh [30] tarafından yürütülen çalışmada ise, 83 fen bilgisi öğretmenin yapay zekâ uygulamalarının kullanımını etkiyen faktörlerin belirlenmesi amaçlanmıştır. Araştırma sonucunda, yapay zekâ uygulamalarını tercih eden fen bilgisi öğretmenlerin yapay zekâ araçlarının kolay kullanılabilir olmasından dolayı tercih ettikleri görülmüştür [30].

Ayrıca yapay zekâ uygulamaları, öğrencilerin öğrenme süreçlerinin takip edilmesiyle birlikte süreç içerisindeki zayıf ve güçlü yönlerinin belirlenmesine katkıda bulunmakta, öğrenme sürecinin değerlendirilmesini sağlamaktadır. Bu değerlendirmeye dayanarak, öğretim materyalleri düzenlenmektedir. Sanca ve arkadaşlarının [24] yürüttüğü çalışmada, bulanık mantık yaklaşımının fen eğitimindeki kullanım amaçları, yöntemleri ve gerekliliği incelenmiştir. Araştırma sonuçlarında, bulanık mantık yaklaşımının performans değerlendirmesi, akademik başarı tahmini, akademik başarı tespiti ve başarıyı etkileyen faktörlerin belirlenmesi gibi etkili olduğunu ortaya koymuştur. Yorgancı ve Işık [26] tarafından yürütülen çalışmada, yapay sinir ağlarının kullanımıyla fen bilgisi öğretmen adaylarının genel not ortalamalarının sınıflandırılması amaçlanmıştır. 4.sınıf 30 fen bilgisi öğretmen adayının çalışma alışkanlıkları, baskın zekâ alanları, yaş ve cinsiyet gibi değişkenlerin genel not ortalamalarına etkisi incelenmiştir. Yapılan araştırma sonucunda, çok katmanlı algılayıcı ağ modelinin kullanılarak elde edilen verilerle en az hata yapılan ağ yapısının belirlenmiştir. Ayrıca bu sisteminin genel not ortalamalarını sınıflandırmada başarılı olduğu sonucuna varılmıştır [26].

Fen eğitiminde yapay zekânın bir diğer önemli faydası ise öğrencilerin problem çözme ve eleştirel düşünme becerilerini geliştirmesine yardımcı olmasıdır [31, 32]. Yapay zekâ destekli simülasyonlar ve deneyler sayesinde öğrenciler, teorik bilgilerini pratikte uygulama fırsatı bulmakta ve gerçek hayattan örneklerle karşılaşarak konuları daha iyi kavramaktadırlar [33, 34].

Gün geçtikçe değişen ve gelişen yapay zekâ teknoloji ile farklı eğitim alanlarında kullanım potansiyeli artmaktadır. Yapay zekâ teknolojisinin fen eğitim alanında kullanımı, gelecekte daha da yaygınlaşacak ve her eğitim alanına uygulanabilir uygulamalar bulunacaktır.

C. Fen Eğitiminde Kullanılan Bazı Yapay Zekâ Uygulamaları

Gün geçtikçe değişen ve gelişen yapay zekâ teknoloji ile farklı eğitim alanlarında yapay zekâ teknolojisinin kullanım potansiyeli artmaktadır. Yapay zekâ teknolojisinin fen eğitim alanında kullanımı, gelecekte daha da yaygınlaşacak ve her eğitim alanına uygun uygulamalar bulunacaktır.

Diffit for Teachers

Diffit for Teachers, öğretmenlerin okuma metni ve soru hazırlama gibi eğitim materyalleri oluşturma sürecini kolaylaştıran bir platformdur. Diffit for Teachers uygulamasında yer alan yapay teknolojisi ile her sınıf düzeyi ve her konu alanına uygun eğitim materyali hazırlanabilmektedir [35].

MagicSchool.ai

MagicSchool AI, öğretmenlerin iş yükünü hafifletmek ve daha verimli olmalarına yardımcı olmak için tasarlanmış bir yapay zekâ (AI) platformudur. MagicSchool.ai, tarayıcı ve masaüstü için tasarlanmıştır. Bu yapay zekâ aracı sayesinde ders planı oluşturma, öğrenci değerlendirme, soru oluşturma ve deney hazırlama gibi pek çok özelliği bulunmaktadır [36].

PictoBlox

PictoBlox, Scratch gibi blok tabanlı kodlamayı içeren ve yapay zekâ eğitimi için geliştirilmiş bir platformdur. Uygulama içinde veri görselleştirme, nesne tanıma, konuşma tanıma, yapay sinir ağları gibi yapay zeka teknolojilerini içermektedir. Uygulama Windows, MacOS, Linux, Android gibi işletim sistemlerin ücretsiz olarak desteklemektedir. PictoBlox ile öğrenciler, kodlama öğrenmeyi eğlenceli ve ilgi çekici hale getiren blok tabanlı bir eğitimsel kod yazmalarına olanak sağlamaktadır. Bu kodlama uygulaması, öğrencilere projelerini programlama yetenekleri kazandırma, disiplinler arası çalışmalar hazırlama ve projeler üzerinde işbirliği yapma fırsatı sunar [37].

Chat GPT

Chat GPT, Gemini gibi bir yapay zekâ tabanlı bir dil modelidir. OpenAI tarafından geliştirilmiş bir yapay zekâ aracı olup, Gemini gibi metin oluşturma, soru oluşturma veya cevaplandırma, dil çevirisi yapmaktadır [38]. Bu yapay zekâ aracının iki farklı versiyonu bulunmaktadır. ChatGPT 3.5 ücretsiz iken, ChatGPT 4 ücretli olarak kullanılmaktadır.

PlantSnap

PlantSnap, bitkilerin fotoğraflarını çekerek veya galerinizden yükleyerek bitki türlerini tanımanıza yardımcı olan bir mobil uygulamadır [39]. Uygulamaya yüklediğiniz bitki görseli veya uygulama üzerinden çektiğiniz bitki fotoğrafı, uygulamanın veri tabanında bulunan geniş bir bitki türü koleksiyonuyla karşılaştırılır ve uygun olan tür bu şekilde bulunmaktadır. Ayrıca uygulama bitkilerin adlarını, özelliklerini, bakım ipuçlarını ve bitkiyi yetiştirme hakkında bilgi sağlamaktadır.

Labster

Labster, STEM müfredatına uygun olarak tasarlanmış bir sanal laboratuvar simülasyonlarını içeren web tabanlı bir platformdur. Labster, genel biyolojiden organik kimyaya kadar çeşitli konuları kapsayan 289 simülasyon içeren bir kütüphaneye sahip olup, içinde yer alan simülasyonlar lise seviyesinden üniversite düzeyine kadar çeşitli eğitim seviyelerine hitap etmektedir [40]. Simülasyon birinci şahıs deneyimi olarak tasarlanmış ve kullanıcılara rehberlik etmesi için Dr. One adlı bir asistan içermektedir. Simülasyon boyunca Dr. One kullanıcıya görevi talimatları vermekte, rehberlik etmekte ve gerektiğinde kullanıcıyı doğru yola yönlendirmektir. Ek olarak simülasyonun içinde çalışma ile ilgili kısa sınavlar bulunmaktadır. Bu şekilde kullanıcının simülasyondaki eğitim süreci takip edilmektedir [40].

Khan Academy

Khan Academy, çeşitli özelliklere sahip ücretsiz bir çevrimiçi öğrenme platformudur. Öğrencilerin bilgi birikimlerini desteklemeye yönelik tasarlanmış olan bu uygulama, 5.5000'den fazla eğitici videoya ve soru içermektedir. Ek olarak uygulama içinde eğitim sürecinin takibi ve rehberlik sağlamak için koçluk özelliği bulunmaktadır [41].

Gamma.App

Gamma.app, yapay zeka teknolojisinden faydalanan bir sunum, web sayfası ve belge hazırlama platformudur. Kullanıcıların, tasarım gibi teknik ayrıntıları hazırlamalarına gerek kalmadan, sadece fikirlerine odaklanarak çarpıcı içerikler oluşturmalarını olanak sağlamaktadır [42].

IV. SONUÇ

Bu çalışmanın amacı, yapay zekanın fen eğitimi üzerindeki etkisini ortaya koymaktır. Yapay zeka, son yıllarda eğitim alanında önemli bir rol oynamaya başlaması ile fen eğitiminde, yapay zeka teknolojileri öğrencilerin öğrenme sürecini destekleyebilir ve daha etkili bir öğrenme ortamı sağlayabilir. Ancak, fen

eğitiminde yapay zeka teknolojilerinin kullanımını doğru bir şekilde yönetmek önem arz etmektedir. Yapay zeka, fen eğitiminde sadece bir araç olarak kullanılmalıdır. Bu çalışma, yapay zekanın fen eğitimindeki etkisine ve nasıl kullanılabileceğine yönelik çalışma olup, yapay zekanın fen eğitimindeki potansiyelini daha iyi anlamamıza yardımcı olacaktır.

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Assessing Turkey's Sustainable Competitiveness with Border Neighbors: An Integrated LODECI-ARTASI Approach

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Abstract – Sustainable competitiveness, which incorporates natural capital, economic Sustainability, and social capital, is widely recognised as critical for long-term economic stability and prosperity in nations worldwide. This paper assesses Turkey's long-term competitiveness with its border neighbours using a new integrated methodology that incorporates the Logarithmic Decomposition of Criteria Importance (LODECI) and the Alternative Ranking Technique based on Adaptive Standardised Intervals (ARTASI). Using variables from the Global Sustainable Competitiveness Index (GSCI) as defined in the Sustainable Competitiveness Report, this study first evaluates the value of these factors using LODECI. Following that, ARTASI is used to rank the countries, providing a sophisticated picture of Turkey's position in relation to its neighbours as well as strategic recommendations for policymakers looking to improve the region's long-term competitiveness. When we review the results of the provided approach, the most influential criterion for determining sustainability competitiveness is governance efficiency, and Bulgaria has the highest score.

Keywords – ARTASI, LODECI, Sustainable competitiveness.

I. INTRODUCTION

Competitiveness is more than just a country's economic success; it also includes its environmental and social performance [1]. Sustainable competitiveness is increasingly recognized as crucial for nations' long-term economic stability and growth [2], integrating environmental stewardship, social inclusion, and economic development. This holistic approach underscores the importance of integrating sustainability into the core of national competitiveness strategies, extending beyond traditional economic metrics to encompass long-term viability and intergenerational equity. Turkey, situated at the strategic crossroads of Europe and Asia, faces unique competitive pressures and opportunities from its border neighbors. The dynamic socio-economic landscape of the region makes the evaluation of competitiveness a complex, multidimensional challenge, necessitating a refined understanding for effective policy-making and strategic planning.

Numerous studies in the literature have been done to analyse countries' long-term competitiveness using a variety of indices. The European Regional Competitiveness Index [3], the Global Competitiveness Index [1], and the Global Sustainable Competitiveness Index [4] are some of the most used indexes. Notably, the World Economic Forum's Global Sustainable Competitiveness Index (GSCI) is a widely long-term approach in these investigations [5].

The assessment of sustainable competitiveness inherently involves multiple criteria, making it a quintessential multi-criteria decision-making (MCDM) problem [6]. Recent advancements in MCDM methodologies have led to the development of innovative approaches such as the Logarithmic Decomposition of Criteria Importance (LODECI) [7] and the Alternative Ranking Technique based on

Adaptive Standardized Intervals (ARTASI) [8]. These methods offer refined tools for analyzing the intricate aspects of competitiveness. Despite the critical importance of these metrics, there has been limited investigation into Turkey's position relative to its neighbors, highlighting a significant research gap that this manuscript aims to address.

This study employs the LODECI and ARTASI methods to evaluate Turkey's sustainable competitiveness with its border neighbors, introducing a novel integrated MCDM approach that contributes both methodologically and empirically. By providing a deeper insight into the competitive dynamics at the regional level, this research aims to assist policymakers and stakeholders in developing strategies that not only enhance Turkey's economic outputs but also its environmental and social footprints. The primary purpose of this study is to rigorously analyze and offer actionable strategies for enhancing Turkey's sustainable development and economic relations with neighboring countries, thereby supporting sustainable growth and regional stability.

II. Literature Review

Several authors have assessed the sustainable competitiveness of countries with MCDM methods. Lu et al. [9] identified the most effective sustainable improvement strategies with the DEMATEL-based ANP and VIKOR methods. Kiseľáková et al. [10] evaluated the objectivity and consequent value variations of the Global Competitiveness Index (GCI) and World Competitiveness Index (WCI) composite indices among the EU (24) countries from 2006 to 2016. Kiseľáková et al. [6] examined the relationship between global competitiveness, business environment, and human development in 28 EU nations from 2006 to 2017. [3] measured the competitiveness of the NUTS 2 (Nomenclature of Units for Territorial Statistics) regions of the 28 European Union Member States using the TOPSIS method. Despotovic et al. [11] utilised panel data linear regression analysis based on a sample of 30 European countries for the social dimension of sustainable competitiveness. Činčikaitė and Meidutė-Kavaliauskienė [12] evaluated the competitiveness of Baltic capitals by SAW and TOPSIS evaluation methods in 2016–2019. Cheba et al. [13] examined the ability of the economies of selected countries to compete in a sustainable way using selected statistical approaches. Činčikaitė and Meidute-Kavaliauskiene [14] applied the SAW and COPRAS methods for competitiveness assessment of the Baltic capitals in the period 2014–2019. (Bilbao-Terol et al. Ghag et al. [15] offered a combination of fuzzy Delphi and neutrosophic DEMATEL for identifying and determining cause-and-effect relationships between international sustainable competitiveness determinants for small and medium enterprises. Štilić et al. [16] applied Entropy and MARCOS (Measurement Alternatives and Ranking according to the Compromise Solution) methods for the evaluation of the competitiveness of Balkan countries for the year 2022 investigated the relative importance of GSCI pillars towards GSCI while considering their interdependence in a probabilistic network context using a Bayesian Belief Network model. Kara et al. [17] investigated Turkey's sustainable competitiveness with border neighbours by developing an integrated methodology consisting of MEREC-AROMAN.

Some research in the literature focused on long-term competitiveness to better understand a country's standing among others. In addition, other authors concentrated on this topic and employed statistical analysis. While Kara et al. [17] attempted to assess Turkey's status using a hybrid MCDM approach based on GSCI indicators, they used the MEREC-AROMAN method for the year 2022. However, as far as we know, no study in the available literature has investigated Turkey's sustainable competitiveness using the LODECI-ARTASI technique using 2023 GSCI indicators.

III. Research Methodology

The proposed approach for evaluating sustainability competitiveness levels to Turkey and its neighbouring countries includes the LODECI and ARTASI methods with the following steps:

A. LODECI Method

Step 1: Develop the decision matrix.
Step 2: Normalize the decision matrix.
Step 3: Calculate the Decomposition Value (DV) of each decision matrix element.

Step 4: Compute the Logarithmic Decomposition Value (LDV) of each criterion.
Step 5: Obtain the importance levels of the criteria.

B. ARTASI Method

Step 1: Construct the decision matrix.
Step 2: Find absolute minimum and maximum values.
Step 3: Normalize the decision matrix.
Step 4: Determine the degree of usefulness of alternatives.
Step 5: Specify aggregated degrees of utility of alternatives.
Step 6: Calculate of final utility functions and rank the alternatives.

IV. APPLICATION OF THE LODECI-ARTASI APPROACH TO EVALUATE THE SUSTAINABLE COMPETITIVENESS

In this study focusing on Turkey's sustainable competitiveness with border neighbours in 2023, six criteria were used: natural capital, resource intensity, social capital, intellectual capital, economic sustainability, and governance efficiency. The scores for these criteria were from the GSCI 2023 report. The investigation covered seven countries: Greece, Bulgaria, Turkey, Georgia, Armenia, Azerbaijan, and Syria. The decision matrix is given in Table 1.

Table 1. The decision matrix

	Natural capital	Resource intensity	Social capital	Intellectual capital	Economic sustainability	Governance efficiency
Greece	38.80	43.90	51.10	45.50	52.10	62.70
Bulgaria	50.10	35.60	49.00	38.80	47.10	66.20
Turkey	45.90	26.80	39.40	58.60	50.30	51.00
Georgia	49.30	29.40	50.90	41.60	40.40	56.90
Armenia	39.90	28.70	60.70	39.30	39.10	58.20
Azerbaijan	42.00	27.70	44.60	42.00	33.50	44.70
Syria	40.40	33.60	33.00	35.40	32.40	33.50

The research application progressed in two independent levels. Initially, criterion weights were determined using the LODECI approach in the first step. Later, in the second step, the countries were rated using the ARTASI technique. The research methodology section explains the steps of this application in a systematic manner.

The criterion weight was derived and shown in Fig. 1 as part of the computation process.

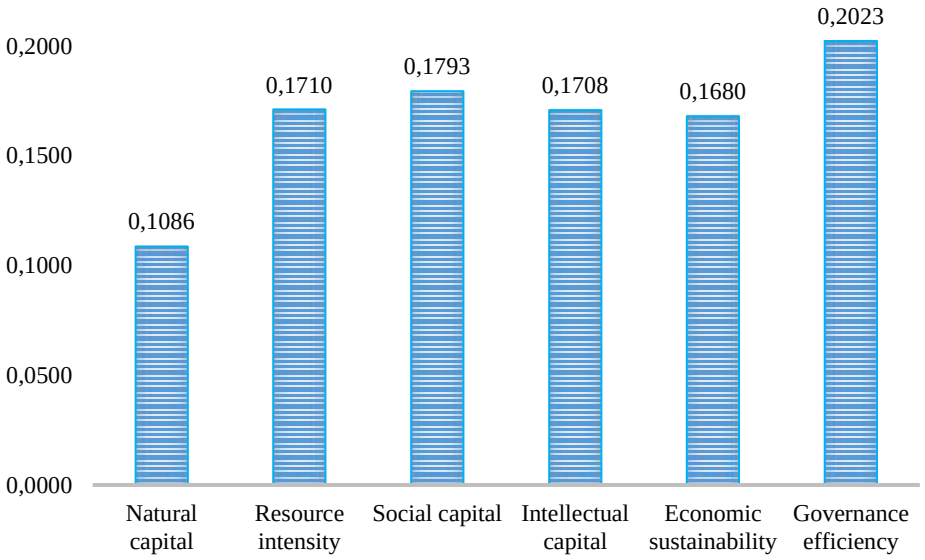

Fig. 1. The weights of criteria

The utility functions matrix was constructed with stated parameters $\psi = 0.5$ and $\tau = 1$ for each country. The final country rankings are shown in Table 2.

Table 2. The ranking of countries

	The final utility function values	Rank
Greece	50.0414	2
Bulgaria	52.7874	1
Turkey	45.3303	4
Georgia	47.3374	3
Armenia	40.9462	5
Azerbaijan	33.5664	6
Syria	15.1248	7

This study suggests that governance efficiency is the most significant factor influencing Turkey's and its neighbouring countries' long-term competitiveness. Social capital emerged as the second-most important factor. The sustainable competitiveness rankings are as follows: Bulgaria, Greece, Georgia, Turkey, Armenia, Azerbaijan, and Syria.

V. CONCLUSION

This study provides a comprehensive assessment of Turkey's sustainable competitiveness in relation to its border neighbors using an integrated approach with the LODECI-ARTASI approach. Our findings reveal that governance efficiency stands as the most significant factor influencing the long-term competitiveness of Turkey and its neighboring countries. This underscores the pivotal role that effective and transparent governance plays in fostering a competitive environment that is sustainable and conducive to economic growth. Social capital emerged as the second-most important factor, highlighting the crucial impact of social networks, cultural norms, and trust in promoting economic development and resilience. The importance of social capital in this context illustrates how social structures and relationships can drive or hinder the economic performance and sustainability of nations.

The sustainable competitiveness rankings derived from our study place Bulgaria at the top, followed by Greece, Georgia, Turkey, Armenia, Azerbaijan, and Syria. These rankings not only reflect the current state of sustainable competitiveness but also offer insights into the potential areas where each country can improve by addressing their specific challenges related to governance and social capital.

The implications of these findings are significant for policymakers and stakeholders in the region. By understanding the critical factors that drive sustainable competitiveness, strategies can be formulated to strengthen governance structures and enhance social capital, thereby improving the long-term economic prospects and stability of these countries. In conclusion, this research highlights the necessity of focusing on governance and social capital to enhance the sustainable competitiveness of Turkey and its border neighbors. It provides a strategic framework that can guide future initiatives aimed at promoting economic stability and sustainable growth across the region.

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The Impact of Fracture Orientation on Particle Transport Behaviour

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Abstract **–** The current study employs Lagrangian particle tracing to investigate the impact of fracture orientation on particle transport, a critical factor in various geological and engineering applications. Understanding how different fracture orientations affect particle movement is essential for optimizing processes such as pollutant transport in groundwater and oil recovery in fractured reservoirs. The simulation models particle motion by solving Newton's second law and force balance equations, tracking their trajectories through fractures with orientations of vertical (90°), inclined (45°), horizontal (0°), and downward (-45° and -90°). The findings reveal distinct trends in particle transport based on fracture orientation. Vertical fractures (90°) demonstrate the highest recovery rates, indicating the most efficient pathways for particle movement. Inclined fractures (45°) also show relatively high recovery rates, while horizontal fractures (0°) exhibit moderate recovery rates. Downward-oriented fractures (-45° and -90°) present the lowest recovery rates, suggesting increased gravitational resistance and path complexity. Hence, optimizing fracture orientation, particularly favoring vertical and positively inclined fractures, is essential for enhancing particle recovery in systems where transport through fractures is crucial.

Keywords – Fracture, Particule, Transport, Orientation, Angle.

I. INTRODUCTION

Fractures are defined as geological discontinuities that play a critical role in various fields, such as hydrogeology and petroleum engineering. These naturally or artificially induced joints significantly impact and enhance the permeability of host rocks, thereby influencing fluid flow and particle circulation within the subsurface. In hydrogeology, fractures serve as primary pathways for groundwater movement [1], affecting aquifer recharge and contaminant migration. In the petroleum industry, understanding fracture networks is essential for optimizing hydrocarbon extraction, particularly in unconventional reservoirs like shale gas and tight oil [2].

Stress fields, tectonic movements, and thermal expansion can create fractures with various orientations and shapes [2]. Hence, considering fracture orientation is imperative in particle transport because it dictates the available pathways for movement. Renner et al. (2009) [3] studied the effect of particle orientation on composite strength, emphasizing the importance of orientation and distribution. Furthermore, Dandekar (2020) [4] analyzed the response of HMX-Sylgard samples to impact and vibration, considering crystal orientation and cleavage planes. Ding et al. (2021) [5] developed a methodology to simulate reactive particle transport in randomly oriented rough fractures, examining the effect of dominant factors on particle transport behavior. Overall, these studies collectively contribute to understanding the influence of fracture

orientation on particle transport and retention in fractured media. The orientation of fractures affects not only the distance that particles can travel but also their deposition patterns. This study aims to investigate the impact of fracture orientation on particle transport in fractured media through a combination of numerical modeling and sensitivity analysis. By systematically varying the orientation of fractures and analyzing the resulting transport behavior, this research seeks to identify the key mechanisms driving particle movement and quantify the sensitivity of transport parameters to fracture orientation. The findings of this study will contribute to a better understanding of particle transport in fractured media.

II. METHODOLOGY

To examine the effect of fracture orientation on particle transport in fractured media, this study employs a Lagrangian particle tracing module using COMSOL Multiphysics software. A 3D parallel plate fracture with dimensions of 50×100 mm² and an aperture of 1.5 mm is constructed. A sensitivity analysis is then developed by varying inclination angles to analyze the impact of fracture orientation (Figure 1).

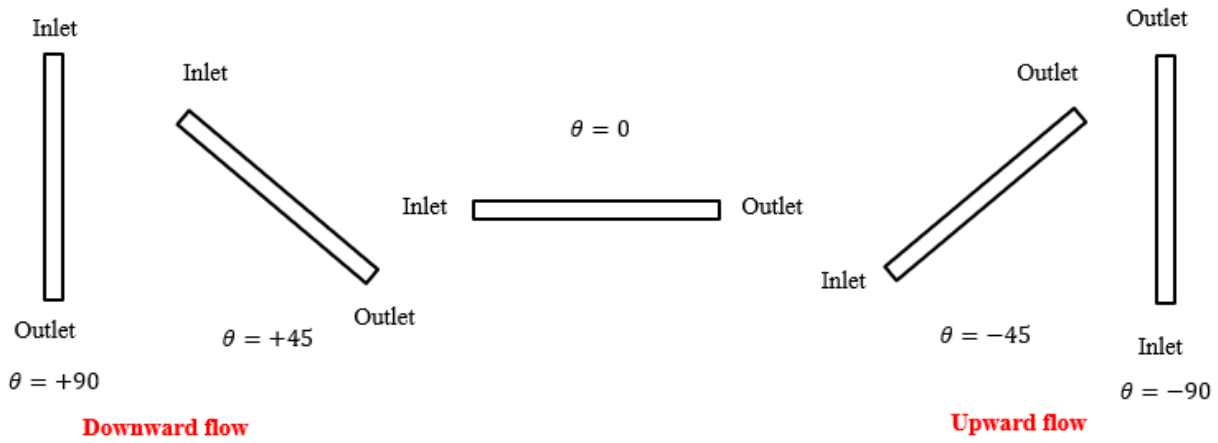

Fig 1. Fracture inclination scenario adopted in this study.

A. *Fluid flow*

The fluid flow is governed by the incompressible Navier-Stokes equations [2] :

$$\rho_f \frac{\partial u_f}{\partial t} + \rho_f (u_f \cdot \nabla) u_f = \nabla \cdot [-pI + K] + F \quad (1)$$

$$\rho_f \nabla \cdot u_f = 0 \quad (2)$$

With ρ_f is the fluid density, u_f is the fluid velocity, ∇p is the pressure gradient, F denote the momentum exchange term, and K is the liquid stress tensor.

B. *Particle trajectory*

A Lagrangian particle tracing simulation is employed to simulate the motion of particles and analyze their trajectories in detail. This method involves solving Newton's second law and force balance equations, allowing for precise tracking of individual particle movements. The simulation accounts for various forces acting on the particles, including gravitational forces, drag forces, and interaction forces between particles and boundaries as follows:

$$m \frac{d\,U}{dt} = \sum F_t \quad (3)$$

Where m and U are the particle masse and velocity respectively, and F_t denote the sum of F_g the gravity and F_d the drag forces.

The gravity force is given as [6]:

$$F_g = \frac{4}{3}\,\pi\, d_p^3(\rho_p - \rho_f).\, g \tag{4}$$

The drag force on a spherical particle is determined by Stokes' law:

$$F_d = \frac{C_D\, {u_f}^2 \rho_f \pi d_p^2}{8} \tag{5}$$

$$C_D = \begin{cases} \dfrac{24}{Re_p} & Re_p \le 0.5 \\ \dfrac{24\left(1 + 0.15{Re_p}^{0.687}\right)}{Re_p} & 0.5 < Re_p < 1000 \\ & Re_p > 1000 \end{cases} \tag{6}$$

$$Re_p = \frac{\rho_f u_f d_p}{\mu} \tag{7}$$

with $d_p$and $\rho_p$are the particle diameter and density, $\rho_f$and μ are the water density and viscosity, C_D is the drag coefficient and Re_p is the particle Reynolds number.

To resemble the phenomena of particle injection, N_0 Particles have been generated with uniform assigned initial positions starting from the inlet of the fracture. particle and fluid properties are represented in Table 1.

Fracture orientation angles are varied within a specified range (e.g., 0° to 90°) while keeping other parameters constant. This allows for the isolation of the effect of orientation on transport.

Table 1. Simulation parameters

Particles property		
Injected particle number at the inlet	10000	
Particle diameter	1	10^{-6} m
Particle density	2200	kg/m^3
Fluid property		
Water density	1000	kg/m^3
Water viscosity	0.001	Pa.s
Water inlet velocity	0.30	10^{-2}m/s

III. RESULTS AND DISCUSSION

The results of the numerical simulations and sensitivity analysis provide valuable insights into the impact of fracture orientation on particle transport.

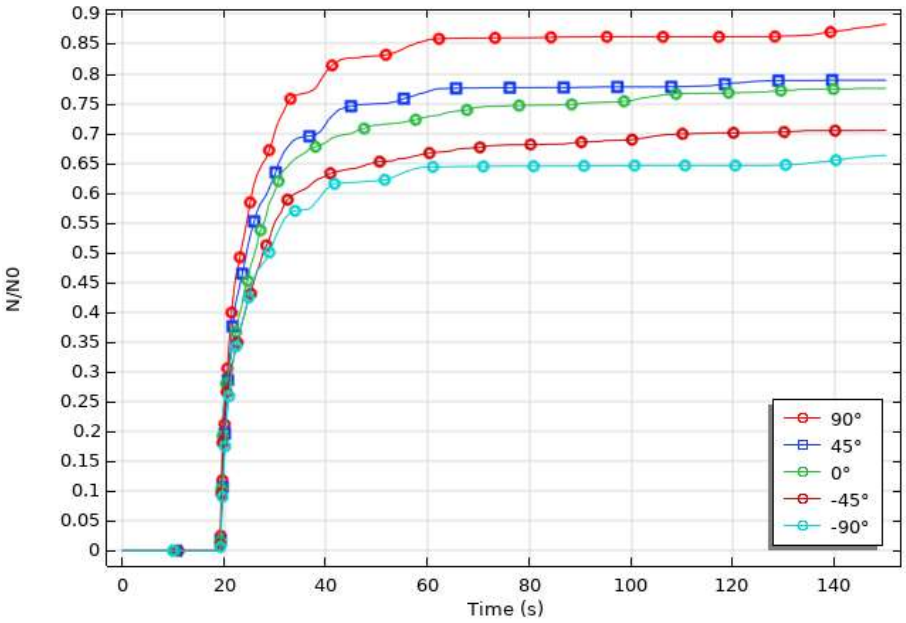

Figure 2. The normalized particle numbers at different fracture orientations.

Figure 2 shows the impacts of fracture orientation on the normalized number of recovered particles (N/N0) over time. Initially, all fracture orientations exhibit a rapid increase in particle recovery within the first 20 seconds, indicating that particles quickly begin to move through the fractures, regardless of orientation.

As time progresses, the differences in recovery rates become more pronounced, highlighting the significant impact of fracture inclination angles. Upward flow in vertical fractures (90°) achieves the highest recovery rates, demonstrating that they provide the most efficient pathways for particle movement. The upward orientation of these fractures likely minimizes resistance and offers direct pathways for particles, leading to efficient recovery.

Inclined fractures at 45° also show relatively high recovery rates, although they are slightly less efficient than vertical fractures. The upward inclination of these fractures still facilitates effective particle transport, albeit with added complexity compared to vertical pathways.

Horizontal fractures (0°) exhibit moderate recovery rates, as their orientation presents more obstacles and longer paths for particles, which can slow down recovery rates.

Downward-oriented fractures (-45° and -90°) show the lowest recovery rates. The downward inclination likely increases gravitational resistance and path complexity, hindering particle movement and reducing recovery efficiency.

IV. CONCLUSION

The study examined the impact of fracture orientation on particle transport with varying fracture inclination angles. The findings suggest that optimizing fracture orientation is crucial for maximizing particle recovery in systems where particle transport through fractures is a key process. Upward-oriented fractures, particularly vertical (90°) and inclined (45°) fractures, are preferable for enhancing recovery efficiency. In contrast, downward-oriented fractures are less effective and should be minimized to improve particle recovery rates.

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Öğretmen Adaylarının Özel Eğitimde Aile Eğitimi Dersi Kapsamında Gerçekleştirdikleri Aile Eğitimi Oturumuna Yönelik Deneyimleri

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Özet **–** Özel eğitim öğretmenliği müfredatında yer alan Özel Eğitimde Aile Eğitimi dersinin içeriğine bakıldığında ailelere öğretme becerilerinin kazandırılması, aile eğitim programlarının hazırlanması, uygulanması ve değerlendirmesine yönelik ifadeler yer almaktadır. Bu doğrultuda Gaziantep ilinde yer alan bir üniversitenin özel eğitim bölümünde eğitim gören öğretmen adaylarından gönüllü olanlar ders kapsamında özel gereksinimli çocuk ailesiyle aile eğitimi oturumu uygulaması yapma deneyimi yaşamıştır. Bu araştırmada özel eğitim öğretmen adaylarının Özel Eğitimde Aile Eğitimi dersi kapsamında gerçekleştirdikleri aile eğitimi oturumuna yönelik ve derse yönelik deneyimlerinin belirlenmesi amaçlanmaktadır. Araştırmanın katılımcılarını dört özel eğitim öğretmen adayı oluşturmaktadır. Araştırma verileri yarı yapılandırılmış görüşme formunun Google Formlar aracılığıyla katılımcılara iletilmesiyle toplanmıştır. Elde edilen verilerin analizi içerik analiziyle gerçekleştirilmiştir. Analiz sonrasında üç ana tema ve 10 alt tema ortaya çıkmıştır. Araştırma sonucunda elde edilen bulgulara bakıldığında özel eğitim öğretmen adaylarının bu derse yönelik hazırlık yapmayı ve sorumlulukların zorlayıcı olduğunu düşünmelerine rağmen yerine getirerek bilgi sahibi olduklarını düşündükleri görülmektedir. Öğretmen adayları aile eğitim oturumu sürecinde makale okumaları ve materyal hazırlığı yaptıklarını, hazırlık yaparken öğretim elemanlarından destek aldıklarını, uygulama sürecinin olumlu deneyim sağladığını ve yeterlilik düşüncelerini arttırdığını ifade etmişlerdir. Görüş ve önerilerine bakıldığında ise, bu deneyimin aile eğitimine yönelik teorik bilgilerini anlamlandırmada faydalı olduğu ve kendilerine katkı sağladığını vurgulamışlardır. Yanı sıra gelecek dönemlerde dersi alacak diğer öğretmen adaylarının da aile eğitimi oturumunu bir aileye uygulama yaparak deneyimlemelerinin onlara katkı sağlayacağını düşündüklerini belirtmişlerdir.

Anahtar Kelimeler – Özel eğitim, *Öğretmen adayları, Aile eğitimi, Aile eğitimi oturumu, Fenomenoloji,*

I. GİRİŞ

Özel eğitim özel gereksinimli bireylerin akranlarından gelişim ve akademik alanlarda geride seyir gösteren bireylere alanında uzman kişiler tarafından bireyselleştirilmiş eğitim programları doğrultusunda sunulan eğitimdir [1]. Bu eğitim sürecinde özel gereksinimli bireye bire bir eğitim sunulması oldukça önemli görülmesinin yanı sıra ailelerinin de çocuklarının eğitim süreçlerine dahil edilerek onları desteklemeleri ilerlemenin sağlanması, kalıcı olması ve günlük yaşam alanlarına da genellemelerinde etkili olmaktadır [2]. Bu doğrultuda aile eğitimi, özel gereksinimli bireylerin ailelerinin bilgi sahibi olması ve onları beceri öğretmeye hazır hale getirmek için oluşturulan, sistematik, uzmanlar tarafından sunulan ve bilimsel temeli olan eğitimlerdir [3]. Aile eğitimleri oturumlar halinde gerçekleştirilmektedir. Bu oturumlar genellikle hazırlık yapılması, eğitim oturumunun uygulanması ve eğitim oturumu sonrasında değerlendirme yapılması olarak gerçekleştirilmektedir [4].

Özel eğitim öğretmenliği bölümünde eğitim gören öğretmen adayları meslek yaşantılarına adım atmadan önce aile eğitimine yönelik eğitim almaktadır. Bu bağlamda geliştirilen müfredatlara

bakıldığında da özel gereksinimli çocukların ailelerinin eğitilmesine yönelik dersin yer aldığı görülmektedir. Yüksek Öğretim Kurumu (YÖK) tarafından 2018 yılında hazırlanan ve hala üniversitelerin ilgili bölümlerinde okutulmaya devam edilen müfredatta da bu ders "Özel Eğitimde Aile Eğitimi" adıyla yer almaktadır. Bu dersin içeriğinde ailelere öğretme becerilerinin kazandırılması, aile eğitim programlarının hazırlanması, uygulanması ve değerlendirmesine yönelik ifadeler yer almaktadır [5]. Yanı sıra 2018 yılı öncesinde YÖK tarafından hazırlanan müfredatta da bu dersin "Aile Eğitimi ve Rehberliği" adıyla yer aldığı görülmektedir.

Alanyazında gerçekleştirilen araştırmalara bakıldığında Yıldırım Parlak (2023) araştırmasında özel eğitim öğretmen adaylarının hazırladıkları aile eğitim programları ve el kitapçıklarının incelenmesini amaçlamıştır. Araştırmada 25 aile eğitim programı ve el kitapçığı incelenmiştir. İnceleme sonucunda kavram öğretimi ve günlük yaşam becerileri çoğunlukta olmakla birlikte farklı becerilerin hedeflendiği, yanlışsız öğretim yöntemleri çoğunlukla olmakla birlikte doğrudan öğretim ve video model öğretim yönteminin ailelere öğretilmesinin hedeflendiği görülmektedir. Öğretmen adaylarının aile eğitim programını uygun olarak hazırladıkları görülürken kaynaklardan yararlanma konusunda desteklenmeleri gerektiği ortaya çıkmıştır [6]. Vural Batık ve Bayrakdar (2017) tarafından yapılan araştırmada 2018 öncesi müfredatta yer alan Aile Eğitimi ve Rehberliği dersini alan son sınıf öğretmen adaylarının görüşlerinin incelenmesi amaçlanmıştır. Öğretmen adaylarının sınıf içerisinde gerçekleştirilen aile eğitimi uygulamalarına yönelik olumlu kazanımlara sahip oldukları, algılarında ve tutumlarında da değişiklikler olduğu ortaya konmuştur. Yanı sıra öz yeterlik algılarında da olumlu artış olduğu belirtilmiştir [7].

Gerçekleştirilen araştırmalar kapsamında özel eğitim öğretmen adaylarının aile eğitimi dersi ve bu kapsamda özel gereksinimli çocuk ailesiyle gerçekleştirilen uygulamalara yönelik deneyimlerinin belirlenmesi ihtiyacı ortaya çıkmıştır. Bu doğrultuda bu araştırmada "Özel Eğitimde Aile Eğitimi" dersini alan ve özel gereksinimli çocuk ailesiyle aile eğitim oturumu deneyimi gerçekleştiren özel eğitim öğretmen adaylarının deneyimlerinin incelenmesi amaçlanmıştır.

II. MATERYAL VE YÖNTEM

Araştırmanın Modeli

Araştırmada Özel Eğitimde Aile Eğitimi dersini almış özel eğitim öğretmen adaylarının bu derse ve ders kapsamında özel gereksinimli çocuğu olan aileyle gerçekleştirdikleri aile eğitimi oturumuna yönelik deneyimlerinin belirlenmesine yönelik nitel araştırma desenlerinden biri olan fenomenoloji (olgubilim) yöntemi kullanılmıştır. Fenomenoloji, bireylerin yaşadıkları deneyimlerin özünü tanımlamayı sağlayan ve bu deneyimlerin "neyi" ve "nasıl" sorularını kullanarak derinlemesine betimlenmesini içeren bir desendir [8]. Araştırmada öğretmen adaylarının deneyimlerine yönelik bilgiler yarı yapılandırılmış görüşme formundaki sorular aracılığıyla elde edilmiştir.

Katılımcılar

Araştırmanın katılımcıları Gaziantep ilinde yer alan bir üniversitenin özel eğitim öğretmenliği bölümünde eğitim gören ve Özel Eğitimde Aile Eğitimi dersini alan öğretmen adaylarından oluşmaktadır. Katılımcıların belirlenmesi sürecinde 2023-2024 eğitim öğretim yılı bahar döneminde aile eğitimi dersi alan 37 özel eğitim öğretmen adaylarıyla yürütülen ders kapsamında geliştirecekleri aile eğitim programını özel gereksinimli çocuğu olan bir anneyle uygulama deneyimi sağlayabilecekleri ve araştırmanın amacı, onam süreci, elde edilen verilerin araştırma dışında farklı bir amaçla kullanılmayacağı vb. açıklanmıştır. Yanı sıra araştırma süreci boyunca çekilme hakları olduğu da belirtilmiştir. Gönüllü olan dört öğrenci araştırmaya katılmayı kabul etmiştir. Öğretmen adaylarına ilişkin bilgiler Tablo 1'de gösterilmektedir.

Tablo 1. Öğretmen Adaylarına İlişkin Bilgiler

Öğretmen Adayı	Yaş	Cinsiyet	Sınıf Düzeyi	Oturum Sorumluluğu
Lale	27	Kadın	3.sınıf	Hedef beceriye yönelik bilgi sunma
Süeda	23	Kadın	3.sınıf	Belirlenen yönteme yönelik bilgi sunma
Sedat	22	Erkek	3.sınıf	Yöntemin hedef beceriyle uygulanmasına yönelik bilgi sunma
Sertap	24	Kadın	3.sınıf	Aileyle birlikte sırasıyla rol oynama

Tablo 1'de yer aldığı üzere katılımcı özel eğitim öğretmen adaylarının 22-27 yaşları arasında olduğu görülmektedir. Katılımcıların üçü kadın ve biri erkektir. Tüm katılımcılar eğitimlerinin üçüncü sınıf düzeyindedir.

Veri Toplama Aracı

Araştırmada özel eğitim öğretmen adaylarının görüşlerine yönelik veri toplanması amacıyla yarı yapılandırılmış görüşme sorularının yer aldığı form hazırlanmıştır. Görüşme formu hazırlanırken öncelikle alanyazında yer alan kavramlar ve benzer araştırmalar incelenmiştir. Ardından görüşme sorularına yönelik bir havuz oluşturulmuştur. Bu sorular özel eğitim alanındaki üç uzmana gönderilerek görüşleri alınmıştır. Uzman görüşü sonrası görüşme formuna son hali verilmesiyle dokuz açık uçlu sorudan oluşmuştur.

Verilerin Toplanması ve Analizi

Özel eğitimde aile eğitimi dersi 2023-2024 bahar döneminde gerçekleştirilmiştir. Ders haftada iki saat olmak üzere 15 hafta boyunca gerçekleştirilmiştir. Dersin sorumlulukları arasında aile eğitim programı ve el kitapçığı hazırlama sorumlulukları bulunmaktadır. Araştırmanın yürütüldüğü üniversiteye bağlı olan özel eğitim uygulama ve araştırma merkezinde çocuğu (Down Sendromu tanısı, 7 yaş, kız) eğitim alan bir annenin çocuğuyla var olan olay doğrultusunda duyguları yansıtma becerisini çalışmaya gereksinimi olması üzerine öğretmen adaylarına gönüllü katılımlarıyla uygulama deneyimi gerçekleştirebilecekleri bildirilmiştir. Gönüllü katılımcı olmak isteyen dört öğrenciye araştırmacı tarafından aile eğitimi oturumunda hedeflenen beceri, kullanılması planlanan yöntem (zihin kuramı) ve oturumlardaki sorumluluklar aktarılmıştır. Ardından oturumdaki sorumluluklar kura yapılarak öğrencilere dağıtılmıştır. Hedeflenen beceri ve yönteme yönelik çalışmaları ve deneyimi olan öğretim elemanına öğrenciler yönlendirilerek aileyle çalışılma sürecinde nasıl uygulama yapacakları hakkında bilgi sahibi olmaları sağlanmıştır. Yanı sıra aile eğitim oturumu gerçekleştirilmeden üç gün önce araştırmacıyla katılımcılar bir araya gelerek hazırlıklarını tamamlamışlar ve dönütler verilmiştir. Aile eğitimi oturumunun uygulanmasına 10.05.2024 tarihinde başlanmıştır. Uygulama sürecinde hedef beceriye yönelik bilgi sunma, belirlenen yönteme yönelik bilgi sunma, yöntemin hedef beceriyle uygulanmasına yönelik bilgi sunma ve aileyle birlikte sırasıyla rol oynama olmak üzere dört oturum özel eğitim öğretmen adayları tarafından gerçekleştirilmiştir.

Öğretmen adaylarının aile eğitim oturumlarına yönelik görüşlerine dair veri toplama sürecinde eğitim öğretim döneminin sonuna gelinmesi ve yüz yüze gelinememesi nedeniyle görüşme formu Google Formlar uygulamasıyla açık uçlu sorular halinde iletilmiştir. Formun ilk maddesi olarak araştırmaya gönüllü katılımlarına yönelik onay maddesi yer almıştır ve tüm katılımcılar bu maddeyi "evet" olarak yanıtlamıştır. Verilerin toplanması katılımcıların görüşlerini detaylı bir şekilde yazmalarını içermesi nedeniyle 08.07.2024-12.07.2024 tarihleri arasındaki beş gün içerisinde gerçekleşmiştir. Google formlardan veriler indirilip kontrol edildiğinde 20 sayfa veri elde edilmiştir.

Elde edilen verilerin analizine yönelik içerik analizi gerçekleştirilmiştir. İçerik analizinde verilerin açıklanmasına imkan tanıyan kod, alt tema ve temaların ortaya konulmasını içermektedir [9]. Bu doğrultuda elde edilen veriler okunmuş ve tekrarlı olarak geçen ifadeler belirlenerek kodlar ortaya çıkmıştır. Birbirleriyle ilişkili olan kodlar bir araya getirilerek alt tema ve temalar ortaya çıkarılmıştır.

III. BULGULAR

Özel eğitim öğretmen adaylarının görüşme formundaki sorulara verdileri yanıtların analizi sonucunda elde edilen bulgular bu başlık altında yer almaktadır. Elde edilen bulgular, Özel Eğitimde Aile Eğitimi dersini alan ve aile eğitimi oturumu deneyimi yaşayan özel eğitim öğretmen adaylarının deneyimlerine yönelik görüşlerini içermektedir. Elde edilen bulgular üç ana tema ve 10 alt temadan oluşmaktadır. Bu başlık altında ana temalar ve alt temalar tablolaştırılarak sunulmuştur.

Tablo 2. Özel Eğitimde Aile Eğitimi Dersine Yönelik Görüşler

Ana Tema	Alt Tema
Özel Eğitimde Aile Eğitimi Dersine Yönelik Görüşler	Dersin işlenişi
	Derse hazırlık
	Kendilerinden beklenen sorumluluklar

Özel eğitim öğretmen adayları, Özel Eğitimde Aile Eğitimi dersinin işlenişine yönelik hem teorik hem de uygulama sürecine yönelik bilgilerin verilerek işlendiğine yönelik görüş belirtmişlerdir. Öğretmen adayı Sertap, *"..Bir beceriyi öğretirken aileye nasıl öğretileceği, hangi yöntemin kullanılacağını, ailelerin pekiştireçleri nasıl kullanılacağını, aile ile toplantıların nasıl düzenlenir, el kitabı hazırlanışını öğrenmiş bulunuyorum."* ifadesiyle dersin içeriği hakkında görüşünü belirtmiştir. Lale ise, *"...keyifli ve verimli geçmesinin önemli bir kısmının öğretim elemanının bu dersin içeriğini örneklerle daha da somutlaştırarak anlatmasıdır."* diyerek dersin işlenişi esnasında örnekler sunulduğunu ifade etmiştir.

Derse hazırlığa yönelik olarak Sedat, "*Bu derse hocamızın da isteği üzere verimli bir şekilde not alarak hazırlandım, ders başlamadan önce hocamızın önceki haftalarda araştırmanızda ve okumanızda fayda var denilen makaleleri okudum derste bunları yorumladık.*" ifadesiyle notlar aldığını ve ders sürecinde makale okuyarak hazırlık yapıldığını belirtmiştir. Ders esnasında kendilerinden beklenen sorumluluklar hakkında ise Sertap "*Sorumluluklarımız derste not alma, verilen makaleyi okuma, okuduğumuz makale hakkında sınıfta düşüncelerimizi paylaşma, ilgili ödevleri yapmak oldu. Görevlerimiz bizim için verimli olduğunu düşünüyorum.*" ve Süeda, *"...ileride çalışacağımız ailelere faydalı olabilmek için dersin sorumluluklarını yerine getirmemiz gerekiyor."* diyerek dersin sorumluluklarının kendileri için verimli olduğunu ve meslek yaşantısında kullanmaları için lazım olacağını belirtmişlerdir.

Tablo 3. Aile Eğitimi Oturumuna Yönelik Görüşler

Ana Tema	Alt Tema
Aile Eğitimi Oturumuna Yönelik Görüşler	Oturumdaki sorumluluklar
	Alınan destek
	Uygulama yapmaya yönelik düşünceler
	Ailelerle çalışmaya yönelik yeterlilik

Araştırmanın ikinci ana teması olan aile eğitimi oturumuna yönelik görüşlere bakıldığında özel eğitim öğretmen adaylarının oturumda farklı sorumluluklara sahip oldukları, süreçte destek aldıkları, uygulama yapmanın kendileri için aile eğitimine yönelik bilgilerini pekiştirdiğini ve kendilerindeki yeterlilik düşüncesini olumlu etkilediği ortaya çıkmıştır. Oturumdaki sorumluluklarına yönelik Lale, "*Bu oturumda duygu nedir, ne işe yarar, duyguların amacı, duyguları tanıma neden önemli, duyguları anlamak*

neden önemli, çocuklara duyguları öğretiminin faydaları nelerdir gibi başlıklar üzerinde bu konuyla ilgili makalelerden faydalanarak aileye bu konuda bilgi verdim." diyerek aileye hedef beceriye yönelik bilgi vermeye yönelik hazırlık yaptığını ifade etmiştir.

Aile eğitim oturumu sürecinde alınan desteğe yönelik Sertap, "*Dersimizin hocasından beceri ile ilgili ailelere daha iyi nasıl anlatabiliriz diye fikir alışverişinde bulunduk. Hocamız bizlerin hazırlamış olduğu slaytı ve kartları kontrol ederek yönlendirmeler yapmıştır."* ve Lale "*Sorumlu olduğum oturumla ilgili dersi aldığım öğretim elemanı ve bölümde olan farklı öğretim elemanından da destek aldım.*" diyerek hem dersin öğretim elemanı hem de konuyla ilgili çalışması ve deneyimi olan farklı bir öğretim elemanından destek aldığını belirtmişlerdir.

Öğretmen adaylarının uygulama yapmaya yönelik düşüncelerine bakıldığında Sedat, "*Gerçekleştirdiğim aile eğitimi oturumu gerçek bir öğrencinin ailesiyle yaptığım ilk buluşmaydı bu yüzden çok heyecanlıydım ve mesleğimi daha çok benimsememe yardımcı oldu bu oturum."* Diyerek özel gereksinimli çocuk ailesiyle ilk defa eğitim gerçekleştirme fırsatı bulduğunu belirtmiştir. Ailelerle çalışmaya yönelik yeterlilik konusunda Lale, "*Aileyle çalışmam ilk tecrübeydi öncesinde herhangi bir deneyimim olmadığı için yeterli yeterliliğe sahip değildim. Aile ile oturum gerçekleştirdikten sonra bu konuda daha fazla tecrübeyle gerekli yeterliliğe sahip olacağımı düşünüyorum.*" ifadesiyle kendisinin ailelerle çalışma konusunda öncesine göre daha yeterli olacağını düşündüğünü belirtmiştir.

Tablo 4. Görüş ve Öneriler

Ana Tema	**Alt Tema**
Görüş ve Öneriler	Dersi alacak öğretmen adaylarının deneyimlemesini isteme
	Katkı sağladığına inanma
	Aile eğitimiyle ilgili bilgilerini pekiştirme

Araştırmanın son ana teması olan görüş ve önerilerde, bu dersi gelecekte alacak öğretmen adaylarının da deneyimlemesini istedikleri, bu deneyimin kendilerine katkı sağladıklarına inandıkları ve aile eğitimiyle ilgili bilgilerini pekiştirdiği görülmüştür. Sertap, "*Hocamız seneye bu dersi tekrardan verecek olursa sınıftaki herkesi uygulama merkezinde gerçek aileler ile bu deneyimi yasamalarına imkan sağlamalarını isterdim.*" ifadesiyle gelecek yıllarda dersi alacak diğer öğretmen adaylarının da özel gereksinimli çocuk ailesiyle aile eğitim oturumu deneyimi olmasını istediği görülmektedir. Katkı sağladığına inanmaya yönelik Sedat, "*…o aileye çocuğun hayatını kolaylaştırmayı etkileyecek bilgi vermek mükemmel bir his.*" diyerek görüşünü belirtmiştir. Aile eğitimiyle ilgili bilgilerini pekiştirmeye yönelik Süeda, "*Derste öğrendiğimiz konuları aileyle uygularken tek tek hatırladım. Teorik olarak okumak farklı ama uygulama yapmak teorik bilgimizi pekiştirdi.*" Diyerek gerçekleştirdiği oturumda aile eğitimine yönelik bilgilerini pekiştirdiğini belirtmiştir.

IV. TARTIŞMA

Bu araştırmada, özel eğitim öğretmen adaylarının Özel Eğitimde Aile Eğitimi dersine ve deneyimlemiş oldukları aile eğitimi oturumuna yönelik görüşleri derinlemesine betimlenmiş ve incelenmiştir. Bu doğrultuda öğretmen adaylarının aile eğitimi dersine yönelik işleniş açısından teorik ve uygulamaya yönelik bilgilerin birlikte verildiğini ve dersin yaşantılarla somutlaştırılarak aktarıldığını belirttikleri ortaya konmuştur. Alanyazında yer alan araştırmada pozitif öğretmen davranışları arasında konuşarı somutlaştırarak açıklamanın da yer aldığı görülmektedir [10]. Yanı sıra özel eğitim öğretmen adaylarının dersin sorumluluklarına yönelik ders esnasında not alma, makale ödevlerini okumak ve sınıfta tartışmak olarak belirtmişlerdir. Bu sorumluluklara yönelik olarak da kendi gelişimleri için gerekli olduğu görüşünde oldukları ortaya çıkmıştır. Gerçekleştirilen araştırmada başarılı öğrencilerin derslere yönelik sorumluluklarının farkında olarak akademik başarılarının arttığı belirtilmekle birlikte öğretim üyelerinin öğrencilerine kendilerinden beklenen sorumlulukları, verimli çalışmayı ve başarıyı nasıl edinebileceklerine yönelik açıklamalar yapmasının faydalı olabileceği belirtilmiştir [11].

Özel eğitim öğretmen adaylarının aile eğitimi oturumuna yönelik görüşlerine bakıldığında makale okuma, sunum hazırlama ve materyal hazırlama gibi farklı sorumluluklar alarak kendilerini aile eğitimi oturumuna hazırladıkları görülmektedir. Gerçekleştirilen bir araştırmada özel eğitim öğretmen adaylarının aile eğitim oturumuna yönelik farklı sorumluluklar edindikleri, sunum ve materyal hazırladıkları görülmesi bu bulguyla paralellik göstermektedir [7].

Aile eğitimi oturumuna hazırlık ve uygulama sürecinde öğretmen adayları hem dersin öğretim elemanı hem de hedef beceriye yönelik çalışmalar yapan öğretim elemanından destek aldıklarını bildirmiştir. Gerçekleştirilen araştırmada öğretmen adaylarının öğretim elemanlarından karşılaştıkları sorunlar ve çözümlerine yönelik dönüt aldıklarını ve bu dönütlerin kendi gelişimleri için faydalı olduğunu ifade etmeleri açısından benzerlik göstermektedir [12]. Alanyazında da öğretmen adaylarına yapılan danışmanlığın onların öğrenmelerine ve zorluklarla başa çıkmalarına yönelik gelişmelerine katkı sağlayacağı vurgulanmaktadır [13].

Özel eğitim öğretmen adaylarının uygulama sürecinin kendileri için ailelerle bir araya gelmelerinde ilk fırsat olduğunu belirtmeleri alana yönelik deneyim kazanmaları açısından katkı sağlamıştır. Yanı sıra daha öncesinde böyle bir deneyime sahip olmadıkları için kendilerinden emin olamazlarken aile eğitimi oturumu sonrasında ailelerle çalışma yeterliliğini hissetmeleri konusunda kendilerinde olumlu ilerlemeler olduğunu düşünmektedirler. Özel eğitim öğretmen adaylarına özel gereksinimli öğrencilerle gönüllü uygulama yapma deneyimi sunulan araştırmada da katılımcıların mesleki deneyime yönelik olumlu kazanımları olduğunu ve kendilerini öğretmen gibi hissettiklerini ifade ettikleri görülmektedir [12].

Öğretmen adaylarının görüş ve önerilerine bakıldığında bu dersi gelecek yıllarda alacak diğer öğretmen adaylarının da özel gereksinimli çocuk ailesiyle uygulama deneyimi kazanmaları gerektiğini belirtmeleri önemli bir bulgu olarak görülmektedir. Öğretmen adaylarının bu süreci öğretmenlik mesleğine adım atmadan önce kendilerine katkı sağlayan bir deneyim olarak gördüğü ortaya çıkmaktadır. Alanyazın incelendiğinde öğretmen adaylarının mesleklerine yönelik ders almaları ve uygulamalara dahil olmalarının mesleklerine bakışlarıyla ilgili değişikliğin önemli unsurları olduğu belirtilmektedir [14, 15]. Özel eğitim öğretmen adaylarının gerçekleştirdiği deneyimle hem özel gereksinimli çocuğa hem de ailesine katkı sağladıklarını düşündükleri görülmüştür. Bu hususta öğretmen adaylarına yapacakları mesleğe yönelik deneyim kazandırılması ve hem aileye hem de çocuklarına olumlu katkı sağlayacakları konusunda inanca sahip olmaları önemli bir husus olarak düşünülmektedir. Nitelikli bir özel eğitim öğretmeni yetiştirmeye yönelik öğretmen yeterlilikleri arasında teorik bilginin yanı sıra öğretim işlem süreçlerine hâkim olma yani uygulamayı da gerçekleştirebilmek yer almaktadır [16]. Bu doğrultuda özel eğitim öğretmen adaylarına teorik bilgilerin sunulmasının yanı sıra bu bilgileri uygulama sürecinde deneyimlemelerini sağlamak ve dönütler sunmak önem arz etmektedir. Aile eğitimi oturumu deneyiminde ders esnasında edindikleri teorik bilgilerin pekişmesine katkı sağladığını ve bu bilgileri uygulama esnasında kullanabildiklerini belirtmişlerdir. Bu hususta teorik bilgilerin edinilmesinin hemen ardından uygulama fırsatı sunulması özel eğitim öğretmen adaylarının aile eğitiminin uygulanmasına yönelik olumlu kazanımlar sağlamıştır. Alanyazında yer alan araştırmalarda da özel eğitim öğretmenliği programının en büyük eksikliğinin uygulama alanında yetersiz kalması olarak görülmektedir [17, 18, 19].

V. SONUÇLAR

Araştırmanın sonuçlarına bakıldığında, özel eğitim öğretmen adaylarının aile eğitimi dersine, derse yönelik sorumluluklara ve bu ders kapsamında gerçekleştirdikleri aile eğitimi oturumu deneyimine yönelik zorlayıcı olduğunu düşünmelerine rağmen mesleğe yönelik gelişimlerinde olumlu katkıları olduğunu düşündükleri görülmektedir. Özel eğitim öğretmen adaylarının derse ve aile eğitimi oturumuna hazırlık yapma sürecinde sahip olduğu sorumlulukların farkında oldukları ve bu sorumlulukları gerçekleştirmenin gelecekteki meslek yaşantılarına katkı sağlayacağını düşündükleri görülmektedir. Ders ve aile eğitimi oturumu esnasında öğretim elemanlarından destek aldıklarını belirttikleri görülmektedir. Bu hususta özel eğitim öğretmen adaylarına sunulan desteği önemli buldukları görülmektedir. Yanı sıra aile eğitimi oturumu deneyimini diğer öğretmen adaylarının da yaşamasının onlara katkı sağlayacağını düşünmektedirler. Alanyazında öğretmen adaylarının meslek yaşantısına geçmeden önce hem ailelerle hem özel gereksinimli öğrencilerle uygulamalar yapmasına yönelik çalışmalarda da benzer bulgular

olduğu görülmektedir. Bu bağlamda öğretmen adaylarına mümkün olan tüm fırsatlarda uygulama deneyimi sunulması ve bu konuda çalışmalar gerçekleştirilmesi önerilmektedir. Bu araştırmanın sınırlılığı uygulamayı gerçekleştiren dört özel eğitim öğretmen adayıyla kısıtlı tutulması ve yarı yapılandırılmış görüşme sorularına ait formun Google Formlar aracılığıyla iletilerek yazılı olarak görüşlerinin alınmış olmasıdır. Gelecek araştırmalarda farklı derslerdeki uygulamalara, farklı özelliklere sahip öğretmen adaylarına yönelik araştırmaların gerçekleştirilmesi ve gerçekleştirilen görüşmelerin yüz yüze yapılması önerilebilmektedir.

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Damage of extra bismuth impurity on crystalline quality of Bi-2223 advanced superconductors

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Abstract **–** This study examines changes in crystalline quality within polycrystalline Bi2.1+xSr2.0Ca2.1Cu3.0Oy high-temperature structures (Bi-2223) due to the addition of bismuth impurity ions using experimental powder X-ray diffraction measurements conducted. Bi2.1+xSr2.0Ca2.1Cu3.0Oy materials with mole ratios ranging from 0.000 to 0.100 are synthesized under ambient conditions. Analysis of the experimental data from partial diffraction peaks indicates that each polycrystalline material retains desired Bi-2223 superconducting phase but with a reduction in the characteristic high superconducting phase fraction depending on the addition amount. For the high-Tc Bi-2223 characteristic superconducting phase, the pure sample has the volume fraction level of 76.8% whereas the Bi5* sample prepared by the highest bismuth ions shows the minimum Bi-2223 phase of 27.0%. This decrease is primarily attributed to the incorporation of bismuth impurity addition into the Bi-2223 crystal system. Furthermore, significant correlations are established among various characteristic features such as reflection intensities of diffraction peaks, Lotgering index, average grain sizes, and lattice cell parameters. In summary, all experimental findings and associated calculations reveal that bismuth impurities cause a decline in the characteristics of the Bi-2223 superconducting phase, c cell parameter, and grain growth.

Keywords – Bi-2223 superconductors; Bismuth impurities; powder X-ray diffraction; Phase volume fraction; grain size

I. INTRODUCTION

High-temperature ceramic materials with their layered structures present superconductivity at temperatures above 77 K [1]. Similarly, these types of the ceramic compounds possess greater critical current carrying capability and larger critical magnetic field magnitude carrying ability. That is exactly why researchers have widely preferred the high-temperature superconducting ceramic materials in several application fields such as accelerators, energy storage, motors, medical diagnosis, heavy industry technology, and advanced engineering applications [2-5]. Of the ceramic superconductors, Bi-containing superconductors, which feature well-aligned superconducting grains adjacent stacked plates and excellent inter-grain contact, are strong candidates for larger magnetic field and energy storage fields [6]. Furthermore, the crystal system's double BiO layers ensures that the grains in Bi-based advaced superconductors align in the preferred directions during fabrication or physical distortions. Moreover, the ceramics show low-angle grain boundaries based on the presence of three components together in their crystal structure. This traditional parent inheritance results in an atomically smooth crystal structure, allowing BSCCO superconductors to be easily crystallographically aligned, making the materials suitable

for winding cables/coils/tapes used in fabrication for generators, motors, magnets, transformers, and medical equipment under deformation [7, 8]. The Bi-containing parents with three main different characteristic superconducting phases show the superconductive temperatures between Tc≈20 K (for the very low-Tc Bi-2201) and Tc≈110 K (for the high-Tc Bi-2223) [9-11]. Among the phases, the last one is mostly preferred in the potential application fields due to its higher critical superconductive temperatures, greater critical current carrying capability, and extremely larger critical magnetic field magnitude carrying capacity. All these features are completely related to the crystal structure of the Bi-containing superconducting parents. With the development in the crystallinity quality of the ceramic compounds, the materials can find a place in many more application areas. In this respect, we analyze the change of the crystallization quality for the extra bismuth impurity added (intervals $0.00 \leq x \leq 0.10$) $Bi_{2.1+x}Sr_{2.0}Ca_{2.1}Cu_{3.0}O_y$ systems with the impurity addition mechanism with the aid of the powder X-ray diffraction measurements. The XRD curves obtained enable us to determine the variation of crucial crystallinity features including lattice cell constants, crystal texturing, grain size, Lotgering indices, phase compositions/purities, and the idea of grain alignment distributions/orientations through the superconductive layers. The experimental results observed reveal that the presence of and augmentation of bismuth ions addition level (until the bismuth molar ratio of x=0.10) disturb considerably the fundamental crystallinity features.

II. Materials and Method

Present study extends the systematic characterization of high-temperature compounds with added bismuth. In our previous publication [12], we detailed the fabrication process, including powder impurities, solid-state reaction, and conditions for calcination medium and main annealing treatments. We also outlined the experimental setups and methods, and investigated the impact of adding extra bismuth impurity ions to the Bi-2223 crystal lattice (at various molar proportions of x = 0.00, 0.01, 0.02, 0.04, 0.08, and 0.10) on mechanical properties such as fracture toughness, elastic hardness coefficient, brittleness indices, and yield strength parameters. These properties were measured using Vickers hardness tests under applied forces for 10 seconds. The Bi-added high-temperature crystal structures prepared are referred to as Bi0*, Bi1*, Bi2*, Bi3*, Bi4*, and Bi5*, respectively. In this part of identification studies, we extensively examine the variation of crystallographic features pertaining to high-temperature structures with bismuth impurity addition in the main system. On this basis, X-ray diffraction (XRD) patterns are measured using a Rigaku Multiflex+XRD 2kW diffractometer with CuKa radiation (1.54 Å wavelength). The measurements are conducted at 36 kV and 26 mA power, with experimental data recorded over a 2θ range from 3° to 60° in 0.02° steps at room temperature, with a counting time of approximately 10 seconds per step. JCPDS index cards with numbers 41-0317 and 41-0374 were used to index the diffraction peaks in the XRD diffractograms, utilizing a tetragonal unit cell and P4/mmm space group. The diffraction peaks intensities in the XRD diffractograms for the Bi-added high-temperature crystal structures enable the determination of key structural parameters such as Lotgering indices, lattice cell constants, crystal texturing, grain size, phase compositions/purities, and grain alignment distributions/orientations through the superconductive layers.

III. Results and Discussion

A. *Differentiation of basic crystallinity parameters for $Bi_{2.1+x}Sr_{2.0}Ca_{2.1}Cu_{3.0}O_y$ structures*

Powder X-ray diffraction (XRD) diffractograms pertaining to different bismuth added high-temperature crystal structures are measured in the 2θ angles intervals 3°-60° under atmospheric pressure in the case of room temperature, one can observe the partial XRD diffractograms for the pure, Bi1*, and Bi2* Bi-2223 ceramic compounds are provided in Fig. 1 graphically. Similarly, the partial XRD diffractograms belonging to the Bi3*, Bi4*, and Bi5* materials are also given in Fig. 2. The differentiation in the peak point places, the disappearance, and occurrence in the XRD diffraction peaks indicates the successful

addition of extra bismuth foreign ions in the bulk Bi-2223 advanced ceramic compounds. In addition, we sign the characteristic and impurity diffraction occurred in Fig. 1 and 2 by using the related Miller indices such as * for the impurity characteristic phase of Bi2O3 phase, (hkl) VL for very low-Tc phase, (hkl)L for low-Tc characteristic phase, and (hkl)H for high-Tc characteristic superconducting phases. The characteristic superconducting phases (appeared in XRD diffractograms) mentioned in the current work are related to the tetragonal crystal phase.

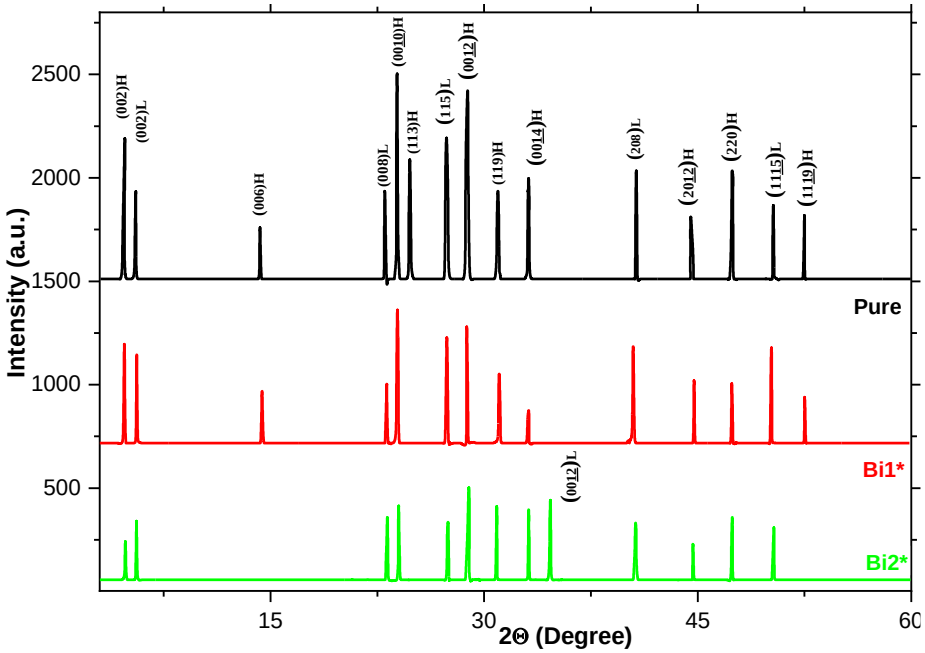

Figure 1 XRD patterns for pure, Bi1*, and Bi2* Bi-2223 ceramic compounds. Notations of "*VL*", "*L*", "*H*" and "*" show low-T_c and high-T_c characteristic superconducting phases, respectively.

At the same time, in Fig. 2 for the polycrystalline Bi4* and Bi5* superconducting materials there appear new diffraction peaks intensities points related to the Bi_2O_3 characteristic phases. The occurrence of the new impurity diffraction peaks indicates that the electron-phonon coupling formations are harmed so does the superconductivity in the crystal system. Additionally, according to both Fig. 1 and Fig 2, the diffraction intensities peaks are generally reflected from the (001) planes, pointing out that the crystal planes are aligned towards the *c*-axis orientation [13].

B. *Change of diffraction peak intensities in XRD diffractograms for different different bismuth added high-temperature crystal structures*

Addition of extra bismuth ions in Bi-2223 matrix is recorded to impair significantly both the low and especially high characteristic superconducting main phases.

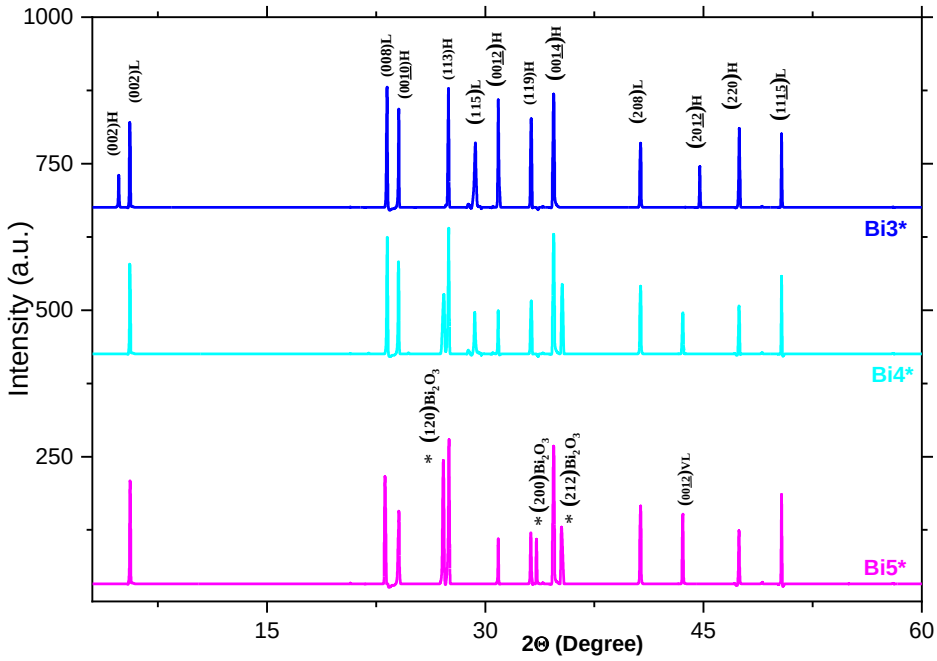

Figure 2 XRD patterns for Bi3*, Bi4*, and Bi5* materials. Notations of "*VL*", "*L*", "*H*" and "*" show very low-T_c, low-T_c, high-T_c characteristic superconducting and Bi_2O_3 impurity phases, respectively.

Specifically, the bismuth ions impurities in the copper oxide layers triggers to accelerate the formation of the very low-Tc superconducting and characteristic impurity phase as much as possible. As a result, the stabilizations of the superconducting Bi-2223 and Bi-2212 phases are affected detrimentally while the especially superconducting Bi-2201 phase becomes more stabilized in the $Bi_{2.1+x}Sr_{2.0}Ca_{2.1}Cu_{3.0}O_y$ main matrix with increasing bismuth impurity addition levels. This indicates that the presence of bismuth ions impurities embedded in the crystal matrix leads to strongly degradation in the fundamental crystallinity quality. Similarly, the diffraction peaks for the superconducting Bi-2212 and Bi-2223 phases obtained from the reflated beams are noted to systematically diminish based on the increase in bismuth impurity additions amounts. As for the numerical parameters, only the pure, Bi1*, Bi2*, and Bi3* superconducting sample have the (002)H diffraction peak at about a 2θ angle of 4.60°. The peak is found to disappear for the other superconducting Bi4* and Bi5* compounds. Relative phase volume fractions are also calculated in the following section. Likewise, the diffraction peak belonging to the (113)H is observed at approximately a 2θ angle of 23.24° for only the pure sample. The other has no longer the (113)H diffraction peak in their XRD diffractograms. Besides, the diffraction peak named as (006)H at nearly a 2θ angle of 14.88°. are observed for only the pure and Bi1* superconducting samples whereas the peak disappears for the other materials. The vanish of the characteristic high superconducting phase results in the Bi-2223 phase volume fraction in the crystals system. Similarly, the XRD peak occurred at nearly 53.04° ascribes to the (11$\underline{19}$)H diffraction peak and is observed for only the XRD patterns of pure and Bi1* superconducting materials. Furthermore, the superconducting (20$\underline{12}$)H peak appeared at nearly a 2θ angle of 44.66° is noted to disappear for the Bi4* and Bi5* crystal structure. The decreased diffraction peaks are singed as (00$\underline{10}$)H, (00$\underline{12}$)H, (00$\underline{19}$)H, and (220)H, respectively. The (119)H peak intensity observed at nearly a 2θ angle of 31.82° is found to decrease for the Bi1* sample, but then a very little increase for the Bi2* material. Then, the peak intensity belonging to the (119)H diffraction peak is observed to reduce regularly with the increase of the bismuth impurity ions in the crystal system. As for the low characteristic superconducting phase intensities, similar to those of Bi-2223 superconducting phase intensities, there appears a systematic decrease. There appears no appearance of new impurity peaks in the XRD diffractograms expect for the (00$\underline{12}$)L diffraction peak. On this basis, the peak immediately appears at 2θ = 35.22° for the polycrystalline Bi2*, Bi3*, Bi4*, and Bi5* samples. However, the characteristic peak of (008)L at 2θ = 22.84° is noted to disappear completely in the XRD pattern for the bulk polycrystalline Bi1*, Bi2*, Bi3*, Bi4*, and Bi5* samples. Additionally, the appears a new peak formation for the very low-T_c characteristic phase assigned as (00$\underline{12}$) VL at 2θ angle of 43.48° for the

bulk Bi4* and Bi5* compounds. Thus, the intensity reaches the highest point for the Bi5* ceramic sample. This is in correspondence to the stabilization of the superconducting Bi-2201 characteristic phase. Furthermore, the Bi4* and Bi5* materials has the impurity phases (signed as *) related to the (120)Bi_2O_3 at 2θ angle of 27.12°.and (212)Bi_2O_3 at 2θ angle of 35.22°. Besides, the phase assigned as (200)Bi_2O_3 impurity peak observed at 2θ angle of 33.52° ascribes to only the Bi5* sample (See in Fig. 1). To sum up, it is obtained that the solubility limit for the bismuth impurity in the bulk superconducting Bi-2223 structure is around x=0.07 [13].

All in all, the bismuth ions impurities addition to Bi-2223 ceramic structure is recorded to diminish remarkably the quality of crystallinity and the superconducting structure by damaging both the low and high phases in the system. Despite this, the characteristic XRD diffraction peak formations indicate that the low Bi-2212 phase remained dominant across all substitution ranges compared to the other phases, depending on the level of extra bismuth ions impurity.

C. *Computation for relative phase volume fractions for Bi2.1+xSr2.0Ca2.1Cu3.0Oy crystal structure*

The relative phase percentages or phase volume fractions of the different characteristic superconducting phases (Bi-2223 high-T_c, Bi-2212 low-T_c, Bi-2201 very high-T_c, andBi_2O_3) present in the bulk polycrystalline Bi-2223 ceramic system are determined using classic calculation equations (Eqs. 1-4). The numerical findings are clearly listed in Table 1.

$$f_{(Bi-2223)}=\frac{\sum I_{Bi-2223(hkl)}}{\sum I_{Bi-2223(hkl)}+\sum I_{Bi-2212(hkl)}+\sum I_{Bi-2201(hkl)}+\sum I_{Bi2O3(hkl)}}x100\% \quad (1)$$

$$f_{(Bi-2212)}=\frac{\sum I_{Bi-2212(hkl)}}{\sum I_{Bi-2223(hkl)}+\sum I_{Bi-2212(hkl)}+\sum I_{Bi-2201(hkl)}+\sum I_{Bi2O3(hkl)}}x100\% \quad (2)$$

$$f_{(Bi-2201)}=\frac{\sum I_{Bi-2201(hkl)}}{\sum I_{Bi-2223(hkl)}+\sum I_{Bi-2212(hkl)}+\sum I_{Bi-2201(hkl)}+\sum I_{Bi2O3(hkl)}}x100\% \quad (3)$$

$$f_{(Bi2O3)}=\frac{\sum I_{Bi2O3(hkl)}}{\sum I_{Bi-2223(hkl)}+\sum I_{Bi-2212(hkl)}+\sum I_{Bi-2201(hkl)}+\sum I_{Bi2O3(hkl)}}x100\% \quad (4)$$

in the relations provided, the abbreviation of I shows the XRD peak intensity for the characteristic superconducting phases.

Table 1 Phase percentages, grain (average) sizes, Lotgering indices, lattice cell (*a* and *c*) deduced from XRD diffraction peaks intensities

Compounds	***Average grain size (nm)***	***Lotgering index, F***	***Volume fraction (≈%)***				***c (Å)***	***a (Å)***
			2212	***2223***	***2201***	***Bi_2O_3***		
Pure	65.42	0.430	23.2	76.8	0	0	37.08	5.41
Bi1*	61.18	0.396	32.5	67.5	0	0	36.92	5.43
Bi2*	60.54	0.354	38.3	62.7	0	0	36.55	5.45
Bi3*	57.38	0.325	44.5	55.5	0	0	36.28	5.46
Bi4*	52.15	0.295	46.0	37.4	10.4	6.2	35.84	5.47
Bi5*	46.94	0.264	49.3	27.0	14.8	8.9	35.66	5.48

The discussions based on the table show that both the bulk pure compound and $Bi_{2.1+x}Sr_{2.0}Ca_{2.1}Cu_{3.0}O_y$ matrices exhibit a combination of characteristic Bi-2212 low-T_c and Bi-2223 high-T_c superconducting phases. However, the Bi4* and Bi5* ceramics also present the characteristic Bi-2201 very low-T_c superconducting and Bi_2O_3 impurity phases. Numerically, the pure ceramic material had phase volume fractions of 23.32% for the Bi-2212 low-T_c phase and 76.8% for the Bi-2223 high-T_c superconducting

phase. As the bismuth ions impurities amounts enhance in polycrystalline $Bi_{2.1+x}Sr_{2.0}Ca_{2.1}Cu_{3.0}O_y$ high-temperature structures, the characteristic high superconducting phase decreases sharply. With bismuth impurity addition increasing to a maximum of x=0.100, both the low and high-T_c superconducting phases decrease steadily. On this basis, the high-T_c superconducting phase reaches its lowest fraction, approximately 27.0%, at x=0.100 due to the emergence of other superconducting and impurity fraction phases in the Bi-2223 structure. In this respect, the sample shows very low-T_c superconducting phase of 14.8% while the impurity phase of Bi_2O_3 impurity is obtained to be about 8.9%. For the bulk Bi4* superconducting ceramic sample, the high-T_c Bi-2223, low-T_c Bi-2212, and vey low-T_c Bi-2201 phases are obtained to possess the percentages of 37.4%, 46.0%, and 10.4%, respectively. The impurity phase appears about 10.4% in $Bi_{2.1+x}Sr_{2.0}Ca_{2.1}Cu_{3.0}O_y$ matrix. As for the polycrystalline superconducting Bi3* compound, the Bi-2223 and Bi-2212 superconducting phases are noticed to be about 55.5% and 44.5%, respectively. Moreover, the Bi2* sample has the Bi-2223 superconducting phase of 67.5% and Bi-2212 superconducting phase of 32.5%. The presence and increase of bismuth impurity ions in the bulk Bi-2223 crystal lattice significantly impair the formation of both the low/high phases [14]. This disruption in the low and high phases significantly affects the formation of copper pairs in the superconducting pathway of the crystal system [15].

D. *Lattice cell constants pertaining to bulk polycrystalline bismuth added high-temperature crystal structures*

Fig. 1 and Fig. 2 show that the powder X-ray diffraction peaks exhibit shifts correlating with increased bismuth impurity additions in Bi-2223 matrices, reflecting changes in lattice cell parameters. Specifically, the 2θ diffraction peaks along the *c*-axis, such as (00<u>1</u>0)H, (00<u>1</u>2)H, (00<u>1</u>4)H, (002)L, (008)L, (0010)L, and (00<u>1</u>2)L associated with the high and low superconducting phases, are noted to shift towards larger angles. This indicates a decrease in the *c*-axis length of the Bi-2223 ceramic system. Conversely, peaks corresponding to the *a* and *b*-axis orientations shift towards smaller angles, suggesting an increase in the *a* and *b* lattice cell constant parameters. Here, the lattice constants (*a*-axis and *c*-axis length) of the bulk polycrystalline $Bi_{2.1+x}Sr_{2.0}Ca_{2.1}Cu_{3.0}O_y$ high-temperature structures are found by using the lattice spacing (d) values and specific diffraction planes (hkl) for the tetragonal unit cell structure. The relevant formula (5) is provided below.

$$\frac{1}{d^2} = \left(\frac{h^2}{a^2} + \frac{k^2}{b^2} + \frac{l^2}{c^2}\right) \quad (5)$$

One can encounter all the numerical calculations for the *a* and *c*-axis lengths for the pure and extra bismuth added bulk polycrystalline $Bi_{2.1+x}Sr_{2.0}Ca_{2.1}Cu_{3.0}O_y$ high-temperature ceramic structures in Table 1. The table shows a systematic decrease in the *c*-axis length (the maximum one belongs to the pure sample whereas the minimum value is attributed to the Bi5* sample) and an increase in the *a* lattice cell (the smallest one belongs to the pure sample whereas the highest value is attributed to the Bi5* sample) with increasing bismuth impurity ions levels. For pure Bi-2223 ceramic material, the *a* and *c* lattice cells are computed to be approximately 5.41 Å and 37.08 Å, respectively. However, with the addition of bismuth ions impurities up to x=0.100, the *a* lattice parameter increases rapidly to a maximum of 5.48 Å while the *c* lattice parameter decreases significantly to value of 35.66 Å. This indicates that the *c*-axis length is directly affected by distortions in the copper oxide layers.

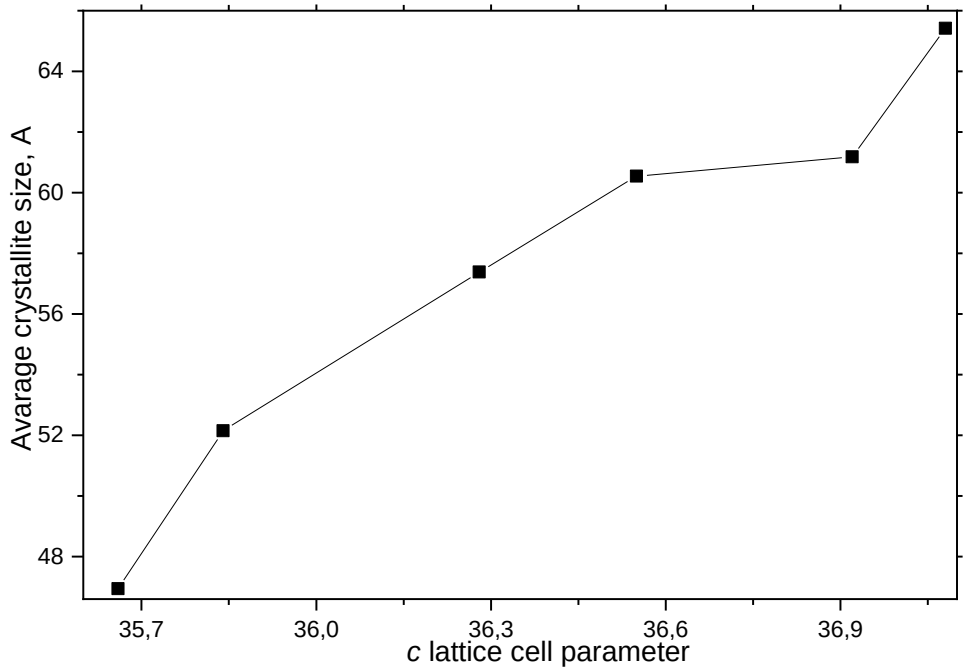

Figure 3 Change in average crystallite size against *c* lattice cell parameters

Consequently, the presence and increment trend in the bismuth ions in the crystal lattice of Bi-2223 materials disrupts the formation of strong electron-phonon coupling, which is essential for superconductivity. In addition, we examine the relationship between c-axis length and average grain size growth for both pure and extra bismuth-added Bi-2223 structures as depicted in Fig. 3. The figure guarantees a linear relationship between these parameters. According to the experimental findings, the presence and increase in the bismuth impurity addition in the system deteriorates significantly the crystallinity and superconducting properties of the Bi-2223 advanced superconducting materials.

E. *Decrement trend in average crystallite size of Bi-2223 superconducting depending on the extra bismuth impurity addition in the crystal system*

The changes in average crystallite size in the advanced Bi-2223 ceramic lattice with the addition of bismuth ions impurities are numerically determined using the Scherrer–Warren approach, which is based on the full width at half maximum (FWHM) calculations of the characteristic diffraction peaks [16]. The formula is shown below.

$$t = 0.941\lambda / B\cos\theta_B \quad (6)$$

in the relation, t reveals the crystal thickness and λ shows incident X-rays wavelength. Furthermore, the Bragg angle, denoted by θ_B, is determined using the FWHM value. According to Eq. 6, all calculations are presented numerically in Table 1. From the table, the crystal growth is calculated to decrease significantly from 65.42 nm to 46.94 nm with increasing amounts of cadmium oxide impurity. This observation strongly indicates a substantial suppression of crystalline quality and the superconducting characteristics associated with effective electron-phonon coupling probabilities.

F. *Lotgering indices for bulk polycrystalline Bi2.1+xSr2.0Ca2.1Cu3.0Oy high-temperature structures*

Concluding section for study examines the influence of bismuth ions impurity levels on the *c*-axis orientation, specifically the Lotgering index related to superconductivity, within the crystal structure [17, 18]. Table 1 also details the Lotgering index parameters for both pure and bulk polycrystalline $Bi_{2.1+x}Sr_{2.0}Ca_{2.1}Cu_{3.0}O_y$ high-temperature structures. Table reveals that, similar to previous observations,

the Lotgering index values are calculated to reduce from 0.430 for the pure Bi-2223 superconducting ceramic to 0.264 for the superconducting Bi5* compound with increasing bismuth impurity ions addition. This decline in the Lotgering index underscores the disruptive effect of bismuth impurities on the crystalline quality of superconducting particle connections and alignment of crystal planes within the Bi-2223 superconducting crystal structure.

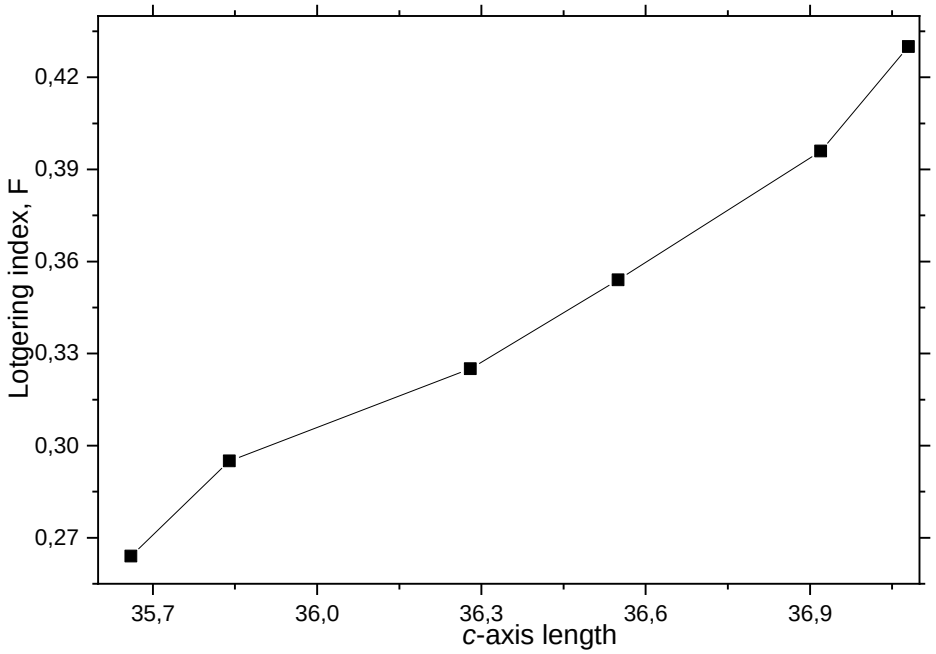

Figure 4 Change of Lotgering indices against *c* lattice parameters

Moreover, in order to examine the impact on crystallinity and effective electron-phonon coupling probabilities, we explore the correlation between the *c*-axis length and the *c*-axis orientation angles in Fig. 4. The figure reveals that the *c*-axis length is significantly more influenced by the amount of bismuth impurity added compared to the *c*-axis orientation angles. This suggests that the addition of bismuth impurity ions has a much stronger adverse effect on the effective electron-phonon coupling probabilities than on the crystalline quality itself.

IV. CONCLUSION

The present study focuses on investigating the effects of bismuth ions impurities addition to polycrystalline Bi2.1+xSr2.0Ca2.1Cu3.0Oy high-temperature structures, exploring key properties such as crystalline quality, texture of superconducting grain connections, and effective electron-phonon coupling probabilities through experimental powder X-ray diffraction measurements. The summarized findings based on XRD diffractograms are as follows:

It is found from the experimental XRD measurements that the presence and increment trend of bismuth impurity ions addition in the bulk Bi-2223 lattice lead to the emergence of characteristic impurity peak positions associated with characteristic Bi2O3 impurity phase, indicating a degradation in crystalline quality and superconducting behavior. This deterioration is further evidenced by a decrease in average crystallite size, which decreases steadily from 65.42 nm to 46.94 nm with increasing Bi2O3 impurity ions addition. Additionally, the study determines that the solubility limit of bismuth impurities in the Bi2.1Sr2.0Ca2.1Cu3.0Oy superconducting crystal system is approximately x=0.07.

Analysis of peak intensity changes for relative volume phase fractions indicates that both high and low superconducting phases exhibit a monotonic degradation with increasing Bi2O3 impurity ions addition concentration. This degradation correlates with a rapid decrease in copper pair formation probabilities and superconductivity in the system. Similarly, changes in lattice cell parameters demonstrates a regular decrease in the c-axis length and an increase in the a-axis length with Bi2O3 impurity ions addition.

Moreover, Lotgering index parameter results highlight that texture formation significantly depends on the concentration of Bi2O3 impurity ions addition, showing a notable decrease as impurity levels increases. Specifically, the unmodified sample exhibits a maximum Lotgering index of 0.430 while the Bi5* ceramic sample shows a minimum value of 0.264. This underscores the disruptive effect of Bi2O3 impurity ions addition on the crystalline quality and texture of superconducting grain connections.

Furthermore, the combined analysis of lattice cell constants and Lotgering index parameters indicates that Bi2O3 impurity ions addition in the Bi2.1Sr2.0Ca2.1Cu3.0Oy crystal structure has a more pronounced detrimental impact on effective electron-phonon coupling probabilities than on crystalline quality itself.

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CNC Program Development: Principles and Practices for Programming a Clutch Hub Turning Process

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Abstract – This paper presents a systematic approach to the fundamental principles and practices essential for developing CNC programs, specifically for the clutch hub turning process. The process involves the turning operation necessary to machine a clutch hub from an initial workpiece, a forged clutch hub. CNC programming is pivotal in creating precise instructions that control the motions and operations of CNC machine tools for precise and efficient clutch hub machining. Key aspects highlighted in this study include the selection of appropriate cutting tools, the incorporation of cutting conditions (such as cutting speed, feed, and depth of cut), and the optimisation of cutting strategies during program development. The paper provides a practical framework for CNC program creation, from initial design through final implementation, emphasising both theoretical foundations and practical completion. The discussion primarily focuses on the integration of G-codes and M-codes into CNC programming, ensuring constant monitoring and control over manufacturing operations. Furthermore, the paper evaluates how advanced technologies such as CAD/CAM integration facilitate CNC programming by improving precision and efficiency. By analysing functional CNC programs, this research serves as a valuable resource for engineers and machinists aiming to deepen their expertise in CNC programming, particularly in the development of effective and dependable CNC programs for manufacturing processes.

Keywords – G-codes, M-codes, CNC Machine Tool, Cutting Tools, CAD/CAM

I. INTRODUCTION

In the contemporary context of manufacturing processes, precision and consistency are imperative in achieving optimal product quality and operational efficiency. The constant monitoring and control over dimensional tolerances, surface finish quality, and workpiece dimensions throughout the machining processes ensure compliance with design specifications, thereby enhancing product durability and reliability. This consistent practice promotes early detection and correction of dimensional imperfections, minimising waste and repairs while maintaining the quality of manufactured workpieces [1].

The advent of CNC (Computer Numerical Control) machine tools has revolutionised modern manufacturing, offering superior accuracy and repeatability in comparison with conventional machine tools. These machine tools are particularly designed for complex and demanding machining processes where precision is paramount. Central to the operation of CNC machine tools is CNC programming, a discipline focused on the transformation of design specifications into executable commands that direct the movements and actions of CNC machine tools [2].

CNC programming refers to the principles used to generate the instructions that drive the CNC machine tools. These instructions are structured into a program, which consists of G-codes and M-codes (Fig. 1a). G-codes, or geometric codes, control the motion of the CNC machine tool. They are standard commands

that begin with the letter "G" followed by a two-digit number, indicating various movements and positions of the machine tool's moving components. The commands dictate the precise geometric positions based on a coordinate system, enabling the machine to move the components and cutting tools accurately in a specified direction and position them precisely in 3D space (Fig. 1b) [3].

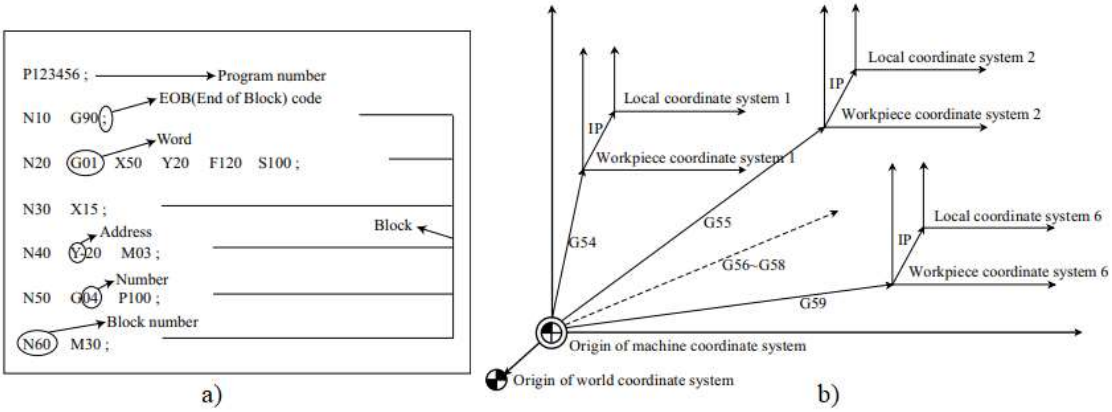


Fig. 1 a) Program structure; b) Machine, workpiece, and local coordinate systems [3]

In addition to G-codes, CNC programming encompasses M-codes, which regulate specific functions of the CNC machine tool, including spindle rotation speed, cutting tool feed rate, tool changes, and coolant application. The M-codes also adhere to an alphanumeric format, beginning with the letter "M" and being followed by two digits. These codes are essential for the operation control of the machine tool and ensure that each workpiece of the manufacturing process is machined correctly and efficiently [4].

The G-code, in the role of a programming language, facilitates the development of specific programs through Computer-Aided Manufacturing (CAM) systems that utilise Computer-Aided Design (CAD) information. These advanced systems play a crucial role in contemporary machining processes, effectively synchronising design with manufacturing. Specifically, CAM systems utilise CAD data to create precise instructions for CNC machine tools, which significantly improves both the design and productivity of machining processes. This integration of CAD and CAM systems facilitates the transition from design to production, thereby enhancing overall manufacturing efficiency and product quality [5].

The principle of developing CNC programs involves a sequence of steps that convert design specifications into commands readable by machine tools. These commands direct and control the movement of the machine tool's moving components and cutting tools during the machining process [6].

Initially, the process commences with designing and modelling the workpiece utilising Computer-Aided Design (CAD) software. This involves developing a detailed two-dimensional or three-dimensional model wherein all features, such as contours, holes, slots, and pockets, are identified and designed. The designed CAD model provides a precise representation of the workpiece to be manufactured [7].

The CAD model is then utilised to develop CNC programs of instructions that define the cutting tools' toolpaths. The toolpaths are the specific paths that the cutting tool traverses in order to machine the workpiece. During this step, the appropriate cutting tools are selected according to material and design requirements. Machining parameters, including spindle speed, rotation direction, feed, depth of cut, and coolant activation, are also defined in the programs of instructions [8].

When the toolpaths are created, they can be visualised as a continuous connection between a series of coordinates that correspond to specific data points. Each coordinate indicates a particular position in the machine tool's working space, defining the precise location of the cutting tool at the determined trajectory. As the machining process progresses, the cutting tool traverses from one coordinate to the next, ensuring precise material removal and shaping of the workpiece [9].

Prior to implementing the G-code on the actual CNC machine tool, the toolpaths can be simulated and verified by utilising the CAM software. This simulation facilitates the visualisation of the machining process and the identification of potential issues, such as collisions, tool breakage, or excessive material removal, which can be anticipated, detected, and eliminated [10].

Upon verification, the program is transferred to the CNC machine tool, typically through USB, network, or other communication protocol. The CNC machine tool is then prepared by securing the workpiece, setting up the workholding, cutting, and control tools, and calibrating the machine tool by setting zero points, which serve as reference points for machining. Once the machine tool is setup, the program is loaded into the CNC machine tool's controller. A dry run, without any actual cutting, is typically performed to ensure the complete accuracy of the toolpaths and the absence of any unexpected movements. When the verification process is completed, the machining process commences, with the CNC machine adhering to the G-code instructions to machine the workpiece [11].

In this context, the development of CNC programs is based on the principle of creating a sequence of coded instructions to guide the CNC machine tools in performing precise machining processes using CAD software to design the workpiece and generate the trajectory of the cutting tools, terms that are reviewed in relevant literature (e.g., [1]–[11]). The paper is structured into five sections: an introduction, an explanation of the research, a presentation of the results, a discussion, and a conclusion with potential applications.

II. Materials and Method

This research illustrates a part of the clutch hub machining process implemented on a CNC turning centre `Hitachi`. The clutch hub is a vital component of a vehicle's clutch system. It plays a crucial role in manual transmission vehicles, functioning as the central component of the clutch disc assembly.

To precisely analyse the machining process, two-dimensional drawings have been created using a CAD system, specifically AutoCAD software. These drawings illustrate details of the machining process and the sequence of the machining operations intended to realise the process. The process involves the turning operation necessary to machine the clutch hub (Fig. 2b) from the initial workpiece, a forged clutch hub (Fig. 2a). In addition to turning, the machining process includes machining operations that relate to turning, such as drilling, facing, boring, and chamfering.

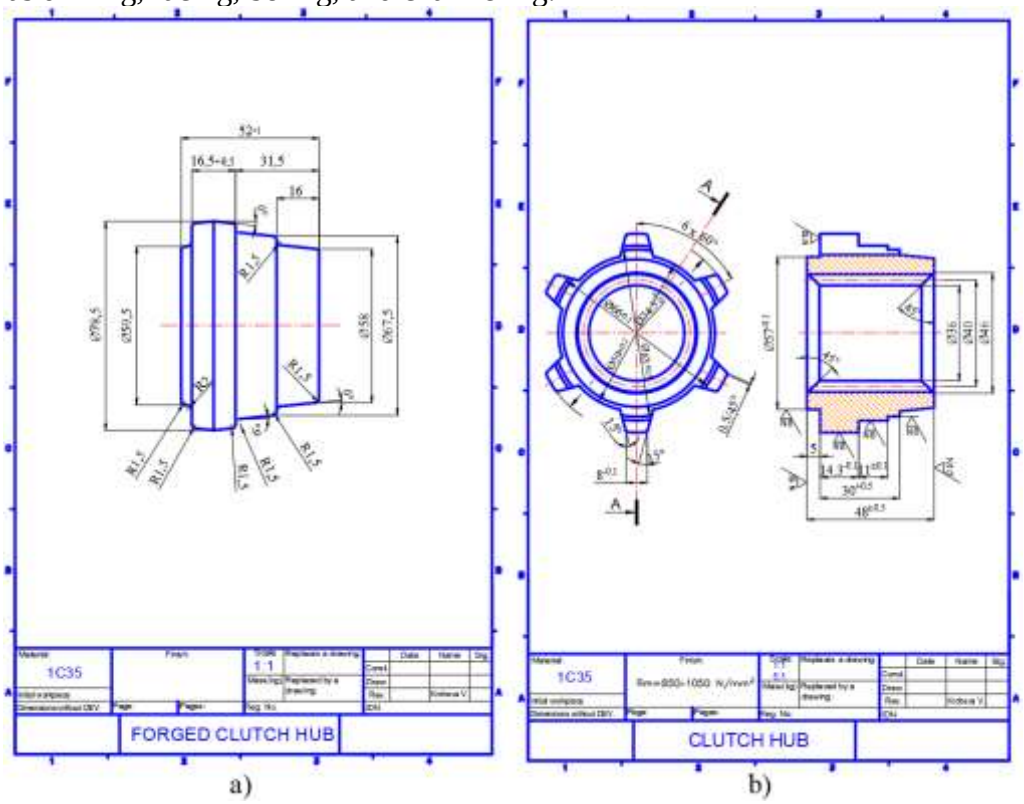
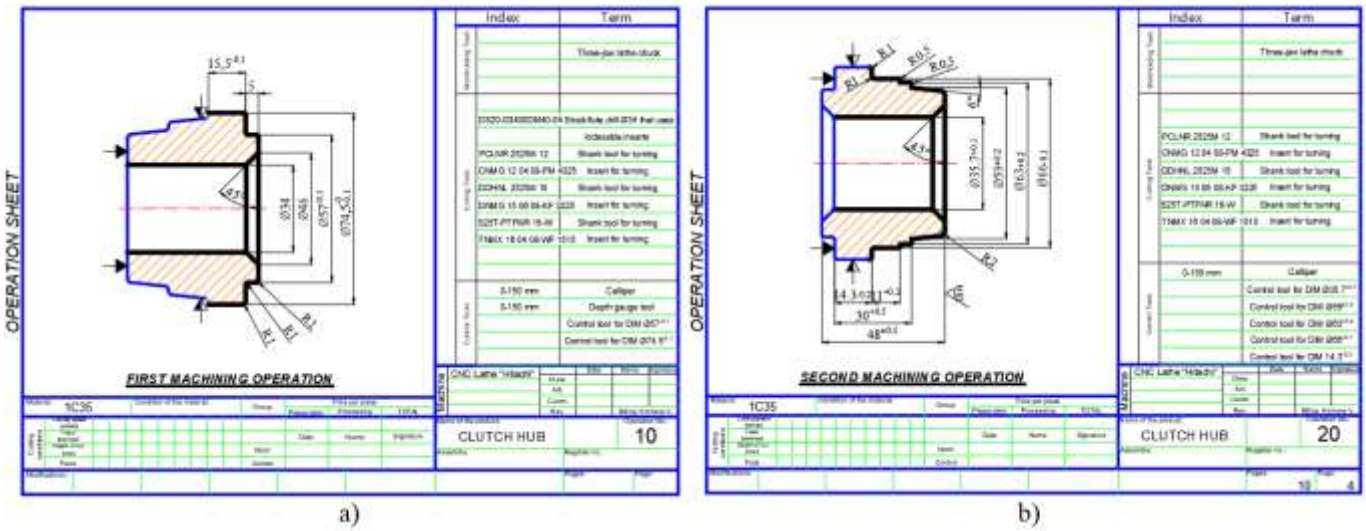


Fig. 2 a) Forged clutch hub; b) Clutch hub

Depending on which side of the clutch hub is machined, two phases in the context of two machining operations are defined. The first machining operation refers to the shorter side of the forged clutch hub (Fig. 3a), while the second refers to the longer side (Fig. 3b).



a) b)

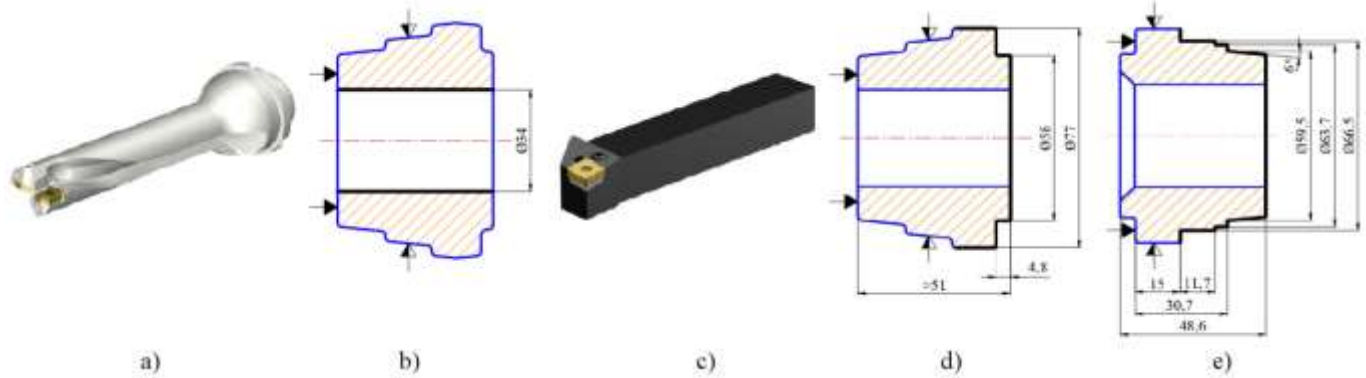
Fig. 3 a) First machining operation; b) Second machining operation

The first machining operation (Fig. 3a) comprises four passes. The first pass (Fig. 4b) involves drilling. The second (Fig. 4d) and third passes (Fig. 5b) involve turning and facing, respectively. The fourth pass (Fig. 6b) includes chamfering.

The second machining operation (Fig. 3b) comprises three passes. The first pass (Fig. 4e) involves turning and facing. The second pass (Fig. 5c) similarly includes turning and facing. The third pass (Fig. 6c) entails chamfering and boring.

The contours of the workpiece illustrated in the drawing play a crucial role in defining the geometry of the cutting tool for each machining pass. The shape and complexity of these contours directly influence the selection of cutting tool parameters such as cutting edge angle, tool lead angle, inclination angle, nose radius, etc. Each specific contour determines the required type of cutting tool holder and indexable insert shape that must precisely match the profile of the workpiece.

Specifically, for the first pass (in the first machining operation), the determined cutting tool is the DS20-D3400DM40–04 straight-flute drill with indexable inserts DS20-0508-P and DS20-0508-C, manufactured by Sandvik Coromant (Fig. 4a). The cutting tool geometry is characterised by a cutting edge angle of 81°, an inclination angle of 0°, and indexable insert corner radii of 0.8 mm and 0.35 mm.



a) b) c) d) e)

Fig. 4 a) Strait-flute drill; b) First pass; c) Shank tool for turning; d) Second pass; e) Second pass

For the second pass (in the first and second machining operations), the determined cutting tool is the PCLNR 2525M 12 shank tool for turning (Fig. 4c) that uses a CNMG 12 04 08-PM 4325 indexable insert, manufactured by Sandvik Coromant. The cutting tool geometry is characterised by a cutting edge angle of 95°, a lead angle of -5°, an inclination angle of -6°, an orthogonal rake angle of -6°, a corner radius of 0.8 mm, an effective length of the cutting edge of 12 mm, and a rhombic 80º insert shape.

The determined cutting tool for the third pass (in the first and second machining operations) is the DDHNL 2525M 15 shank tool for turning (Fig. 5a) that uses a DNMG 15 06 08-KF 3225 indexable insert, manufactured by Sandvik Coromant. The cutting tool geometry is characterised by a cutting edge

angle of 107.5°, a lead angle of -17.5°, an inclination angle of -7°, an orthogonal rake angle of -6°, a corner radius of 0.8 mm, an effective length of the cutting edge of 14.7 mm, and a rhombic 55º insert shape.

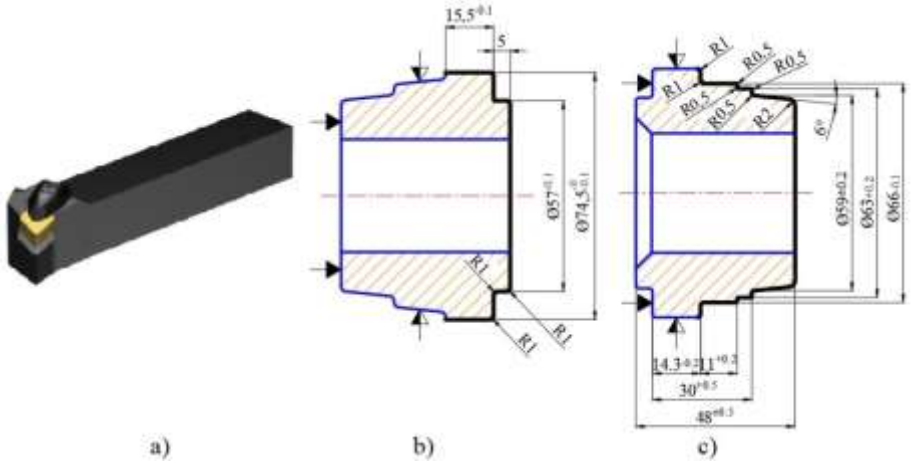


Fig. 5 a) Shank tool for turning; b) Third pass; c) Third pass

And for the last, fourth pass (in the first and second machining operations), the determined cutting tool is the S25T-PTFNR16 16-W shank tool for turning (Fig. 6a) that uses a TNMX 16 04 08-WF 1515 indexable insert, manufactured by Sandvik Coromant. The cutting tool geometry is characterised by a cutting edge angle of 91°, a lead angle of -1°, a corner radius of 0.8 mm, an effective length of the cutting edge of 15.7 mm, and a triangular insert shape.

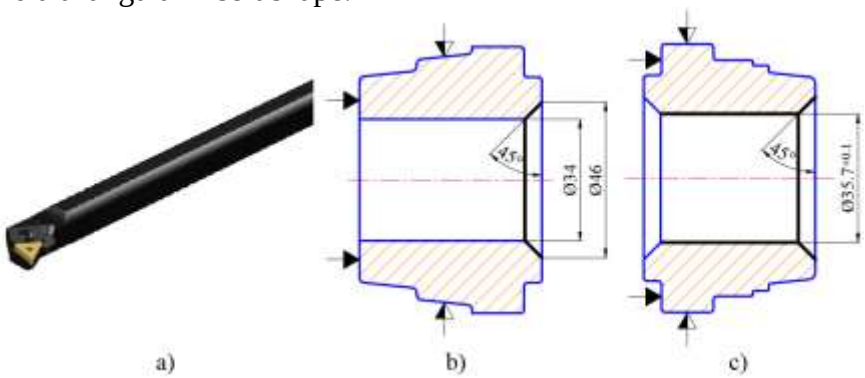


Fig. 6 a) Shank tool for turning; b) Fourth pass; c) Fourth pass

This CAD model has been meticulously developed to enable a precise analysis of turning operations, including all relevant passes. It serves as the essential foundation for providing coordinates from annotations and for the subsequent development of CNC programs. Through detailed examination, this model ensures accuracy in translating design intentions into executable CNC programs.

III. RESULTS

The development of the CNC programs involved a series of detailed steps to ensure the desired geometry and contour of the workpiece were followed by the cutting tool. The process began with understanding the workpiece CAD model design through two-dimensional design specifications, which included all dimensions, tolerances, and surface finish requirements.

Next, appropriate cutting tools were selected based on the material of the workpiece and the number and type of passes required. The geometry of the cutting tools, including diameters, linear and radial lengths, and shape, was considered as it directly affects the programming of the tool paths.

The workpiece coordinate system (WCS) was then established on the CNC turning centre `Hitachi`, with the origin point (X, Y, and Z coordinates) defined as the reference for all dimensions. The origin (0,0,0) was defined at the highest point and centre of the workpiece's surface.

```
%
077;
N005 M40;
N010 G99;
N015 G18;
(FIRST PASS);
N020 T0900;
N025 M40;
N030 G99;
N035 G18;
N040 G50 S450;
N045 G96 S450 M3;
N050 G00 X0. Z30. Y0.;
N055 Z4.;
N060 G01 Z-56. F0.07 M8;
N065 G00 Z10. M9;
N070 G28 U0 V0 W0 M5;
(SECOND PASS);
N075 T0100;
N080 M40;
N085 G99;
N090 G18;
N095 G50 S750;
N100 G96 S750 M4;
N105 G00 X82. Z10. Y0.;
N110 Z-5.7 M8;
N115 G01 X58.7 F0.12;
N120 Z-1.1;
N125 X33.;
N130 Z2.;
N135 G00 X33.;
N140 G01 Z-1.2;
N145 X55.;
N150 G03 X58. Z-2. R1.;
N155 G01 Z-5.9;
N160 X77.;
N165 G01 Z-23.;
N170 X77.;
N175 G00 Z10.;
N180 G28 U0 V0 W0 M5;
(THIRD PASS);
N185 T0500;
N190 M40;
N195 G99;
N200 G18;
N205 G50 S800;
N210 G96 S800 M4;
N215 G00 X33. Z10. Y0.;
N220 Z4.;
N225 G01 Z-0.5 F0.2 M8;
N230 X53.;
N235 G03 X56.8 Z-2. R2.;
N240 G01 Z-5.5;
N245 X70.5;
N250 G03 X74.4 Z-7. R2.;
N255 G01 Z-21.9 F0.14;
N260 X73.4;
N265 X76.;
N270 G00 Z10.;
N275 G28 U0 V0 W0 M5;
(FOURTH PASS);
N280 T0300;
N285 M40;
N290 G99;
N295 G18;
N300 G50 S750;
N305 G96 S750 M3;
N310 G00 X46. Z10. Y0.;
N315 Z2.;
N320 G01 Z-1. F0.12 M8;
N325 X34. Z-5.5;
N330 G00 Z10.;
N335 G28 U0 V0 W0 M5;
N340 M30;
%
```

Fig. 7 CNC program for the first turning operation

Planning the tool paths for turning involved identifying the contours and profiles that the cutting tool must follow, including outer and inner diameters, fillets, chamfers, and other features.

```
%
O78;
N005 M40;
N010 G99;
N015 G18;
(FIRST PASS);
N020 T0100;
N025 M40;
N030 G99;
N035 G18;
N040 G50 S700;
N045 G96 S700 M4;
N050 G00 X32. Z10. Y0.;
N055 Z0.;
N060 G01 Z-1. F0.12 M8;
N065 X52.;
N070 G03 X57. Z-3.2 R2.5;
N075 G01 X59.5 Z-16.3;
N080 X63.7;
N085 Z-21.3;
N090 X66.;
N095 Z-33.;
N100 X75.;
N105 G00 Z-3.5;
N110 X59.;
N115 G01 X32. F0.1;
N120 G00 Z-1.;
N125 X59.;
N130 Z-4.4;
N135 G01 X30.;
N140 Z10.;
N145 G28 U0 V0 W0 M5;
(SECOND PASS);
N150 T0500;
N155 M40;
N160 G99;
N165 G18;
N170 G50 S900;
N175 G96 S900 M4;
N180 G00 X30. Z1. Y0.;
N185 G01 Z-3.9 F0.14 M8;
N190 X52.3;
N195 G03 X56.6 Z-5.2 R2.;
N200 G01 X58.8 Z-16.5;
N205 X61.4;
N210 G03 X63.2 Z-17.5 R2.;
N215 G01 Z-21.7;
N220 X63.9;
N225 G03 X65.9 Z-22.7 R2.;
N230 G01 Z-32.9;
N235 X72.;
N240 G03 X74.4 Z-34.1 R2.;
N245 G01 Z-34.5;
N250 G00 X76.;
N255 Z10.;
N260 G28 U0 V0 W0 M5;
(THIRD PASS);
N265 T0300;
N270 M40;
N275 G99;
N280 G18;
N285 G50 S750;
N290 G96 S750 M3;
N295 G00 X46. Z0. Y0.;
N300 G01 Z-0.8 F0.12 M8;
N305 X35.7 Z-4.5;
N310 Z-50.;
N315 G00 X30.;
N320 Z10.;
N325 G28 U0 V0 W0 M5;
N330 M30;
%
```

Fig. 8 CNC program for the second turning operation

The CNC programs were developed using G-code that primarily control the movement of the CNC turning centre `Hitachi` along the axes (X, Y, and Z) and specify the type of motion to be performed. Additionally, M-codes were used to control various auxiliary functions of the CNC turning centre, such as tool changes, spindle speed, spindle control, feed rate, and other functions.

The developed CNC programs were specified for each machining operation and included all passes. For space conservation, these programs are presented as figures.

The program of instructions for the first turning operation (including four passes) is depicted in Fig. 7. and the second turning operation (including three passes) is depicted in Fig. 8.

IV. DISCUSSION

The first CNC program is structured to drive and control the CNC turning centre through a detailed series of instructions to shape the shorter side of the clutch hub. Each section of the program represents a specific phase of the turning process, referred to as a "pass". The program starts (and ends) with a command `%` to signal the beginning (and the end) of the program and the identifier `O77` is used to give the CNC program a unique identification number.

This program starts by preparing the CNC turning centre for the drilling operation. The code `T0900` is used to select the straight-flute drill that is placed in a designated position within the CNC turning centre's tool carousel and the code `S450` to set the spindle speed to 450 RPM. Rapid traverses (G00 commands) are used to quickly position the cutting tool to the initial cutting point at X0, Z30, and Y0. This initial position ensures precise alignment before the drilling pass is begun. Once in position, this pass is initiated by the program. Linear interpolation (G01) is used to slowly lower the cutting tool to the Z-56 coordinate at a feed rate of 0.07 units per revolution, ensuring a controlled penetration into the material. The spindle is rotated in the clockwise direction (M03), maintaining a consistent cutting speed. After the pass is completed, the cutting tool is rapidly moved to Z10, and the spindle is stopped (M09). To prepare for the next pass and cutting tool change, a return to the machine's reference point (G28 U0 V0 W0) with a spindle stop (M05) is commanded by the program.

In the second pass, the code `T0100` is used to select the determined cutting tool by the program, and the code `S750` is used to adjust the spindle speed to 750 RPM in the counterclockwise direction (M4). A rapid traverse to the defined point with coordinates X82, Z10, and Y0 is initiated to begin the actual pass. Then, linear interpolation (G01) is implemented in the program to make precise cuts at varying depths and contours. For instance, the cutting tool is moved from Z-5.7 to Z-1.1 while turning along the X-axis. A rapid movement to X33 is then implemented, and the process is repeated, demonstrating the ability of the CNC turning centre to perform complex machining tasks. Circular interpolation (G03) is used to facilitate curved cuts, which are essential for creating intricate geometries on the workpiece. Similar to the first pass, the second pass is finished with a command to return to the turning centre's reference point (G28 U0 V0 W0 M5) and preparation for the subsequent pass.

For the third pass, the determined cutting tool `T0500` is selected, with the spindle speed set to 800 RPM in a counterclockwise direction (M04). The turning process is accelerated by this higher spindle speed, which is suitable for machining tougher materials or achieving finer surface finishes. Rapid traverses and linear interpolations are commanded by the program to cut along designated paths, with adjustments made to the feed (F) and depth of cut (Z-axis) to meet turning requirements. Circular interpolations (G03) are utilised again to create fillets and curved surfaces, with movements exemplified by shifts from X53 to X70.5 and corresponding changes in Z-axis coordinates. Upon completion of the third pass, the CNC turning centre is directed by the program to return to its reference point (G28 U0 V0 W0 M05), ensuring accurate positioning and readiness for the next pass.

The determined cutting tool `T0300` is activated for the fourth pass, with the spindle speed set back to 750 RPM in a clockwise direction (M03). Optimal cutting conditions are provided for the specific cutting tool and material combination by this return to forward rotation. The program's systematic approach is continued, with linear interpolations employed to achieve the specified contours. Efficient chamfering operation is ensured by rapid traverses between the defined points, while accuracy throughout the

machining process is maintained by the program's code of spindle stops (M05) and return to reference points (G28 U0 V0 W0).

The second CNC program is structured to drive and control the CNC turning centre through a detailed series of operations to shape the longer side of the clutch hub. Each section of the CNC program represents the distinct phases of the turning process, referred to as "passes". The command `%` is used to signal the beginning and end of the program and `O78` is the unique identifier for this particular program.

The initial setup commands ensure that the CNC turning centre is ready for machining. The spindle is started by the `N005 M40` command. The feed mode is set by the `N010 G99` command, and the XZ plane for turning operation is selected by the `N015 G18` command.

For the first pass, the determined cutting tool `T0100` is selected. The spindle is set to rotate at a maximum speed of 700 RPM, maintaining a constant surface speed of 700 RPM in a counterclockwise direction (M04). The cutting tool is rapidly moved to the initial position at coordinates X32, Z10, and Y0. Then, it is descended to Z0 with the same rapid traverse command. The cutting process begins with a linear interpolation command, `N060 G01 Z-1. F0.12 M08`, that moves the cutting tool to Z-1 at a feed rate of 0.12 units per revolution, with coolant on. Various linear and circular interpolation commands are continued in the program to shape the workpiece. For instance, the cutting tool is moved to X52 by the `N065 X52` command, and a clockwise arc to X57, Z-3.2 with a radius of 2.5, is created by the `N070 G03 X57. Z-3.2 R2.5` command. Linear movements to specified coordinates are defined by the subsequent commands `N075 G01 X59.5 Z-16.3` and `N085 Z-21.3`. The rapid traverse command to X75 is then used to quickly move the cutting tool to the new positions without cutting. After performing the necessary cuts, the cutting tool is returned to the reference position using the `N145 G28 U0 V0 W0 M05` command with the spindle stopped.

The second pass is initiated by changing the cutting tool with the `N150 T0500` command. The spindle speed is increased to a maximum of 900 RPM using the `N170 G50 S900` command and set to maintain a constant surface speed of 900 RPM with the `N175 G96 S900 M04` command in a counterclockwise direction. The cutting tool is rapidly positioned at the point of X30, Z1, and Y0 coordinates using the `N180 G00 X30 Z1 Y0` command. The turning process begins with `N185 G01 Z-3.9 F0.14 M08`, moving the cutting tool to Z-3.9 at a feed rate of 0.14 units per revolution with coolant on. Similar to the first pass, various linear and circular interpolation commands are followed to shape the workpiece according to the desired geometry. A clockwise arc is created by `N195 G03 X56.6 Z-5.2 R2`, while a linear cut is defined by `N200 G01 X58.8 Z-16.5`. The program is continued with these commands to achieve the specified contours and depths. After the necessary cuts are completed, the cutting tool is returned to the reference position with `N260 G28 U0 V0 W0 M05`, ensuring the spindle is stopped and the CNC turning centre is ready for the next pass.

The determined cutting tool for the third pass is selected with the `N265 T0300` command. The spindle speed is set to a maximum of 750 RPM, and a constant surface speed of 750 RPM is maintained in a clockwise direction (M03). The cutting tool is rapidly moved to the starting position of X46, Z0, and Y0 coordinates with the `N295 G00 X46 Z0 Y0` command. The turning process is initiated with the `N300 G01 Z-0.8 F0.12 M08` command, moving the cutting tool to Z-0.8 at a feed rate of 0.12 units per revolution with coolant on. Various linear interpolation commands are used by the program to perform precise cuts along the specified paths. Specifically, the cutting tool is moved to the position at coordinates X35.7 and Z-4.5 with the `N305 X35.7 Z-4.5` command, and the pass is continued to Z-50 with the `N310 Z-50.` command. After the pass is completed, the cutting tool is rapidly returned to the reference position using the `N325 G28 U0 V0 W0 M05` command, with the spindle stopped.

V. CONCLUSION

This paper presents a systematic approach to the fundamental principles and practices for the development of CNC programs specific to the clutch hub turning process. Through a detailed exploration of cutting tool selection and toolpath strategy optimisation, the study provides a practical framework for CNC program creation that spans from initial design to final implementation. The research highlights

methods to improve precision and efficiency in CNC programming by effectively integrating G-codes and M-codes and ensuring constant monitoring and control over machining operations.

The performance of optimising toolpaths and minimising errors underscores the importance of accuracy and reliability in CNC program development. Advanced technologies, such as CAD/CAM integration, are evaluated for their impact on improving precision and efficiency, demonstrating how modern technologies can significantly facilitate the CNC programming process. By analysing functional CNC programs, the paper serves as a valuable resource for engineers and machinists, contributing to the advancement of expertise in the creation of effective and dependable CNC programs for precise and efficient manufacturing operations.

In conclusion, this research not only demonstrates the theoretical foundations of CNC programming but also offers practical insights into the implementation of these principles. It underscores the critical role of well-structured and carefully chosen G-codes and M-codes in achieving high-quality CNC programs. As such, this paper is a valuable resource for those aiming to deepen their understanding and improve their skills in CNC programming, particularly in the context of developing robust programs for clutch hub turning processes.

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Inspection of flux pinning capability and microstructural properties of Bi2.1+xSr2.0Ca2.1Cu3.0Oy ceramics

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Abstract – This study examines the impact of varying bismuth addition (0.00≤x≤0.10) on the artificial flux pinning capability, strength of coupled vortices, surface view, microstructure, and crystalline quality features of bulk polycrystalline Bi2.1Sr2.0Ca2.1Cu3.0OyOx ceramics. Using critical current density measurements at 77 K (Jc), electron dispersive X-ray (EDX), and scanning electron microscopy (SEM) findings, we observe that while the ceramic matrices are produced successfully, the increase in the bismuth impurity addition triggers a monotonic diminish of copper content and an incremental enhancement of the bismuth content. Correspondingly, EDX evidence guarantees that there is a sensitive link between surface appearance and bismuth ions levels. SEM images reveal significant deterioration in microstructural, surface morphology appearance, and crystalline quality based on the reduction in the formation of platelet-like stacked layers. This is attributed to increased micropores, microcrystal coalescence orientations, voids, melting regions, cracks, and particle size distribution. The critical current density measurements also indicate that additional bismuth significantly reduce he flux pinning capability, strength of coupled vortices, and elasticity due to weakened interaction strength between grains. All in all, the bismuth addition in the Bi2.1Sr2.0Ca2.1Cu3.0OyOx ceramic structures is not a good preference to increase the magnetic field-carrying ability and especially engineering current.

Keywords – Bi-2223 material; Bi impurity; Jc; SEM; EDX

I. INTRODUCTION

The discovery of the first superconductor in mercury metal with a critical transition temperature below 4.2 K dates back to 1911 [1]. Since then, researchers have focused on finding new materials that exhibit superconductivity. Over the years, a variety of materials have been discovered, including rare earth borocarbides, pure elements, nitrides, organic compounds, sulfides, oxides, A-15 inorganics, magnesium diboride, metal-based compounds, chalcogens, Chevrel phases, pyrochlorine oxides, heavy fermions, metals, semi-metal-containing materials, alloys, carbon/silicon-based compounds, fullerites, rutheno-cuprates, and cuprate-layered perovskites [2].

Among these, high-temperature superconducting cuprate-layered perovskite compounds (containing Bi, Tl, and Hg), particularly Bi-based superconducting ceramics, have garnered immense attention due to their exceptional characteristics. Notably, Bi-2212 (with a critical transition temperature of 85 K), Bi-2223 (100 K), and Bi-2201 (20 K) have been extensively studied [3]. The Bi-2223 superconducting ceramic comppunds, in particular, is favored for its superior thermodynamic stability, high superconductive temperatures, magnetic field carrying ability, dc current carrying capacity, electronic, and optical properties, resistance to humidity, simple chemical composition, and ease of

deformation/shaping/rolling into long cables. Its easy access to cooling systems, stabilization performance with oxygen content, and low energy losses make it widely applicable in various fields such as applied sciences, innovative energy infrastructure, energy-related industries, generators, electro-optics, sensitive process control, refrigeration systems, power transmission, and large-scale applications [4–14].

The presence of BiO layers with Van der Waals bonds in Bi-based compounds facilitates easy shaping, deformation, and rolling for long tape-casting and cable construction. Consequently, these Bi-containing superconducting components, particularly the Bi-2223 phase, have gained significant prominence in the literature. However, their practical utilization faces challenges due to inherent brittleness within the micaceous structure [15]. Additional issues include randomly oriented microcrystals, intergranular boundaries, characteristics of mobile carriers in space, layered anisotropic micaceous structure, high sensitivity to applied magnetic fields, multiple phase compositions, large penetration depth, coupling problems between layers, granular structure, stabilization of main phases, short coherence length, and mechanical stabilization. These challenges necessitate resolution through appropriate preparation methods such as doping mechanisms, metallic interfaces, cation or anion substitutions in crystal structures, transition metal evaporation/diffusion, multilayered structures, and chemical additions in crystal lattices [16, 17]. One preferred method to enhance crystallinity quality and grain connectivity while mitigating crystal structure problems, crack-initiating defects, and non-recoverable stress concentration regions involves doping mechanisms [19].

Here, we inspect the differentiation of basic artificial flux pinning capability, surface appearance, crystalline quality, and microstructural features by means of current density measurements taken at 77 K and scanning electron microscopy measurements (SEM) in detail. Furthermore, the elemental distributions for the ceramic material surfaces are extensively analyzed using by the EDX measurement tests.

II. Materials and Method

This research builds upon our previous work [20] by further characterizing bulk Bi-added Bi2.1Sr2.0Ca2.1Cu3.0OyOx ceramic materials. In Ref. [20], we described the fabrication process, including details on powder impurities, the solid-state reaction, and the calcination and sintering conditions. We also explained the measurement setups and methods used. The study focused on the impact of introducing additional Bi impurity ions at various molar ratios between 0.000-0.10 (0.00, 0.01, 0.02, 0.04, 0.08, and 0.100) on the general mechanical properties as regards brittleness index, elastic hardness coefficient, fracture toughness, and yield strength constants belonging to bulk Bi-2223 crystal lattice. The investigation utilized Vickers hardness tests with different loads.

In the present work the influence of extra bismuth ions doping on the change of the capability of the strength of coupled vortices for movements, vortex lattice period, artificial flux pinning centers, elasticity, the main microstructural, surface morphological, and crystalline quality features is examined by means of the critical current density at 77 K and scanning electron microscopy tests. In more detail, we conduct critical current measurements using a homemade system at 77 K in liquid nitrogen without applying any magnetic field strengths of the pure and various bismuth ions added Bi-2223 ceramics structures to find out the variation of artificial pinning regions, pinning capability, strength of vortices coupled for movements, interaction strength between grains, vortex lattice period, and elasticity.

Secondly, we are interested in the influence of extra bismuth addition on the surface morphology view, texturing, boundary coupling problems, micropores, grain size distributions and alignments, partial melting sites, and layered structure of typical Bi-2223 crystal systems using a FEI Quanta FE-SEM electron microscope measurements performed at 20 kV external accelerating voltage. The images are pictured at 30000X magnification under secondary electron image. Additionally, the element distributions on the local specimen surface for the ceramic systems are inspected with a SEM equipped with an Oxford X-ray micro-probe and IXRF System Model 550i analyzer. For clarity, the different Bi-added materials are referred to as pure, Bi1*, Bi2*, Bi3*, Bi4*, and Bi5*, respectively.

III. RESULTS AND DISCUSSION

A. *Microstructural and surface appearances for Bi-added Bi-2223 ceramic compounds*

The crucial influence of extra bismuth impurity addition on the surface morphology view, texturing, boundary coupling problems, micropores, grain size distributions and alignments, partial melting sites, and layered structure of Bi2.1Sr2.0Ca2.1Cu3.0OyOx ceramic samples produced are extensively analyzed by use of SEM measurements performed at 30000X magnification. It is observed that with the augmentation of bismuth impurity ratios, all the characteristic surface morphologic properties and crystalline quality are found to degrade regularly. Thus, we depict only the SEM pictures pertaining to the best (pure) and the worst (Bi5*) samples in Fig. 1 a and b. However, all SEM photographs will be given and discussed in detail in the oral presentation. It is visible that the bismuth impurity negatively affects the surface morphology view, texturing, boundary coupling problems, micropores, grain size distributions and alignments, partial melting sites, and layered structure of Bi-2223 ceramic system.

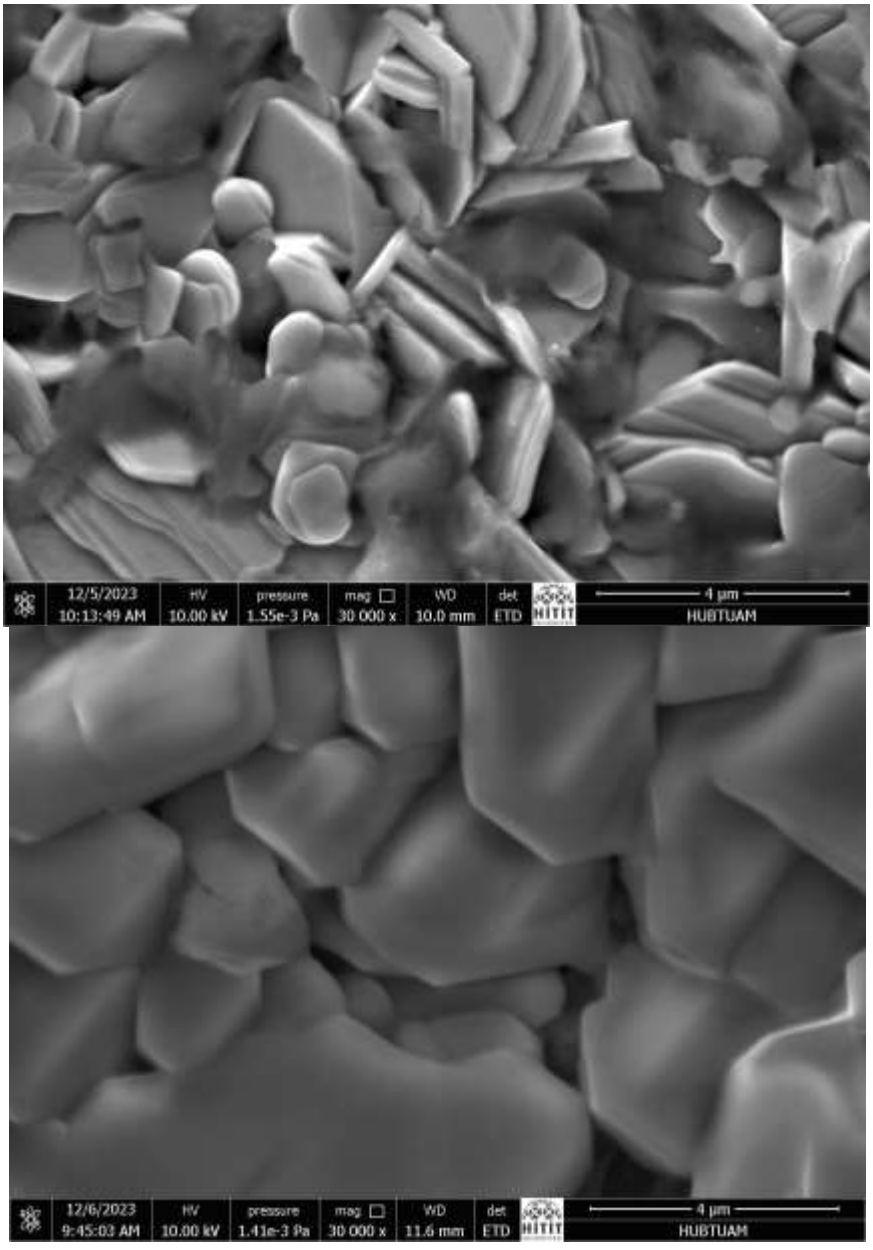

Figure 1 30000x magnified SEM images for a-) the bulk Bi0* ceramic structure and b-) the polycrystalline Bi*5 superconducting materials.

It is apparent that similar to the findings for the values of J_c parameters, the considerable change in surface morphology of Bi-2223 matrices doped with extra bismuth impurity stems from the successful addition of new bismuth ions in the crystal system. Moreover, Fig. 1a and b indicates that all the crystallinity quality and related surface view features diminish seriously. In more detail, the SEM images picture that these two (Bi0* and Bi5*) ceramic compounds possess the classic granular structure, stacked layers but in the randomly distributed superconducting layer alignments. Besides, SEM pictures reveal that the existence of extra bismuth ions in the $Bi_{2.1}Sr_{2.0}Ca_{2.1}Cu_{3.0}O_yO_x$ ceramic crystal system harms the formation of flaky, platelet-like layers in the grains. This disruption was due to the induction of different layer orientations, and the formation of melting regions, primarily resulting from the shrinkage of particle sizes of the samples. Hence, the pure sample including more homogeneous structure, more uniform surface view and more grain boundary couplings. At the same time, the bulk Bi0* compound with well-linked platelet shapes and crystal orientations indicates greater sample quality and larger grain sizes along Bi-2223 materials. In this respect, the workpiece possesses the densest/smoothest crystal morphology, attributable to minimum porous structure compared to the other workpieces (Fig. 1a). On the other hand, as for the highest bismuth impurity ion doped Bi-2223 superconductor there seems a strong increase in the partial melting sites and related boundary coupling problems in the main matrix. On this basis, there appearance a lot of irregular grain misorientations, cracks, voids, and micropores in the SEM image as seen in Fig. 1b. SEM images show that surface morphology view, texturing, and grain boundary couplings are strongly dependent upon the extra Bi impurity addition level.

B. *EDX inspections for Bi2.1+xSr2.0Ca2.1Cu3.0Oy systems*

The variations in local elemental composition distributions (Bi, Cu, Sr, Ca, and O) using typical EDX (energy dispersive X-ray) experiments for Bi2.1+xSr2.0Ca2.1Cu3.0OyOx crystal system are experimentally analyzed. Thus, we verify whether the desired bismuth impurity ions dopant is successfully incorporated along the materials produced. The numerical values for the distributions of elements are presented in Table 1. Hence, it is confirmed that every bulk ceramic system contains the required compositions [21].

Table 1. EDX results for $Bi_{2.1+x}Sr_{2.0}Ca_{2.1}Cu_{3.0}O_yO_x$ matrix

Component	**Line**	**Distribution Content (wt.%)**					
		Bi0*	**Bi1***	**Bi2***	**Bi3***	**Bi4***	**Bi5***
Bi	L_α	41.776	41.828	41.889	41.920	41.955	41.998
Sr	L_α	16.685	16.684	16.772	16.564	16.675	16.596
Ca	K_α	8.124	8.086	8.002	8.186	8.161	8.225
Cu	K_α	18.206	18.188	18.151	18.132	18.108	17.984
O	K_α	15.209	15.214	15.186	15.198	15.101	15.197

Moreover, it is observed that the elemental distributions of calcium, strontium, and oxygen are random whereas the distribution of bismuth ions increases systematically as intended. In contrast, the elemental distribution analyses of copper show a significant decrease with the increase in bismuth elements. Further, we also illustrate changes in atomic distributions with respect to bismuth ions doped as given in Fig. 2. The visuals indicate that the bismuth content increases significantly with the addition of bismuth ion impurities in Bi2.1Sr2.0Ca2.1Cu3.0OyOx compounds. Numerically, the bismuth composition is found to be approximately 41.776% for Bi0*, 41.828% for the Bi1* workpiece, 41.889% for the bulk

Bi2* crystal structure, 41.920% for the Bi3* material, 41.955% for the Bi*4 sample, and 41.998% for the bulk polycrystalline Bi5* material, respectively. In terms of copper composition in the Bi2.1+xSr2.0Ca2.1Cu3.0OyOx ceramic system, the value decreases from 18.206% in the pure material to 17.984% in the bulk Bi5* ceramic workpiece. The others exhibit the moderate ratios changing from 18.188% to18.108% for the Bi1* and Bi4* samples. Thus, the increase in bismuth ions addition leads to a dramatic decrease in the copper content.

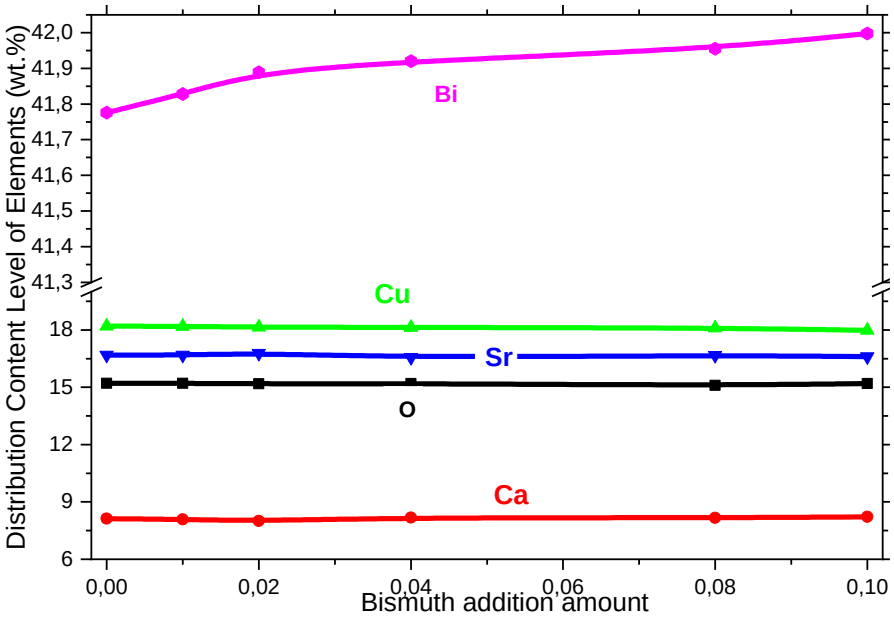

Figure 2 Local elemental distributions for Bi2.1+xSr2.0Ca2.1Cu3.0OyOx superconductors.

Additionally, the oxygen content is found to vary from 15.214% (for the bulk Bi2* workpiece) to 15.101% (for the bulk Bi4* material). The strontium elemental distribution shows the similar trend with the oxygen content. On this basis, the maximum strontium elemental distribution of 16.772% belongs to the Bi2* material whereas the minimum strontium distribution of 16.564% ascribes to the Bi3* crystal structure. At the same time, the calcium elemental distributions are observed to change from 8.002% for the Bi0* sample to 8.225% belonging to the Bi5* material, respectively. To sum up, the EDX results show that the reduction of microstructural, crystalline quality, flux pinning ability, and surface morphological features of Bi2.1+xSr2.0Ca2.1Cu3.0OyOx matrices depending on the bismuth ions stems from the considerable decrease in the copper contents.

C. *Transport critical current densities of Bi-added Bi2.1+xSr2.0Ca2.1Cu3.0Oy ceramic systems*

For the second part of paper, we sensitively focus on the determination of variation in the capability of the artificial flux pinning centers, strength of coupled vortices for movements, vortex lattice period, and elasticity related to the numerical critical current density parameters (Jc) for self-field transport at 77 K for polycrystalline bulk Bi2.1+xSr2.0Ca2.1Cu3.0Oy structures. In other words, the role of addition of impurity ions on the crystallographic misorientations and structural deformations present in the Bi-2223 crystal system is extensively examined by the experimental findings to develop the resistance of materials to applied magnetic field strengths. This is because the Bi-2223 ceramic with strong anisotropic and layered crystal structure is known to be weak to the applied fields depending on the thermally movements of flux vortices under any external magnetic field strength by easily overcoming the pinning barriers. This mechanism is called as copper pair-breaking for the adjacent multiple layers [22, 23].

Table 2 Change of Jc values of Bi2.1+xSr2.0Ca2.1Cu3.0Oy systems

Materials	Jc (A/cm2)
Pure	62
Bi1*	58
Bi2*	53
Bi3*	48
Bi4*	41
Bi5*	35

At the same time, the numerical Jc parameters obtained without any external magnetic field strengths applied for the pure and extra Bi-added Bi-2223 superconductors are depicted in Table 2. It is observed that the numerical values of Jc parameters are noted to vary harshly depending on the bismuth impurity addition level. This means that the addition idea of bismuth impurity ions in the bulk Bi-2223 crystal system is successfully performed as it should be. Besides, the table shows that as the bismuth impurity addition increases in the main system, the values of Jc parameters are found to decrease dramatically 62 A/cm² to 35 A/cm². In the current work, the maximum value belongs to the bulk Bi0* sample whereas the minimum value of 35 A/cm² ascribes to the Bi5* ceramic superconductor. The other extra Bi-added Bi-2223 ceramic compounds possess the values of Jc constants 58 A/cm², 53 A/cm², 48 A/cm², and 41 for the bulk Bi1*, Bi2*, Bi3*, and Bi4* superconducting compounds, respectively. It is obvious that the increase in the bismuth impurity ions in the system either damages seriously the formation of artificial flux pinning ability regions or increases the random distribution of pinning centers as seen in Fig. 3.

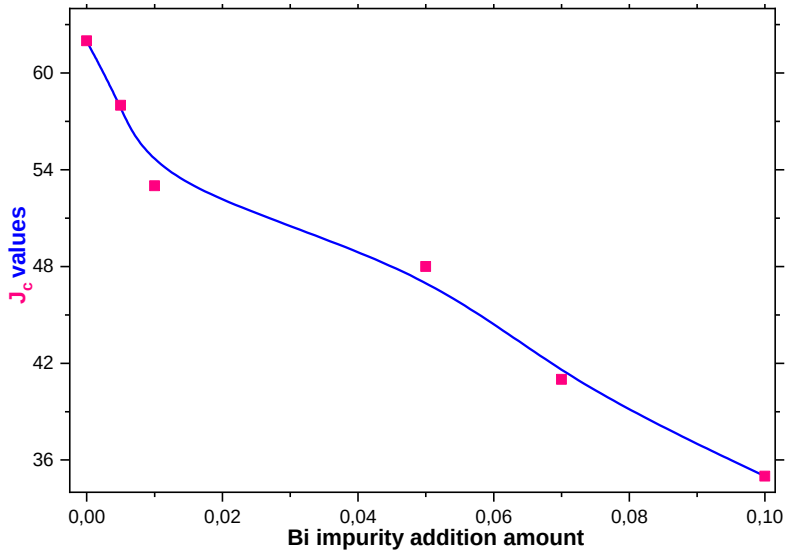

Fig. 3 Change of critical current densities values based on bismuth impurity addition amount.

In this respect, the pancake vortices begin to thermally move. This means the beginning of the energy dissipation based on the ohmic resistance in the superconducting system (transition of electrical energy to the heat energy [24, 25]. Correspondingly, the extra bismuth addition idea is not a good preference to develop magnetic field-carrying ability and especially engineering current depending on the decrease of the artificial flux pinning capability, strength of coupled vortices for movements, vortex lattice period, and elasticity. Besides, the degradation in the interaction strength between grains and crystal structure quality.

IV. CONCLUSION

In the current work, we investigate the serious changes in artificial flux pinning capability, strength of coupled vortices for movements, sample quality, microstructural features, and surface appearances of bulk polycrystalline Bi2.1+xSr2.0Ca2.1Cu3.0Oy structures with varying bismuth addition using Jc tests

and SEM experiments. It is gathered that the extra bismuth added Bi-2223 structures are successfully produced. At the same time, the elemental distribution for copper content is found to decrease monotonically with increasing bismuth impurity addition in the Bi-2223 superconductors. Local elemental content of bismuth impurity is measured to enhance incrementally with the addition mechanism. The EDX findings confirm a sensitive link between surface appearance and bismuth ions levels in the Bi-2223 crystal structure. Moreover, SEM images reveal that the microstructural, crystalline quality, and surface morphological features deteriorate significantly due to a reduction in the formation of flaky, platelet-like layers in the grains. This deterioration was attributed to an increase in micropores, microcrystal coalescence orientations, voids, melting regions, cracks, and particle size distribution. Finally, Jc measurements show that the extra bismuth addition idea leas to the reduction of the artificial flux pinning capability, strength of coupled vortices for movements, vortex lattice period, and elasticity due to the suppression in the interaction strength between grains.

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The Importance of Carbon Footprint Measurement for Environmental Sustainability

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Abstract **–** This study aims to evaluate the importance, measurement, and environmental impacts of carbon footprint (CF). CF is one of the most popular environmental indicators today. It is based on greenhouse gas emissions (GGE) as a measure of environmental impact. It is a concept that measures the amount of activities of individuals and businesses that lead to the GGE. Although it is usually measured by CO2 emissions (CE), other greenhouse gases can also be included. The CF is used to help reduce negative environmental impacts and take steps towards a sustainable future. The measurement of CF contributes to identifying and evaluating various environmental negative effects such as air pollution and deterioration of the natural ecosystem due to GGE in the fight against the threat of climate change. Thus, this measurement guides efforts to reduce negative environmental impacts, contributing to the adoption of more sustainable and environmentally friendly practices. These include measures such as increasing energy efficiency, switching to renewable energy sources, opting for sustainable transportation options, improving waste management, and opting for environmentally friendly products.

Keywords – carbon footprint, carbon footprint measurement, sustainable development, sustainable environment

I. INTRODUCTION

CF is a concept that is widely used and embraced in public debate on responsibility for the threat of global climate change and efforts to reduce environmental pollution (EP). Although there is no clear definition of this concept, the generally accepted basic understanding is that the CF represents significant GGE associated with climate change and occurs as a result of human production or consumption activities. In conclusion, the concept of CF is an important tool that helps us understand and reduce our personal and corporate environmental impact. Monitoring this can help us take steps towards a sustainable future [1].

Measuring the CF is very important in terms of environmental sustainability (ES). Namely, an accurate assessment of the CF is one of the key elements for assessing progress towards sustainable development (SD). Calculating the CF enables the determination of GGE of personal or corporate activities. This calculation includes various factors such as energy consumption, transportation, waste management, and shopping habits. CF calculation results help develop strategies to reduce GGE. Individuals and businesses can take various steps to reduce their CF.

CF in discussions in the context of SD; refers to GGE released into the atmosphere through consumption, food production, transportation, or other related processes originating from products, industrial activities, institutions, or individuals. Reducing the CF has become an integral part of the environmental agenda. The environmental commitments taken at COP27 state that all environmental policies must reduce GGE and ensure the protection of the natural environment [2].

Today, increasing CE is the main cause of global climate change, endangering natural ecosystems and human security. Approximately 70-80% of energy consumption and related CE originate from large cities. By 2050, more than 60% of the world's population is expected to live in cities [3]. Therefore, cities contribute to the issue of CE and energy consumption, and should also be part of the solution to this problem [4].

This study can contribute to the literature for a sustainable future by examining the importance of CF in the context of sustainable development goals (SDG) of countries, measurement methods, and its role in combating environmental impacts. In the second part of the study, after the introduction, SD and CF were conceptually evaluated. In the third part, the calculation of CF is evaluated with examples and the importance of this calculation in terms of ES is mentioned. The study was completed with conclusions and policy recommendations.

II. Sustainable Development and Carbon Footprint

A. Sustainable Development

The origin of the concept of SD is based on the report called "World Conservation Strategy" prepared by the International Union for Conservation of Nature and Natural Resources (IUCN) in 1980. However, the general acceptance and widespread use of the concept was realized with the report titled "Our Common Future" published by the World Commission on Environment and Development in 1987. In the report, SD is defined as "development that meets today's needs without compromising the ability of future generations to meet their own needs" [5].

In Environmental Law No. 2872, SD is defined as development and progress based on the principle of balancing environmental, economic, and social goals that ensure the healthy living environment of current and future generations [6]. The fundamental principles underlying SD are environmental integrity, social justice, and economic prosperity. These principles entail ensuring that human activities do not negatively impact the environment, ensuring equal access to natural resources, avoiding harm to irreplaceable resources, and simultaneously addressing global social injustices to ensure economic prosperity as part of SD [7], [8].

According to Munasinghe (2009), the approach proposed for SD outlines the fundamental components and their interconnections, as depicted in Figure 1. In this approach, the core elements of SD are economic, environmental, and social domains, each with distinct drivers and goals: (i) The economic domain focuses on enhancing human well-being by increasing consumption of goods and services. (ii) The environmental domain aims to preserve the integrity and resilience of ecosystems. (iii) The social domain emphasizes enriching and empowering human relationships and facilitating individuals/groups to achieve their goals. The interconnections and balance among these three domains form the foundation of SD [9].

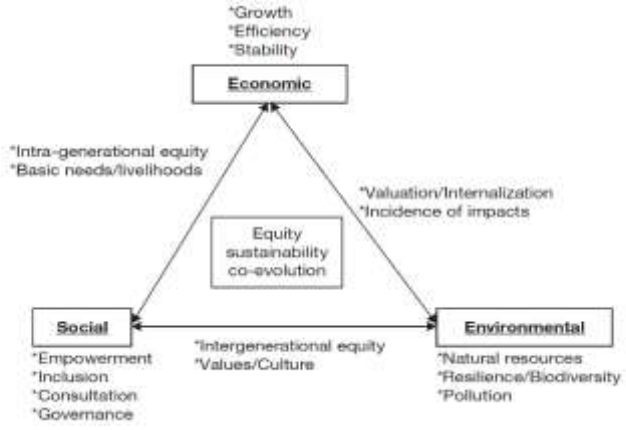

Figure 1. Sustainable Development Triangle

SD is a developmental model that aims to use natural resources effectively and efficiently to meet the needs of both current and future generations while maintaining environmental, social, and economic

balance. This model seeks the sustainability of economic growth, social welfare, and environmental protection simultaneously [10]. The primary goal of SD is to adopt an approach that meets today's needs while also considering the requirements of future generations to leave a livable world for them. This model aims to ensure the sustainable use of natural resources, enhance social justice and welfare, balance economic growth with environmental protection, and reduce global inequalities [11].

SD also encompasses a variety of principles and strategies to maintain the balance between the environment, economy, and society. The implementation of these principles and strategies includes work in areas such as reducing GGE, protecting natural habitats, increasing the use of renewable energy sources, adopting environmentally friendly technologies, reducing inequalities, and increasing well-being. As a result, SD is a development model that includes environmental, social, and economic dimensions and forms the basis of a livable future for the whole world [12].

B. Carbon Footprint

Factors such as rapid population growth, urbanization, economic activities, and changing consumption habits put increasing pressure on the environment and natural resources. This situation causes problems such as EP, climate change, desertification, deforestation, water scarcity, and global warming to maintain their place on the world agenda. To achieve SDG, the concept of a "green economy" is gaining more and more importance [13].

Various indicators are used for SD. One of these indicators is the ecological footprint (EF) [14]. The largest component of the EF is the CF with a rate of 46%. CF is the most important factor released into the atmosphere as a result of human activities and affecting the global warming process [15]. This process leads to negative changes in the climate with the increase in global warming and threatens natural life [16]. The increase in GGE in the atmosphere with the rise of industrialization has caused average temperatures to rise and unexpected changes in the climate.

Unconscious and inefficient use of fossil fuels triggers global warming by causing an increase in GGE in the atmosphere, especially CE. Countries needed an international convention because they could not set specific targets for reducing GGE and could not prepare the necessary infrastructure. In this context, the Kyoto Protocol, which entered into force in 2005, accelerated the determination of CF by establishing various mechanisms [17].

According to the Intergovernmental Panel on Climate Change (IPCC), there is a statistical confidence of 95% that climate change is caused by human activities [18]. The concept of CF quantifies the amount of CE and other GGE released into the atmosphere directly or indirectly through individual or organizational activities such as transportation, heating, energy consumption, and product purchases. These emissions significantly contribute to climate change. Therefore, CF is a crucial term for measuring human impact on the environment [1].

Another definition of CF is the measure of GGE, especially CE, emitted into the atmosphere as a result of human activities over a specified period. It serves as an indicator of the environmental harm caused by individuals and typically consists of primary and secondary components [19]. The primary footprint measures direct CE from activities like household energy consumption and transportation fueled by fossil fuels. The secondary footprint, on the other hand, measures indirect CE associated with the production, use, and disposal of products [20].

The CF definitions of some institutions are shown in Table 1.

Table 1. Various Carbon Footprint Definitions

Institutions	Definitions
British Petrol	A CF is the amount of CE emitted by your daily activities – from doing laundry to transporting children to school.
British Sky Broadcasting	The CF is calculated by measuring GGE from factors such as companies' activities, company vehicles, business trips, and waste disposal.
Carbon Trust	CF is a method that calculates the total carbon equivalent of GGE generated during the production, transportation, use, and disposal stages of a product. This calculation covers emissions during the raw material procurement, manufacturing, distribution, and decommissioning phases, but does not include emissions during the use of the product.
Energetics	These are direct and indirect CE resulting from business activities.
ETAP	CF is a measurement that represents the total amount of GGE released into the atmosphere as a result of the daily activities of people and organizations. This measurement is expressed in tons in CE equivalent.
Global Footprint Network	It is the need for biological capacity to capture CE from the burning of fossil fuels through photosynthesis.
Parliamentary Office of Science and Technology	CF refers to the total GGE released during the life cycle of a product or activity. This calculation involves the conversion of GGE other than CE into CE equivalent according to their global warming potential.

Source: Wiedmann and Minx, 2008.

III. Calculating the Carbon Footprint and Its Importance for Environmental Sustainability

A. Calculating the Carbon Footprint

CE is the most common GGE released into the atmosphere as a result of human activities. The volumetric equivalent of CE released by individuals forms the numerical value of their CF Calculating the CF is crucial as it determines how much biocapacity we need and helps measure our environmental impact. Before starting efforts to reduce CF, calculating the current CF is of critical importance. CF calculation quantifies the amount of carbon released into the atmosphere by individuals through their transportation, heating, energy consumption, and product purchases. Initiatives to reduce CF are significant steps toward mitigating the effects of climate change and global warming [21], [22].

International agreements such as the Kyoto Protocol aim to minimize the human-induced impacts of global warming and climate change. In this regard, governments and organizations that are committed to reducing GGE calculate their CF and implement measures to mitigate these emissions. CF calculation serves as a crucial tool to quantify and mitigate the environmental impact of human activities [23].

The CF calculation process calculates the damage that individuals and companies cause to the earth. Normally, per capita biocapacity is expected to be greater than the EF per capita. The CF per person is usually about 4 tons. In this context, measures such as reducing electricity and water consumption, switching to electric or hybrid vehicles in transportation, adopting effective waste management, and reducing the use of plastics are effective steps in reducing CF [24].

Carbon calculations are now recognized as an important tool in assessing environmental impacts. These calculations are usually made to determine the GGE and CF of an organization, product, service, or activity throughout its vital cycle. CF refers to the sum of direct and indirect GGE and is used as an important indicator in terms of ES. In addition, CF calculation methods have been revealed as a result of various research and methodological development studies. These calculation methods are generally based on scientific principles and are considered an important tool in assessing environmental impacts [24].

Life Cycle Assessment (LCA) is one of the methodologies that underpin CF calculations. LCA systematically assesses the environmental impact of a product or service throughout its entire life cycle (ISO 14040, 2006). CE and other environmental impacts are calculated by taking into account the stages of production, use, and disposal. LCA is a widely used methodology for analyzing the ES performance of products and services [25].

The concept of CE equivalent plays an important role in standardizing the CF. This concept is based on the fact that different GGE (methane, oxides of nitrogen, etc.) It is converted to CE, making its effects on climate change comparable [26]. Global warming potentials (GWP) are determined for GGE and CE equivalent calculations are made. Scientific data and models are the cornerstones of CF calculations. The emission factors used in the calculations are usually determined based on regional or national energy production data and are updated continuously [1]. This data is obtained from scientific research and industrial databases, increasing the accuracy of the calculation.

National and international standards are important to ensure that CF calculations provide consistent and comparable results. For example, the ISO 14040 and ISO 14044 standards guide the implementation and reporting of LCA methods [27].

CF calculation is often used to assess the environmental impact of personal or corporate activities. These calculations provide a quantitative measurement of environmental impacts through factors such as electricity consumption. For example, the CF of an individual or organization from electricity use can be determined depending on the resources used to generate the energy and the regional electricity generation mix [28].

For example, when the annual electricity consumption of a home or workplace is determined as 10,000 kWh, the CF of this consumption can be calculated. Let's assume that electricity is obtained from 50% coal, 30% natural gas, and 20% renewable energy sources. In this case, the CF of electricity consumption can be calculated as follows:

Coal: 10,000 kWh * 50% * (emission factor)

Natural Gas: 10,000 kWh * 30% * (emission factor)

Renewable Energy: 10,000 kWh * 20% * (emission factor)

This calculation gives the total CF resulting from electricity consumption. Emission factors often vary according to the regional electricity generation mix, and standard values used in CF calculations can be obtained from national or international sources [29].

To give a simple example of personal energy carbon accounting, we can explain how to calculate an individual's CF based on their annual household electricity consumption using default emission factors and standard methods.

Step 1: Determining Electricity Consumption

Suppose the annual electricity consumption of an individual's home is set at 12,000 kWh.

Step 2: Determination of Emission Factors

Emission factors are determined according to the sources used in the production of electrical energy. Let's assume that the electrical energy used in this example is obtained from 60% coal, 30% natural gas, and 10% renewable energy sources.

Coal: 2000 g CO2e/kWh

Natural Gas: 1000 g CO2e/kWh

Renewable Energy: 0 g CO2e/kWh (assuming zero emissions)

In this case, if we calculate the average emission for 1 kWh of electrical energy:

Coal : 2000 g CO2e/kWh * %60 = 6000 g CO2e/kWh

Natural Gas : 1000 g CO2e/kWh * %30 = 300 g CO2e/kWh

Renewable Energy : 0 g CO2e/kWh * %10 = 0 g CO2e/kWh

Total average emission factor = (6000 + 300 + 0) g CO2e/kWh

= 6300 g CO2e/kWh

As a result of this calculation, the total average emission factor of the electrical energy used throughout the supply chain was found to be 6300 g CO2e/kWh or 6.3 kg CO2e/kWh. This value is used to determine emissions from electricity consumption in CF calculations.

Step 3: Carbon Footprint Calculation

CF calculation of annual electricity consumption:

Total carbon footprint = Electricity Consumption (kWh) * Average Emission Factor (g CO2e/kWh)

Example:

Electricity consumption = 2,000 kWh

Average emission factor = 6.300 g CO2e/kWh (6.3 kg CO2e/kWh)
Total carbon footprint = Electricity consumption × Average emission factor
= 2,000 kWh × 6.3 kg CO2e/kWh
= 12,600 kg CO2e (12.6 tons).

As a result of this calculation, the CF of this individual resulting from annual electricity consumption is calculated as 12.6 tons of CO2e. As a result, CF calculation methods are based on a scientific basis and maintain their importance as a field that is constantly being developed. These calculations help individuals and organizations assess their environmental impact, develop strategies to reduce EP, and set sustainability goals.

B. The Impact of Carbon Footprint Measurement on Environmental Sustainability

The relationship between carbon calculations and the environment can be examined from various aspects. First, these calculations provide a quantitative measurement of environmental impacts. For example, by calculating the CF of a product, GGE can be determined starting from the production process through the supply chain to transportation and the end user. In this way, the environmental impact of the product or service can be understood more clearly [30]. Secondly, carbon calculations allow for improved environmental performance. Once the CF in an organization or industrial process has been determined, steps such as reducing GGE or transitioning to alternative environmentally friendly technologies can be planned. This, in turn, can improve ES in the long run [31].

Third, carbon calculations contribute to environmental policymaking. A country's or region's CF data can help make science-based decisions in the creation of environmental policies. For example, tax incentives or restrictive regulations to reduce GGE can be designed based on the results of carbon calculations [32].

As a result, carbon calculations form the basis of environmental management and sustainability strategies. An accurate and comprehensive carbon accounting process allows for understanding, mitigating, and controlling potential impacts on the environment. This, in turn, can contribute to the conservation of natural resources by improving environmental quality in the long run [33].

IV. CONCLUSION

SD is one of the most important global goals of our time. This goal aims to observe environmental, economic, and social dimensions in a balanced way. The concept of CF plays a critical role in the SD agenda. CF refers to the total amount of GGE released into the atmosphere as a result of the activities of individuals, organizations, and products. The measurement of CF is used as an important indicator of climate change and ES. In summary, CF measurement includes the following elements: (i) Direct and indirect CE from daily activities, (ii) GGE from company activities, vehicles, business trips, and waste disposal, (iii) GGE during the production, transportation, use and disposal of products, (iv) Conversion of GGE other than CE into CE equivalent according to their global warming potential.

CF provides an important tool in combating this threat by measuring GGE that causes climate change. This measurement helps identify and assess environmental issues such as air pollution and natural ecosystem degradation. It also guides to reduction of negative environmental impacts and encourages the adoption of more sustainable practices. In conclusion, CF measurement has a critical role in achieving SDG. This measurement helps individuals, organizations, and products understand and reduce their environmental impact. Thus, it offers an important tool for building a more sustainable future. In this context, to reduce the CF, individuals and workplaces should take measures to reduce energy consumption and policy makers should be guided in this regard. More environmentally friendly options should be preferred in transportation and consumption habits should be reviewed.

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KCL çamuruna eklenen çeşitli tarımsal atıkların çamur özelliklerine etkisinin incelenmesi

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Özet- Sirkülasyon kaybı olarak adlandırılan çamur kaçağı sondaj sırasında görülen en yaygın sorunlardandır. Kuyuya gönderilen çamurun formasyondaki çatlaklar içine kaybolmasına, zaman ve madde kaybına neden olur. Sirkülasyon kaybını gidermek ve azaltmak için çok sayıda yöntem üzerinde çalışılmaktadır. Bu yöntemler teknik olarak veya farklı malzeme kullanımı üzerine olabilmektedir. Sirkülasyon kaybını önlemek için önleyici tedbirler alınır ve devre kaybı oluştuğunda düzeltici teknikler uygulanır. Kuyu duvarını güçlendirme yöntemleri arasında, sondaj sıvısına kayıp önleyici malzemeler ekleyerek çamur ağırlığını artırmak veya çamur keki özelliklerini iyileştirmek yaygın ve iyi bilinen uygulamalardır. Son yıllarda atıkların petrol sektöründe kayıp önleyici malzeme olarak kullanılması, dikkat çeken bir konu haline gelmiştir. İyileştirici teknikler arasında, formasyondaki çatlakları kapatmak amacıyla sondaj çamuruna kayıp önleyici malzemeler (LCM) eklenmesi yaygın bir yöntemdir. Kayıp önleyici malzeme olarak birçok farklı malzeme kullanılmaktadır. Bu çalışmada, çeşitli tarımsal atıkların çamur kaybını önlemede kullanılabilirliği incelenmiştir. Çamur olarak, yaygın kullanılışı olan ve kuyu dayanıklılığı açısından sorun yaratmayan KCl çamuru tercih edilmiştir. Hazırlanan KCl çamurunun içine eşit miktarda limon kabuğu, fındıkkabuğu, siyah çekirdek kabuğu, ceviz kabuğu, yer fıstığı kabuğu, buğday samanı, Siirt fıstığı kabuğu ve kereviz sapı tozu eklendikten sonra, farklı malzemelerin çamurun reolojik ve filtrasyon özelliklerine etkisi incelenmiştir. Eklenen tüm malzemelerin çamur kaybını azaltmada etkin olduğu görülmüş, buğday samanı hariç diğer malzemelerin kek kalınlığını artırıcı etki gösterdiği görülmüştür. Ceviz kabuğu ve fındıkkabuğu dışındaki tüm maddelerin plastik veya görünür viskoziteyi artırdığı gözlemlenmiştir.

Anahtar Kelimeler – Tarımsal atık, sondaj çamuru, filtrasyon özellikleri, reolojik özellikler, kayıp önleyici malzeme, çamur kaçağı

I. GİRİŞ

Petrol sondajı, petrol ve doğal gaz gibi hidrokarbonların yer altındaki rezervuarlardan çıkarılması için yapılan işlemleri ifade eder. İlk olarak petrol rezervlerinin belirlenmesi için yer yüzeyinde jeolojik ve jeofizik araştırmalar yapılır. Bu çalışmalar, potansiyel petrol kaynaklarının varlığını ve yerini belirlemeye yöneliktir. Belirlenen petrol rezervuarlarının detaylı analizleri sonucunda bir sondaj planı hazırlanır. Bu plan, sondajın derinliği, yerleşim yeri, ekipman gereksinimleri ve çevresel etkiler gibi faktörleri içerir. Deniz üzerinde ise deniz tabanında sabitlenen veya yüzeyde yüzen platformlar kullanılır. Kara üzerinde ise mobil sondaj kuleleri veya derin delme makineleri kullanılır. Sondaj platformu üzerindeki ekipmanlarla delme işlemi başlatılır. Delme sırasında özel matkap uçları kullanılarak yeraltındaki kayalar delinir ve sondaj devam eder. Delme tamamlandıktan sonra delik içine bir tüp (kılavuz borusu) yerleştirilir ve bu tüp deliği korur. Ardından, delik çevresine çimento enjekte edilerek deliğin stabilizasyonu ve çevresinin

korunması sağlanır. Delme tamamlandıktan sonra, kuyunun üretim aşamasına geçilir. Bu aşamada, hidrokarbonların yeraltından çıkarılması için gerekli ekipmanlar (pompa, boru hatları vs.) kurulur ve üretim başlatılır.

Petrol sondajında kullanılan sondaj akışkanı, sondaj kulesinden yeryüzüne çıkan kuyu içindeki sıvı veya gaz akışkanıdır. Bu akışkanlar, sondaj işlemi sırasında çeşitli amaçlar için kullanılır ve çeşitli özelliklere sahip olabilir.

Genellikle petrol sondajında kullanılan ana sondaj akışkanları şunlardır:

Sirkülasyon Sıvısı (Drilling Mud): Sirkülasyon sıvısı, sondaj sırasında delme matkabından çıkan kırık taş, çamur ve diğer atıkları kuyu içinde tutmak ve yüzeye taşımak için kullanılır. Ayrıca, sondaj kuyusunun stabilitesini sağlar, sondaj deliğinin duvarlarını korur, basınç dengesini sağlar ve hidrokarbonların taşınmasını kolaylaştırır. Sirkülasyon sıvıları genellikle su bazlı veya petrol bazlı olabilir ve içlerinde kil, polimerler, kimyasal katkılar ve bazen ağırlıklandırıcılar bulunabilir.

Köpük Sıvısı (Foam): Köpük sıvısı, düşük yoğunluğa sahip olan ve genellikle gaz (örneğin, hava veya azot) ile karıştırılarak oluşturulan bir sondaj akışkanıdır. Köpük sıvısı, derin denizlerde veya çökmüş bölgelerde kullanılabilir ve sıvının yoğunluğunu düşürerek sondaj kuyusunun stabilitesini sağlar.

Hidrolik Akışkan (Hydraulic Fluid): Hidrolik akışkanlar, sondaj sırasında hidrolik sistemlerde kullanılır. Bu akışkanlar, hidrolik pompa ve silindirlerde basınç ve hareket kontrolü sağlar.

Sondaj akışkanları, kullanıldıkları ortama, sondaj derinliğine, sondaj kuyusunun jeolojik özelliklerine ve sondaj operasyonunun gereksinimlerine bağlı olarak seçilir ve uygulanır.

Sondaj sırasında çamurun kuyu duvarlarından sızması veya kaybolması durumunda "çamur kaybı" yaşanır. Bu durum, sondajın güvenliğini ve verimliliğini etkileyebilir ve gerektiğinde önlemler alınarak yönetilmesi gereken önemi bir durumdur.

Çamur kaybını önleyici malzemeler, görünüşlerine, uygulamalarına, kimyasal ve fiziksel özelliklerine göre sınıflandırılır. Bu malzemelerin sınıflandırılması, çamur kaybını önlemek veya iyileştirmek amacıyla seçim yapma aşamasında önemli bir rol oynar. Kayıp önleyici malzemeler için fiziksel görünümlerine göre yapılab geleneksel sınıflandırma Tablo 1'de gösterilmektedir.

Tablo 1. Kayıp önleyici malzemeler için geleneksel sınıflandırma [1]

Lifli Yapı	Granüler	Pul	Karışımlar
Yer fıstığı kabuğu	Pekan cevizi kabuğu	Öğütülmüş Mika	Film, lif ve talaş
Ağaç kabuğu	Badem kabuğu	Selofan	Tekstil lifi ve talaş
Tüyler	Plastik	Mika	Selüloz lifi ve talaş
Kabuklar	Perlit	Pamuk Tohumu	Perlit ve Kalın bentonit
Cam lifi/ Ahşap lifi	Asfalt	Polietilen plastik cips	
Deri	Fındık kabuğu	Plastik laminant	
Şeker kamışı	Kalsiyum Karbonat	Mantar	
Mineral lifleri	Öğütülmüş ceviz kabuğu	Mısır Koçanı	
Kenevir			

Petrol ve doğal gaz endüstrisinde, sirkülasyon kaybıyla mücadele edilirken kuyu ömrüne bağlı olarak köprüleme, jelleştirme ve çimentolama maddeleri gibi faydalanılır.

Tarımsal atıkların ise tekrar kullanılabilir bir ürüne dönüştürülme potansiyeli oldukça yüksektir. Bu atıklar, inşaat mühendisliği, bina inşaatı, ahşap işleri gibi çeşitli alanlarda kullanılmaktadır. Özellikle petrol ve doğal gaz endüstrisinde, tarımsal atıkların kullanımı genellikle çamur kaybının önlenmesi amacıyla gerçekleştirilmiştir [2-4].

Tarımsal atıkların kayıp önleyici malzeme olarak kullanımı, hem çevresel sürdürülebilirlik açısından hem de ekonomik fayda sağlaması açısından önemli bir konudur. Bu atıkların yeniden değerlendirilmesi ve kullanılması, çeşitli avantajlar sunabilir.

Ancak, tarımsal atıkların kayıp önleyici malzeme olarak kullanımıyla ilgili bazı zorluklar da vardır. Atıkların toplama, işleme ve uygulama süreçleri, teknik zorluklar ve ekonomik maliyetler içerebilir. Ayrıca, atıkların kalite kontrolü ve standartlaştırılması da önemli bir konudur, çünkü atıkların bileşimi ve özellikleri bölgeden bölgeye değişiklik gösterebilir.

II. MATERYAL VE YÖNTEM

Bu çalışmada çamur kaybını azaltmak amacıyla çeşitli tarımsal atıkların kullanılabilirliği araştırılmıştır. Bu amaçla, çeşitli kuru yemiş kabukları ve tarımsal atıklar sondaj çamuruna eklendikten sonra fiziksel ve reolojik özelliklerinde meydana gelen değişim incelenmiştir. Çalışmada kullanılan tarımsal atıklar arasında ay çekirdeği, ceviz, Siirt fıstığı, yer fıstığı, fındık gibi çeşitli kuruyemiş kabukları, buğday samanı, limon kabuğu ve kereviz sapı tozu bulunmaktadır. Malzemeler, laboratuvarda hazırlanan 500 mL sondaj çamuruna 0,250 mm büyüklüğünde 7,5 g olarak eklenmiştir. [5]

Tarımsal atıkların çamur kaybını önlemedeki etkilerini araştırmak amacıyla özellikle şeyl ve kil içerikli formasyonların sondajında tercih edilen, su bazlı bir çamur olan ve yaygın olarak kullanılan KCl çamuru kullanılmıştır. Laboratuvarda hazırlanan çamurun bileşimi Tablo 2'de verilmiştir. Çamur hazırlanırken önce 1 litre su alınmış ve karıştırılmaya başlanmış, bu aşamada diğer maddeler yavaşça eklenmiştir. Maddeler eklenirken karıştırıcı açık tutulmuş ve tüm maddeler eklenip iyice karıştırıldıktan sonra karıştırıcı kapatılmış ve testler yapılmıştır.

Tablo 2. Laboratuvarda hazırlanan KCl çamurun bileşimi

Bileşen	Miktar
Su	1000 mL
Soda külü	1,5 g
NaOH	1,5 g
KCl	88 g
Nişasta	13,6 g
XCD	1,5 g
PAC-LV	8 g
NaCl	140 g
$CaCO_3$	27 g
Barit	0 g

Çalışılan malzemelerin sondaj çamurunda meydana getirdiği değişimleri belirlemek amacıyla çamur ağırlığı, pH, sıvı kaybı, filtre keki kalınlığı, görünür viskozite, plastik viskozite, kopma noktası ve jel mukavemeti gibi fiziksel ve reolojik özellikler ölçülmüştür. Tüm deneyler oda sıcaklığında gerçekleştirilmiştir.

Deneyler Batman Üniversitesi Petrol ve Doğalgaz Mühendisliği Laboratuvarlarında gerçekleştirilmiştir. Tüm cihazların kalibrasyonu TPIC (Türkiye Petrolleri İşletmesi AŞ) tarafından gönderilen saha ekibi tarafından kontrol edilmiştir.

Çamur yoğunluğu çamur terazisi kullanılarak belirlenmiş, pH değerleri ise pH kâğıtlarıyla ölçülmüştür. Eklenen maddelerin sondaj sıvılarının pH değerini 8 ile 10 arasında olması gereken ideal değerler aralığına uygun olup olmadığı belirlenmiştir.

Görünür viskozite, plastik viskozite, kopma noktası ve jel mukavemeti ölçümleri için 6 ayrı hızda ölçüm yapabilen döner viskometre cihazı (Fann model 35 SA), kullanılmıştır. Farklı hızlarda okumalar yapıldıktan sonra görünür viskozite Formül 1'den, plastik viskozite Formül 2'den ve kopma noktası ise 600 ve 300 rpm okumaları kullanılarak Formül 3'ten hesaplanmıştır. Elde edilen viskoziteler cP (centipoise) biriminde, kopma noktası ise lb/100 ft² (pound per 100 square feet) biriminde ifade edilmiştir.

Görünür Viskozite = [600 rpm okuması]/2 (1)
Plastik Viskozite = [600 rpm okuması] - [300 rpm okuması] (2)
Kopma Noktası = [300 rpm okuması]-Plastik Viskozite (3)

Jel mukavemeti ölçümleri için sondaj çamuru döner viskozimetrede şu yöntem kullanılmıştır:

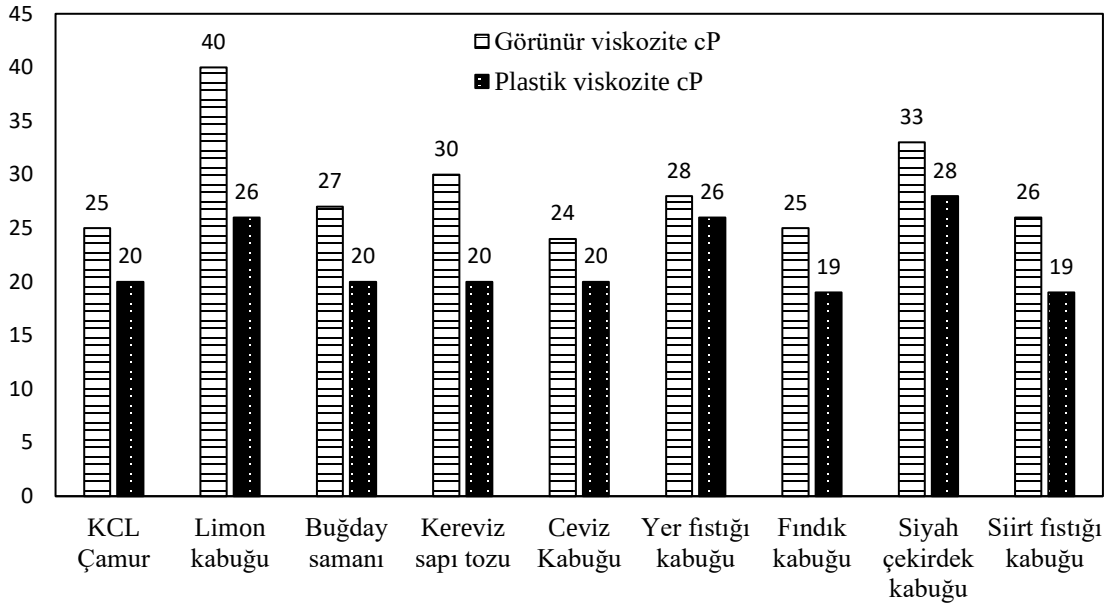
1. Çamur önce 600 rpm'de 10 saniye boyunca çalıştırılmış ve ardından 10 saniye boyunca hareketsiz bekletilmiştir.
2. Daha sonra cihaz 3 rpm'de çalıştırılmış ve ölçülen maksimum jel kuvveti lbf/100ft² birimi olarak kaydedilmiştir.

Bu işlemin 10 dakika için tekrarlanmasıyla 10 saniye ve 10 dakika jel mukavemeti değerleri elde edilmiştir.

Çamurun filtrasyon özelliklerini belirlemek için düşük basınç düşük sıcaklık filtrasyon cihazı (OFİTE) kullanılmış olup , çamur belirli bir basınç altında 30 dakika boyunca süzülmeye bırakılmıştır. Sonrasında süzüntü hacmi ve filtre kâğıdında biriken katı madde kalınlığı dijital kumpas yardımıyla ölçülmüştür. Filtrasyon işleminde elde edilen süzüntü miktarı formasyonda kaybedilen sıvı miktarını gösterirken, filtre kâğıdında oluşan kek kalınlığı ise geçirgen kuyu cidarında biriken kekin göstergesi olarak düşünülebilir. Tüm bu fiziksel ölçümler oda sıcaklığında yapılmıştır.

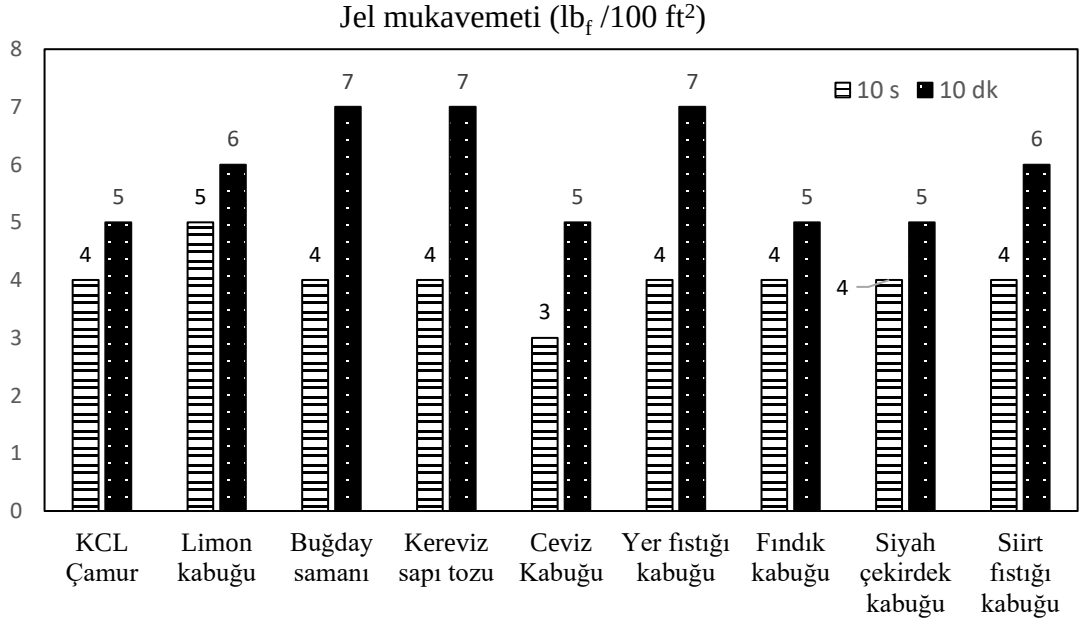
III. BULGULAR

Limon kabuğu, fındıkkabuğu, siyah çekirdek kabuğu, ceviz kabuğu, yer fıstığı kabuğu, buğday samanı, Siirt fıstığı kabuğu ve kereviz sapı tozu kayıp önleyici malzeme olarak kullanılmıştır. Bu malzemelerin reolojik özellikleri üzerinde yapılan analizlerde plastik ve görünür viskozite Şekil 1'de, jel mukavemeti Şekil 2'de, kopma noktası ise Şekil 3'te incelenmiştir.



Şekil 1. Tarımsal atıkların görünür ve plastik viskoziteye etkisi

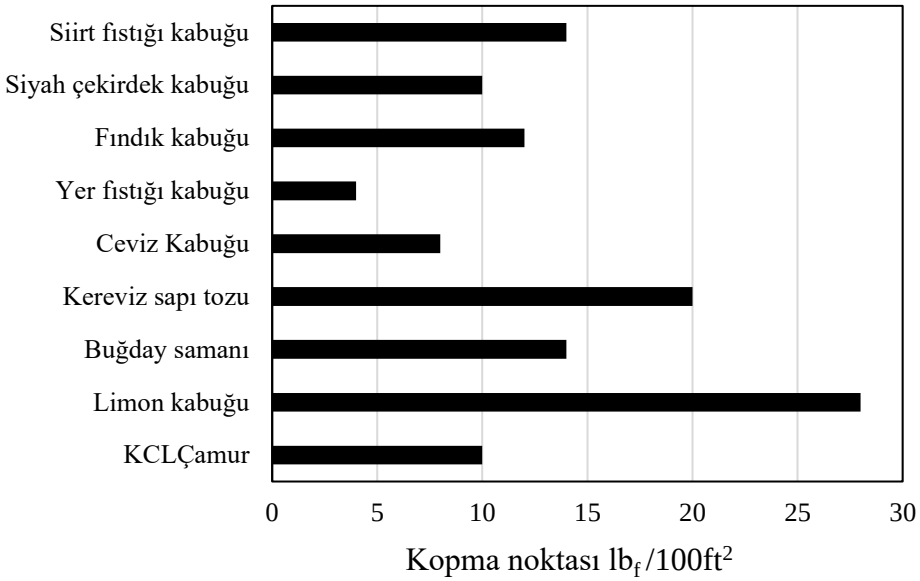
Şekil 1'de yapılan incelemeye göre, en belirgin etki limon kabuğunda görülmekle birlikte genel olarak ceviz kabuğu ve fındıkkabuğu dışındaki tüm maddelerin plastik viskoziteyi veya görünür viskoziteyi artırdığı gözlenmiştir. Siyah çekirdek kabuğu her iki viskoziteyi artırırken, kereviz sapı tozu ise sadece görünür viskoziteyi artırmış, plastik viskozite üzerinde belirgin bir etki göstermemiştir.



Şekil 2. Tarımsal atıkların jel mukavemetine etkisi

Şekil 2'den görüldüğü üzere, 10 dakikalık süre boyunca jel mukavemeti değerleri incelendiğinde, ceviz kabuğu, fındıkkabuğu ve siyah çekirdek kabuğu ilavesinin jel mukavemetini değiştirmediği gözlenmiştir. Diğer malzemeler ise (buğday samanı, kereviz sapı tozu ve yer fıstığı kabuğu), jel mukavemetinde belirgin bir artışa neden olmuştur. Ceviz kabuğu ve limon kabuğu dışındaki tüm malzemelerde 10 saniye içinde

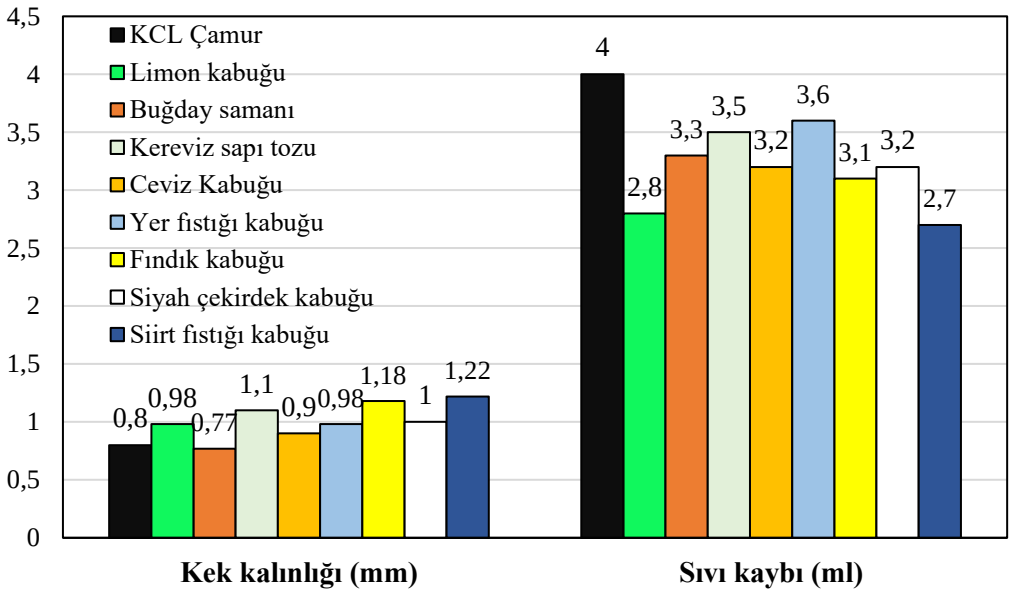
ölçülen jel mukavemeti değerleri aynı kalmıştır. Ceviz kabuğu eklenmesi jel mukavemetinde düşüşe, limon kabuğu eklenmesi ise artışa neden olmuştur.



Şekil 3. Tarımsal atıkların kopma noktasına etkisi

Şekil 3'te, limon kabuğunun kopma noktasını 2,5 kat, kereviz sapı tozunun ise 2 kat artırdığı gözlenmiştir. Buğday samanı ve fındıkkabuğu eklemesi az bir artışa, ceviz kabuğu ise çok az bir azalmaya neden olurken, siyah çekirdek kabuğunda belirgin bir değişim gözlenmemiştir. En düşük kopma noktası yer fıstığı kabuğunda elde edilmiştir.

Kayıp önleyici olarak eklenen malzemelerin filtrasyon özellikleri ve oluşan keklerin görüntüleri Şekil 4 ve Şekil 5'te gösterilmiştir. Bu görseller, eklenen malzemelerin sondaj çamurunun filtrasyon davranışı üzerindeki etkilerini görsel olarak göstermektedir.



Şekil 4. Tarımsal atıkların oluşturduğu sıvı kaybı miktarları ve filtre keki kalınlıkları

Şekil 5. Tarımsal atıkların oluşturduğu filtre keklerinin görüntüleri

Şekil 4'ten görüldüğü üzere, eklenen tüm malzemeler sıvı kaybını azaltıcı etki göstermişlerdir. Buğday samanı dışındaki tüm malzemeler ile yüksek kek kalınlığını elde edilmiştir. En yüksek sıvı kaybı limon kabuğu ve Siirt fıstığı kabuğu ile elde edilmiştir, bunu fındıkkabuğu, siyah çekirdek kabuğu ve ceviz kabuğu takip etmektedir. Kek kalınlığını en çok artıran malzemelerin Siirt fıstığı kabuğu ve fındıkkabuğu olduğu Şekil 4'ten görülmüştür.

Şekil 5'te görüldüğü gibi, tüm atık malzemeler ince filtre keki oluşturmuşlardır. Bu durum, bu malzemelerin sondaj çamurunun filtrasyon özelliklerini iyileştirdiğini göstermektedir.

IV. TARTIŞMA

Sondaj akışkanlarında viskozitenin uygun bir değerde olması önemlidir. Yüksek plastik viskoziteye sahip bir sondaj çamuru istenmez çünkü bu durum [6-8] :

1. **Pompa Basınçları ve Dolaşım Yoğunluğu:** Sıvının kuyu deliğinde pompalanması için daha yüksek pompa basınçları gerektirir, bu da eşdeğer dolaşım yoğunluğunu artırabilir.
2. **Penetrasyon Hızı:** Yüksek plastik viskoziteli bir akışkan, penetrasyon hızını azaltabilir.
3. **Akma Noktası ve Plastik Viskoziye Oranı:** Plastik viskozitenin düşük ve akma noktasının yüksek olduğunda, akma noktası/plastik viskozite oranının yüksek olmasına neden olur. Bu durum, sondaj kesintilerinin daha iyi taşınmasına yardımcı olabilir.
4. **Enerji Gereksinimi:** Viskozitenin artmasıyla birlikte sıvıyı pompalamak için gereken enerji de artar.
5. **Formasyonun Çatlama Basıncı ve Çamur Kaçakları:** Yüksek pompalama basıncı, formasyonun çatlama basıncını aşabilir ve yeni çamur kaçaklarına neden olabilir.

Bu nedenlerle, sondaj çamurlarının viskozite özellikleri dikkatlice kontrol edilmeli ve uygun değerlerde tutulmalıdır, böylece etkin ve güvenli bir sondaj işlemi sağlanabilir.

Jel mukavemeti, akışın olmadığı durumlarda ve matkap kesintileri sırasında matkap kesiklerini ve ağırlık yapıcı malzemeleri askıda tutmak için önemlidir. Ayrıca, yüksek jel mukavemeti birçok ciddi delme probleminden önleyebilmektedir.

API standartlarına göre, jel mukavemetinin kabul edilebilir üst sınırları 10 saniye için 15 lb/100 ft², 10 dakika için ise 31 lb/100 ft² olarak belirlenmiştir. Belirlenen jel mukavemeti değerleri bu standart değerlerin altında olduğu için, bu malzemelerin sondaj çamuruna olumsuz yönde bir etkisi olmayacaktır. Aksine, oluşan jellerin iyi özelliklerde olduğu ve kesintileri en iyi şekilde askıda tutabileceği söylenebilir. Bu durum, sondaj işlemlerinin daha güvenli ve verimli bir şekilde yürütülmesini sağlar [9].

Kopma noktası, sondaj çamurunun kesilen parçaları delikten dışarı taşıyabilecek kadar yüksek olmalıdır, ancak bu işlem sırasında pompa basıncını aşırı yükseltmemelidir [10]. API standartlarına göre, kopma noktasının 50 lb/100 ft² değerinden küçük olması gereklidir. Verdiğiniz bilgilere göre, denenen tüm malzemelerin kopma noktası bu standart değerin altında kaldığı için, bu malzemelerin sondaj çamurunun bu önemli özelliğine uygun olduğu söylenebilir.

Söz konusu çamur özellikleri bakımından literatür bulguları ile uyumlu bulunmuştur [5].

V. SONUÇLAR

KCl çamurunun içine limon kabuğu, fındıkkabuğu, siyah çekirdek kabuğu, ceviz kabuğu, yer fıstığı kabuğu, buğday samanı, Siirt fıstığı kabuğu ve kereviz sapı tozunun ilave edilerek çamur kabını azaltma yeteneklerinin araştırılması amacıyla çamurun reolojik ve filtrasyon özelliklerindeki değişim incelenmiştir.

Fındıkkabuğu ve ceviz kabuğunun dışında kalan diğer kabukların çamurun viskozite ve kopma noktası gibi özelliklerine olumlu etki gösterdiği, özellikle limon kabuğu ve siyah çekirdek kabuğunun viskoziteyi artırmada etkili olduğu ve kereviz sapı tozunun hem viskoziteyi artırdığını hem de kopma noktasını önemli ölçüde yükselttiği görülmektedir. Bu sonuçlar, çamurun mekanik özelliklerini iyileştirme potansiyeline sahip olduğunu göstermektedir.

Tüm çamurlar herhangi bir sorun yaratmadan kesintileri iyi şekilde askıda tutacak seviyededir.

Eklenen atık malzemelerin filtrasyon özellikleri incelendiğinde tüm maddelerin sıvı kaybını azalttığı buğday samanı dışında tüm maddeler ise daha kalın filtre kekleri elde edildiği görülmüştür. En düşük sıvı kaybı limon kabuğu tozu ve Siirt fıstığı kabuğu tozu ile elde edilirken, yer fıstığı kabuğu ve kereviz sapı tozu ile KCl çamura yakın sıvı kaybı değerleri elde edilmiştir. Ö ncelikle limon kabuğu tozu olmak üzere buğday samanı ve ceviz kabuğu hem düşük sıvı kaybı hem de ince filtre keki oluşturan malzemeler olarak sayılabilir. Bu bulgular, çamurun filtrasyon özelliklerini iyileştirmek için potansiyel olarak etkili malzemeler olarak değerlendirilebilir.

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Pektinin Kayıp Önleyici Malzeme olarak Kullanımının İncelenmesi

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Özet – Sirkülasyon kaybı yani çamur kaçağı, sondaj operasyonları sırasındaki en büyük sorunlardan biridir ve bir sondaj operasyonu sırasında sondaj çamurunun, kuyu cidarından formasyona geçmesi durumunu ifade eder. Sondaj operasyon maliyetleri olumsuz etkilediğinden sondaj operasyonunun, öncesinde dikkatlice planlanması ve sirkülasyon kaybı için gerekli önlemlerin alınması gerekmektedir. Sirkülasyon kaybını önlemek veya azaltmak için çeşitli yöntemler kullanılmaktadır. Kuyu cidarı güçlendirme teknikleri, çamur keki özelliklerini iyileştirmek veya sondaj sıvısına kayıp önleyici malzemeler ekleyerek çamur ağırlığını arttırmak iyi bilinen ve çokça karşılaşılan uygulamalardır. Atıkların petrol sektöründe kayıp önleyici malzeme olarak kullanılması ise son yıllarda üzerinde çokça durulmaya başlanan bir konu olmuştur. Farklı çamur tipleri olmakla birlikte çamurun türü ve bileşimi sondajın yapıldığı formasyona bağlı olarak değişmektedir. Bu çalışmada hem maliyet hem de kuyu stabilitesi açısından sorun yaratmayan KCl çamuru kullanıldı. Yörenin önemli ticari ürünlerinden olan Siirt fıstığının kabuğu da tarımsal atık olarak ilave edildikten sonra farklı miktarlarda pektin ilave edilerek kayıp önleyici malzeme olarak kullanılabilirliği araştırıldı. Pektin bitkilerin hücre duvarlarında bulunan doğal bir polisakkarit (karbonhidrat) polimeridir. Gıda sanayinde jelleşme özelliklerinden dolayı yaygın olarak kullanılan pektinin bu özelliğinin sondaj çamurlarında da etki sağlayıp sağlayamayacağı görülmek istendi. Çamura eklenen pektin miktarlarının atması hem reolojik özelliklerin hem de filtrasyon özelliklerinin artmasına neden olmuş jel yapıda ise değişiklik oluşturmadığı görülmektedir.

Anahtar Kelimeler – Sondaj Çamuru, Sirkülasyon Kaybı, Kayıp Önleyici Malzeme, Reolojik özelikler, Filtrasyon, Pektin

I. GİRİŞ

Sondaj, genellikle yeraltı kaynaklarının keşfi, çıkartılması veya jeoteknik incelemeler için yapılan bir teknik işlemdir. Bu işlem genellikle aşağıdaki hedef belirleme ve planlama, kesici takım seçimi, sondaj makinesinin kurulması, sondaj çamuru hazırlanması, delme işlemi, kesici takım değişimi ve testler ve sonuçların değerlendirilmesi gibi adımları içerir. Sondaj, genellikle karmaşık ve teknik bir süreç olup, doğru planlama, ekipman seçimi ve operasyonel yetkinlik gerektirir. Ayrıca, çevresel ve sosyal etkilerin yönetilmesi de önemli bir unsurdur.

Sondaj operasyonları sırasında çeşitli sorunlarla karşılaşılabilir. Bu sorunlar, jeolojik koşullar, kullanılan ekipmanların performansı, sondaj çamuru bileşimi ve diğer çevresel faktörlerden kaynaklanabilir. Yaygın olarak karşılaşılan sondaj sorunları arasında kil ve kum sıkışması, çökme ve yıkılma, kayıp ve sızıntı, kesici takım problemleri, yüksek basınçlı gaz veya sıvı göçü, doğal kaynakların keşfi, çevresel ve toplumsal faktörler sayılabilir.

Bu sorunlar, sondaj operasyonlarının karmaşıklığını ve risklerini gösterir. Bu nedenle, sondaj planlaması ve yürütülmesi sırasında kapsamlı bir risk yönetimi ve uygun teknik çözümler uygulanması önemlidir. İyi

planlanmış bir sondaj operasyonu, karşılaşılabilecek potansiyel sorunları en aza indirir ve verimliliği artıracaktır.

Sondaj çamuru, petrol ve doğal gaz arama ve üretim süreçlerinde kullanılan özel bir karışımdır. Temel olarak, sondaj sırasında kuyu içindeki sıvı ve katı malzemelerin kontrol altında tutulmasını sağlayarak sondaj işleminin etkin ve güvenli bir şekilde yapılmasını amaçlar. Sondaj çamurunun temel bileşenleri ve işlevleri aşağıdaki şekilde sıralanabilir:

Su: Sondaj çamurunun temel taşıyıcı maddesi genellikle su veya bazı durumlarda deniz suyu olabilir. Su, diğer bileşenlerin karışımı ve taşınması için gerekli olan solvent görevini görür.

Kil (Bentonit): Bentonit, sondaj çamurunun viskozitesini artıran ve stabilitesini sağlayan bir kil mineralidir. Ayrıca, kuyu duvarlarından sızan suyun emilmesini ve kaybını önlemek için de kullanılır.

Polimerler: Sondaj çamuruna polimerler eklenerek viskozite kontrol edilir, çamurun stabilitesi artırılır ve kayıp önleme sağlanır. Polimerler genellikle sentetik malzemeler olup, çözünürlük ve reolojik özelliklerini ayarlamak için kullanılırlar.

Kum ve Çakıl: Bazı durumlarda, sondaj çamuruna kum veya çakıl gibi katı malzemeler eklenerek çamurun reolojisini ayarlamak ve delme sürecinde kuyu duvarlarının stabilizasyonunu sağlamak mümkün olabilir.

Kimyasallar: Sondaj çamuruna kimyasal katkı maddeleri eklenerek çeşitli işlevler sağlanabilir. Örneğin, pH ayarlamak, köpük oluşumunu önlemek veya çamurun çevresel etkilerini azaltmak gibi.

Sondaj çamuru, sondaj kulesinden kuyu içine pompalanır ve delme sırasında kuyu içinde dolaşarak sondajın sorunsuz bir şekilde yapılmasını sağlar. Çamurun taşıdığı kesme artıkları ve diğer katı malzemeler, kuyudan yüzeye çıkarılarak analiz edilir ve sondaj operasyonunun kontrol altında tutulmasını sağlar.

Sondaj çamuru, petrol ve doğal gaz endüstrisinde vazgeçilmez bir rol oynayan özel bir karışımdır. Sondaj işleminin verimli, güvenli ve çevre dostu bir şekilde gerçekleştirilmesini sağlamak için çeşitli bileşenlerin dengeli bir şekilde kullanılması önemlidir.

Sondaj sorunları içeresinde kayıp ve sızıntı önemli yer tutar ve bu durumu gidermek veya iyileştirmek için özel çamurlar hazırlanır. Çatlaklı yapılarda kullanılan sondaj çamuru, genellikle çatlakların kontrol altında tutulması, kuyunun stabilitesinin sağlanması ve çevresel etkilerin azaltılması amacıyla özel olarak formüle edilmiş bir tür sondaj çamurudur. Çatlaklı yapılarda kullanılan bu çamurların özellikleri ve kullanım amaçları şunlar olabilir:

Stabilite Sağlama: Çatlaklı yapılar genellikle jeolojik olarak zayıf bölgelerde bulunabilir. Bu nedenle, sondaj çamuru kuyunun duvarlarını stabil tutarak çökme veya çatlamaları önlemek için özel olarak tasarlanabilir.

Kayıp Önleme: Çatlaklı yapılar genellikle kayıplara ve çamurun kuyu duvarlarından sızmasına eğilimli olabilir. Bu durumu önlemek için çamurun viskozitesi artırılabilir ve kayıp önleyici malzemeler eklenerek çatlakların kapatılması sağlanabilir.

Korozif Etkilerin Azaltılması: Bazı çatlaklı yapılar, yüksek tuz veya asit içeriği gibi çevresel faktörlere maruz kalabilir. Sondaj çamuru, bu etkileri azaltmak veya önlemek için uygun kimyasallar içerebilir.

Delme Performansının Artırılması: Çatlaklı yapılar genellikle delme performansını olumsuz etkileyebilir. Sondaj çamuru, kesici takımların daha verimli çalışmasını sağlamak için özellikle reolojik özellikleri ve viskozitesi kontrol edilmiş olabilir.

Çevresel Duyarlılık: Çatlaklı yapıların bulunduğu alanlar genellikle çevresel duyarlılık gerektiren bölgeler olabilir. Bu nedenle, çevre dostu malzemeler ve prosesler kullanılarak çamurun çevresel etkileri minimize edilebilir.

Çatlaklı yapılarda kullanılan sondaj çamuru, genellikle jeolojik ve çevresel koşullara bağlı olarak özel olarak adapte edilir. Bu çamurların formülasyonu ve kullanımı, genellikle yerel koşullar ve sondaj hedefleri göz önünde bulundurularak belirlenir. Bu şekilde, hem sondaj operasyonunun etkinliği hem de çevresel sürdürülebilirlik sağlanmış olur.

Kayıp Önleyici Malzemeler

Sondaj çamuruna eklenen kayıp önleyici olarak eklenen malzemeler, genellikle sondaj işlemleri sırasında kuyu duvarlarına doğru sızan veya kaybolan çamurun kaybını önlemek için kullanılan bileşenlerdir. Bu malzemelerin temel işlevleri; kuyu duvarı sızıntılarını önleme**,** çamurun viskozitesini artırma**,** kuyu duvarlarını güçlendirme olarak sayılabilir. Bazı durumlarda, çevresel etkileri azaltmak için doğal ve çevre dostu malzemeler kullanılabilir. Bu malzemeler, sondaj çamurunun çevredeki etkilerini minimize eder. [1]

Kayıp önleyici malzemeler genellikle bentonit, kil ve polimerler gibi doğal veya sentetik maddelerden oluşabilir. Örneğin, bentonit, suda şişerek jel oluşturan bir kil mineralidir ve sondaj çamurunun viskozitesini artırarak kayıpları önler. Polimerler ise genellikle suda çözünerek viskoziteyi artırır ve kuyu duvarlarındaki sızıntıları engeller. [2-4]

Sonuç olarak, sondaj çamuruna eklenen kayıp önleyici malzemeler, sondaj operasyonlarının güvenli ve verimli bir şekilde gerçekleştirilmesi için kritik öneme sahiptir. Bu malzemelerin seçimi, yerel koşullar, sondaj derinliği ve çevresel etkiler gibi faktörlere bağlı olarak değişiklik gösterebilir. Ayrıca sondaj çamurunun türü, katkı maddesinin türü, oluşum ve kırılma türü, parçacık boyutu dağılımı ve eklenen katkı maddesinin konsantrasyonu gibi kayıp önleyici maddelerinin performansını etkileyen çeşitli parametreler vardır. [5-6]

Pektin

Pektin, bitkilerin hücre duvarlarında bulunan doğal bir polisakkarit (karbonhidrat) polimeridir. Genellikle meyvelerin kabuklarında ve hücre duvarlarında bulunur ve özellikle elma, armut, turunçgil gibi meyvelerde yüksek miktarlarda bulunabilir. Pektin, özellikle meyve olgunlaşması sırasında meyve yumuşadığında salınarak meyvenin dokusunu koruyan ve destekleyen bir rol oynar.

Pektin, galaktronik asit ve D-galaktoz birimlerinden oluşan bir polimer zinciridir. Bu zincir, alfa-1,4 ve bazen beta-1,4 glikozidik bağlarla birbirine bağlanmış galaktoz birimlerinden oluşur. Pektin molekülleri, bu yapılarından dolayı su ile temas ettiğinde hidrofilik (su seven) bir özelliğe sahiptirler. Suda çözündüğünde, jel oluşturan ve sıvıyı kalınlaştıran bir yapıya sahiptir. Bu özellikleri sayesinde, reçel üretiminde meyve suyunun kıvamını ve jöle benzeri yapısını oluşturmak için ideal bir bileşen olarak kullanılır.

Gıda endüstrisinde pektin, özellikle meyve suları, reçeller, jöleler ve diğer gıda ürünlerinin üretiminde kullanılan önemli bir bileşen olarak bilinir. Pektin, suda çözünür ve bu özelliği sayesinde reçel gibi ürünlerde jelleşmeyi sağlar. Ayrıca, pektin lifleri insan sindirim sistemi tarafından kısmen parçalanabilir, bu da bağırsak sağlığı için yararlı olabilir.

II. MATERYAL VE YÖNTEM

Bu çalışmada sirkülasyon kaybını azaltmak için pektinin kayıp önleyici malzeme olarak kullanılabilirliği araştırıldı. Pektinin farklı miktarlarda eklenmesiyle çamurun fiziksel özelliklerinde meydana gelen değişim incelendi. Taşıyıcı sıvı olarak, su bazlı bir çamurlar içerisinde kullanımı çok yaygın olan ve bileşimi Tablo 1'de verilen KCl çamuru kullanıldı. KCL çamuruna önceden yöresel bir atık olan Siirt fıstığı kabuğu (7,5 g 0,125 mm) ilave edilip daha sonra 500 mL çamura 1 g,1,5 g ve 2 g pektin ilave edilerek çamurun fiziksel özelliklerindeki değişimi incelendi. [7]

Değişimi incelenen özellikler; çamur ağırlığı, pH, filtrasyon özellikleri (sıvı kaybı, filtre keki) ve reolojik özellikleri (görünür viskozite, plastik viskozite, kopma noktası ve jel mukavemeti) dir. Batman Üniversitesi Petrol ve Doğalgaz Mühendisliği Laboratuvarlarında gerçekleştirilen tüm deneyler oda sıcaklığında yürütüldü. Cihazların kalibrasyonu TPIC 'den gelen saha ekibi tarafından kontrol edildi.

Tablo 1. Laboratuvarda hazırlanan KCl çamurun bileşimi

Bileşen	**Miktar**
Su	1000 mL
Soda külü	1,5 g
NaOH	1,5 g
KCl	88 g
Nişasta	13,6 g
XCD	1,5 g
PAC-LV	8 g
NaCl	140 g
$CaCO_3$	27 g
Barit	0 g

Çamur yoğunluğu , ±0,1 lb/gal veya ±0,5 lb/ft^3 hassasiyete sahip çamur terazisi, pH değeri pH kâğıtları kullanılarak belirlendi.

6 hızlı (600, 300, 200, 100, 6 ve 3 rpm) döner viskometre cihazı (Fann model 35 SA), görünür viskozite, plastik viskozite, kopma noktası ve jel mukavemetini belirlemek için kullanıldı. Görünür viskozite Formül 4.1'den, plastik viskozite Formül 4.2'den ve kopma noktası 600 ve 300 rpm okumaları kullanılarak Formül 4.3'den hesaplandı. Viskoziteler cP, kopma noktası ise lb/100 ft^2 biriminde elde edildi.

Görünür Viskozite = [600 rpm okuması]/2 (1)

Plastik Viskozite = [600 rpm okuması] - [300 rpm okuması] (2)

Kopma Noktası = [300 rpm okuması]-Plastik Viskozite (3)

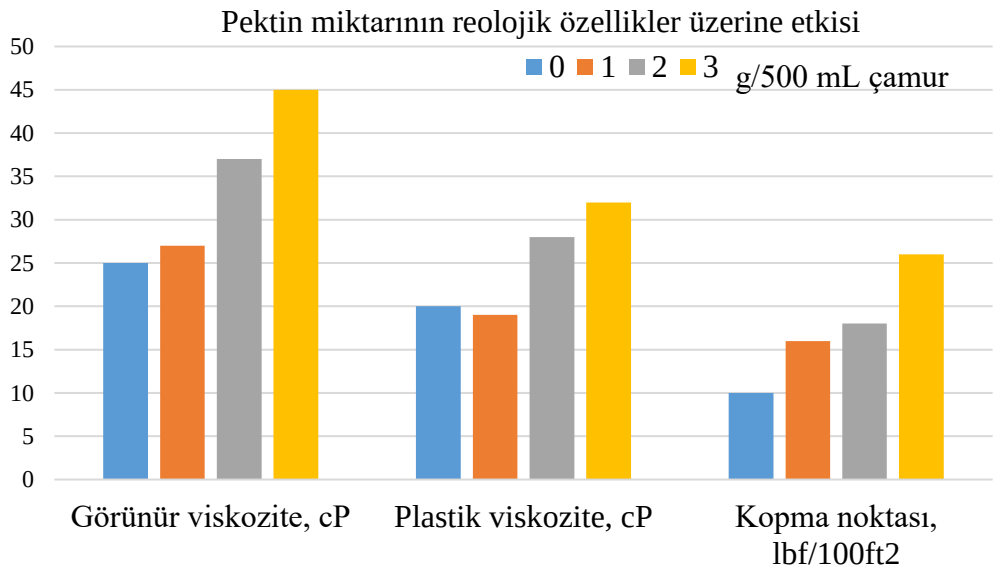
Jel mukavemetini ölçmek için, sondaj çamuru döner viskozimetrede 600 rpm de 10 saniye çalıştırıldıktan sonra 10 saniye hareketsiz bekletildi. Sonra cihaz 3 rpm 'de çalıştırılıp ölçülen maksimum jel kuvvetinin lbf/100ft² olarak kaydedilmesi ile belirlendi. Aynı işlem 10 dakika için de tekrarlandı bu sayede 10 saniye ve 10 dakika jel mukavemeti değerleri elde edildi.

Çamurun sıvı kaybı ve kek kalınlığı gibi filtrasyon özelliklerini belirlemek için düşük basınç düşük sıcaklık filtrasyon cihazı (OFİTE) kullanıldı. Sondaj sıvısı tanımlanmış basınçta 30 dakika süreyle süzülmeye bırakıldı. Süre sonunda süzüntü hacmi ve filtre kâğıdında biriken katı madde kalınlığı ölçüldü. Süzülen sıvı miktarı formasyonda kaybedilen sıvı miktarını gösterirken ve filtre kâğıdında oluşan kek ise geçirgen kuyu cidarında biriken kekin göreceli bir göstergesidir. Çok ince olan kek kalınlığı ise dijital kumpas ile belirlendi.

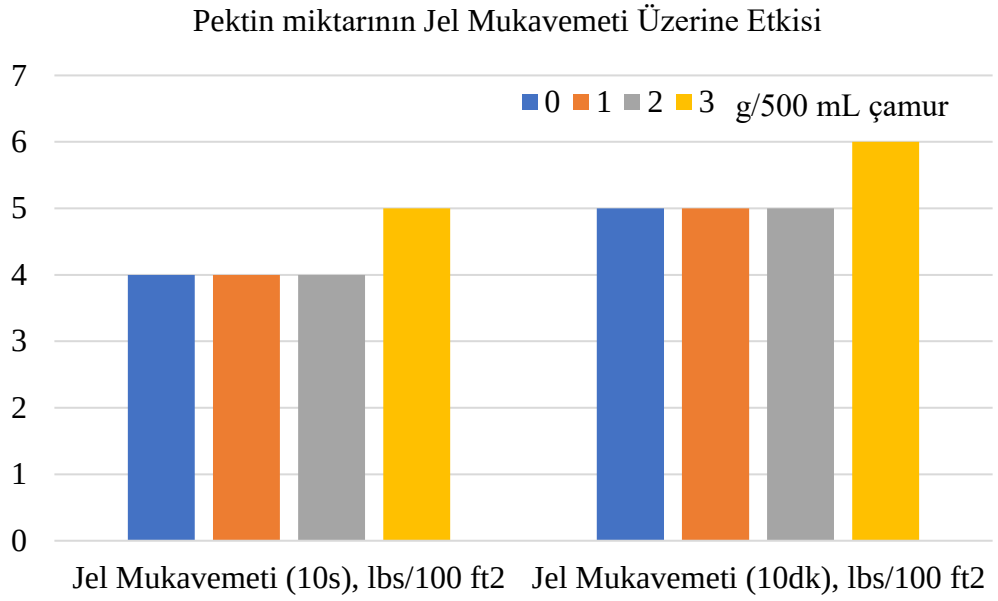
III. BULGULAR

Farklı miktarlarda Pektin ilavesini çamur yoğunluğunda ve PH'ında bir değişim meydana getirmemiştir. Çamur yoğunluğu tüm şartlarda 72 lb/ft^3, pH 9 olarak belirlenmiştir. Sondaj sıvılarında 8 ile 10 arasında olması gereken pH değerini sağladığı görülmektedir.

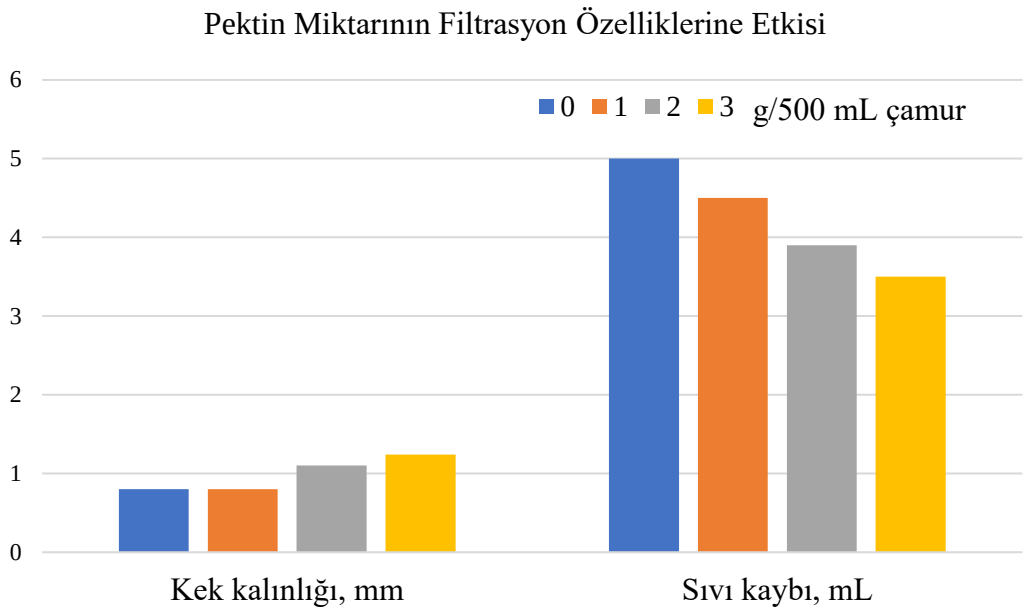
Laboratuvarda hazırlanan KCl çamurunun içine 7,5 g 0,125 mm çapında Siirt fıstığı kabuğu eklendikten sonra sırasıyla her 500 mL çamura 1g, 1,5 g ve 2 g pektin ilave edilerek fiziksel özelliklere etkisi araştırıldı. Görünür ve Plastik viskozite ile kopma noktası Şekil 1'de, Jel Mukavemeti Şekil 2'de, filtrasyon özelliklerine etkisi ise Şekil 3'de verilmiştir.



Şekil 1. Pektin miktarının çamurun viskoziteleri ve kopma noktası üzerine etkisi



Şekil 2. Pektin miktarının jel mukavemeti üzerine etkisi



Şekil 3. Pektin miktarının çamurun filtrasyon özellikleri üzerine etkisi

Şekil 1'den görüldüğü gibi, ilave edilen pektin miktarının artmasıyla görünür viskozite, plastik viskozite ve kopma noktası önemli ölçüde artarken, Şekil 2'den görüldüğü üzere, jel mukavemetinde sadece 10 g eklenmesi ile küçük bir değişim gözlenmiştir. Jel oluşturma özelliği olan pektinin çamurdaki miktarı artıkça filtre keki kalınlığı artarken sıvı kaybı önemli ölçüde azaldığı Şekil 3'den görülmektedir. Pektin ilavesinin de hem reolojik hem de filtrasyon özelliklerinde iyileşmeye neden olduğu oluşan jel yapıda ise değişiklik oluşturmadığı görülmektedir.

IV. TARTIŞMA

Çamur viskozitesinin optimum değerde tutulması kuyu stabilitesini ve sıvı kaybı kontrolünü sağlamak için önemlidir. İnce çamur, ucu temizleme ve delme hızını optimize etme konusunda tercih edilmesine rağmen delikten kaba çakılı çıkarmak için de kalın çamurlara ihtiyaç vardır [8-9] . Sıvıyı harekete geçiren kuvvet olan kopma noktası çamurun kuyu temizleme kapasitesini de göstermektedir [10]. Bu bağlamda incelendiğinde ilave edilen pektin miktarlarının çamur viskozitesi açısından sorun yaratmadığı ancak daha yüksek miktarlarda ilave edilmesinin aşırı jel oluşturarak sirkülasyonda sorun yaratma ihtimali bulunmaktadır.

Filtrasyon yeteneği, çamurdaki katılarının kuyu duvarlarında birikmesiyle formasyondaki sıvı kaybını azaltmasının bir ölçüsünü ifade etmektedir. Sondaj işlemleri sırasında sondaj sıvısı, delik içinde formasyona göre daha büyük olan hidrostatik basınç nedeniyle sondaj deliğinden formasyona doğru hareket eder. Sondaj sıvısı akışı meydana geldikçe, sondaj sıvısı katıları sondaj deliğinin duvarlarında birikir ve filtre keki adı verilen su geçişini nispeten azaltan bir tabaka oluşur. İdeal olarak, filtre kekinin belli bir kalınlığı aşmaması ve bariyer direncinin yüksek olması istenir. Filtre kekinin kalınlığı genellikle formasyonun geçirgenliğinin bir fonksiyonu olarak düşünülür. Eklenen pektin miktarının artması su kaybını azaltmakta ancak kek kalınlığını önemli ölçüde artırmayarak çamur kaybını önlemede önemli bir parametreyi yerine getirmiştir.

V. SONUÇLAR

Laboratuvarda hazırlanan ve içerisinde farklı miktarlarda Siirt fıstığı bulunan klasik KCl çamuruna farklı miktarlarda pektin ilave etmenin fiziksel özelliklere etkisi incelendi.

Çamura Siirt fıstığı yanı sıra eklenen pektin miktarının artmasıyla viskoziteler ve kopma noktası artmış, jel mukavemeti 3 g/500 mL derişimde kadar sabit kalıp sonra artmıştır. Sıvı kaybında pektin miktarının artışı olumlu etkisini sürdürürken kek kalınlığında sorun olmayacak miktarda artışa neden olmuştur.

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A Study on the Flexural Response of Core-Shell Sandwich Panels: Impact of Core Structure Design Using Finite Element Analysis

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Abstract – This study investigates the mechanical performance of sandwich panels fabricated from ABS material using the Fused Deposition Modeling (FDM) process, focusing on the critical role of core structure design. By comparing three distinct core geometries (hexagonal, rectangular, and triangular) under varying conditions of wall thickness and relative density, we comprehensively analyze their structural behavior through simulations in ANSYS following ASTM D790-10 standards. The study underscores the significant impact of relative density on enhancing mechanical properties, with higher densities leading to increased strength and stiffness. Additionally, the flexibility of the FDM process in precisely engineering core design parameters is highlighted, offering significant potential for the development of customized, high-performance sandwich panels across various engineering applications. The results revealed that the hexagonal core consistently exhibited superior performance, demonstrating the highest resultant forces and flexural modulus values due to its efficient stress distribution and load-bearing capacity compared to rectangular and triangular core designs. The rigorous design and analysis methodology employed ensures the reliability of these findings, providing valuable insights for optimizing lightweight, high-strength materials in aerospace, automotive, and structural engineering fields.

Keywords – Sandwich Panels, Core Structure Design, Hexagonal Core, Rectangular Core, Triangular Core, Relative Density, ANSYS Simulations, Flexural response

I. INTRODUCTION

Additive manufacturing (or 3D printing) involves transforming virtual objects into physical materials using specialized programs and appropriate materials. This method is remarkable for producing 3D objects from polymers, composites, and resins through thermal or chemical processes. Recent advancements in architectural additive manufacturing techniques have enhanced flexibility in geometry and material selection, allowing the creation of complex and free-form shapes [1]. Additionally, the ability to optimize energy absorption through engineering design has made 3D-printed structures increasingly popular [2].

Research highlights the significant influence of printing parameters (such as nozzle temperature, extrusion speed, and layer thickness) on the quality of printed objects [3]. Pulipaka et al. (2023) discovered that higher nozzle temperatures and print speeds reduce tensile strength and modulus in 3D-printed PEEK, while lower layer heights enhance these properties [4]. Khabia and Jain examined how changing layer thickness in FDM printing affects tensile strength, finding no significant impact when specimens are loaded parallel to the print layers, as tested under ASTM D 638 standards on different FDM printers and ABS filaments [5]. Arifvianto et al. (2021) demonstrated that 3D-printed parts exhibit varying tensile strengths and stiffness depending on printing orientation [6].

Advanced experimental design and optimization techniques, such as those utilized by Auffray et al. (2021) and Seyedzavvar (2023), have been implemented to efficiently analyze the effects of different

printing parameters and optimize them for maximum mechanical properties [7,8]. Birman and Kardomateas (2018) in a review article outlined the advancements in sandwich structure research, focusing on sophisticated modeling, innovative core designs, and multifunctional applications, alongside challenges in environmental effects and materials integration. Accordingly, opportunities in biomedical applications and ongoing research needs underscore the dynamic evolution in this field [9]. A study published by Gibson et al. (2015) further explored the relationship between printing parameters and mechanical properties, providing insights into optimizing 3D printing processes for various materials [10].

Sandwich structures, known for their lightweight and high stiffness, have gained attention for their excellent energy absorption properties. One of the key advantages of the lightweight core is its ability to provide high bending stiffness and resistance to buckling [11]. By incorporating a core material with suitable mechanical properties, sandwich panels can effectively distribute and withstand external loads, ensuring structural integrity and stability. The core's resistance to bending forces is particularly crucial in applications where the panels may experience bending or flexural loads, such as aerospace structures or wind turbine blades. Research continues to focus on developing new designs and improving core structures, such as the frequently used honeycomb core, which offers superior performance in terms of failure and fatigue resistance [12,13].

Hexagonal sandwich structures, also known as honeycomb sandwich structures, offer numerous advantages attributed to their exceptional properties, including high stiffness, strength, and low density [14]. Additionally, they demonstrate superior energy absorption capabilities, remarkable stiffness-to-weight ratios, excellent ballistic resistance performance, and notable thermal and acoustic isolation properties [15]. These desirable characteristics make honeycomb sandwich structures highly suitable for a broad range of applications, encompassing satellites, aircraft, ships, automobiles, rail cars, wind energy systems, and bridge construction [16].

Experimental tests have been the primary method to study mechanical behavior of core-shell structures, but they are often time-consuming and costly. Therefore, theoretical modeling is used to save time and resources [17,18]. Meraghni et al. (1999) validated theoretical predictions by comparing experimental results on the mechanical properties of sandwich structures [19]. Similarly, Zhang et al. (2020) analyzed the impact resistance of honeycomb sandwich panels through both experimental and numerical methods [20].

In addition, among the additive manufacturing techniques, the material extrusion process, also known as fused deposition modeling (FDM), has emerged as a rapidly growing method for producing polymeric core structures for light weight sandwich panels (LWSPs) [21,22]. This technique offers several advantages over traditional manufacturing processes, particularly in its ability to directly fabricate intricate and customized geometries based on CAD models. Acrylonitrile butadiene styrene (ABS) is a widely used thermoplastic in FDM processes. Researchers like Godfrey and Rayegani have explored the relationship between process parameters and tensile strength in ABS, finding that minimum layer thickness and negative air gap improve strength, while part orientation significantly affects tensile strength [23]. Kuruoglu et al. used experimental design methodologies to predict the surface roughness and tensile strength of 3D-printed specimens, achieving results close to actual values [24]. However, the extensive core shell design options of the LWSPs makes the optimal choice of fabrication of the core structures using the FDM process difficult [22].

In this study, the mechanical properties of three different sandwich panel-shaped core structures were analyzed using ANSYS at four different densities, focusing on resultant force, equivalent stress, flexural stress, and modulus of elasticity. The study aims to investigate the effects of different conventional and hybrid core structures on the flexural response of composite core-shell structures.

II. MATERIALS AND METHOD

A. Material properties

In this study, Acrylonitrile Butadiene Styrene (ABS) was used for the core material. The material properties were obtained from the "Material Property Data for Engineering Materials" file, available on the ANSYS 2024 R1 official website. The properties are presented in Table 1 below. As the goal of this study

is to recognize the appropriate core design that is suitable for 3D printing of the final specimen, the mechanical properties were applied as recommended in the ANSYS data set.

Table 1. ABS Material Properties applied in ANSYS simulation.

Density (kg/m^3)	1000 – 1200
Tensile strength (MPa)	28 - 55
Young's modulus (MPa)	1.1 – 2.9
Yield strength (MPa)	19- 51
Fracture toughness (MPa√m)	1.2 – 4.3
Melting temperature (°C)	88 – 130
Specific heat (J/kg.°C)	1400 – 1900
Thermal conductivity (W/m.k)	0.19 – 0.34
Thermal expansion (1/°C)	85 - 230

B. Core Structure Design

This research involved a comparative analysis of three different core geometries: rectangular, triangular, and hexagonal (Figure 1), as the main core structures that have been reported separately in the literature. Each geometry was analyzed to evaluate its mechanical response under 3-point bending loading. In the literature, Kolken & Zadpoor (2017) examined the mechanical properties of 3D-printed polymeric sandwich structures with auxetic cores, highlighting their energy absorption and failure mechanisms [25]. Similarly, Zhang et al. (2020) reviewed the large deformation and energy absorption of auxetic materials, emphasizing their mechanical benefits [26]. Li et al. (2018) explored the use of auxetic materials to enhance mechanical properties like energy absorption and structural integrity [27]. Najafi et al. (2022) investigated the flexural properties of sandwich beams with auxetic cores, providing insights into their structural performance [28]. Additionally, Wu et al. (2017) analyzed the mechanical properties of hierarchical anti-tetrachiral metastructures, noting their unique mechanical behaviors and suitability for engineering applications [29].

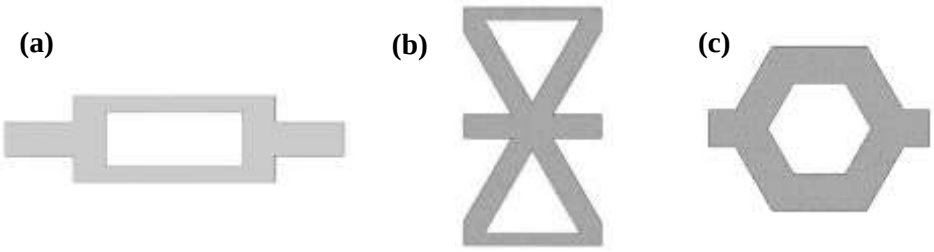

Fig. 1 General views of core geometries design; a) Rectangular, b) Triangular, and c) Hexagonal.

This study meticulously examines the critical role of core structure in shaping the mechanical performance of sandwich panels fabricated from an ABS material. Recognizing its profound influence, the research delves into a systematic comparison of three distinct core configurations: hexagonal, triangular, and rectangular, as represented in Figure 1. Each geometry undergoes meticulous analysis to unveil its advantages, limitations, and impact on structural integrity, weight efficiency, and overall functionality. This comprehensive investigation aims to provide valuable insights for informed design and engineering decisions, ultimately maximizing performance and efficiency across diverse applications.

During the design process, precise attention was paid to achieving prescribed relative densities (0.5 and 0.4) and specified wall thicknesses (1 and 1.25 mm). To ensure accuracy, structures were iteratively

modeled and fine-tuned through successive adjustments. This rigorous process resulted in 12 distinct structures, illustrated in Figure 2, each tailored to meet specific parameters. Such calibrated relative densities and wall thicknesses offer more reliable insights into real-world behavior under similar conditions.

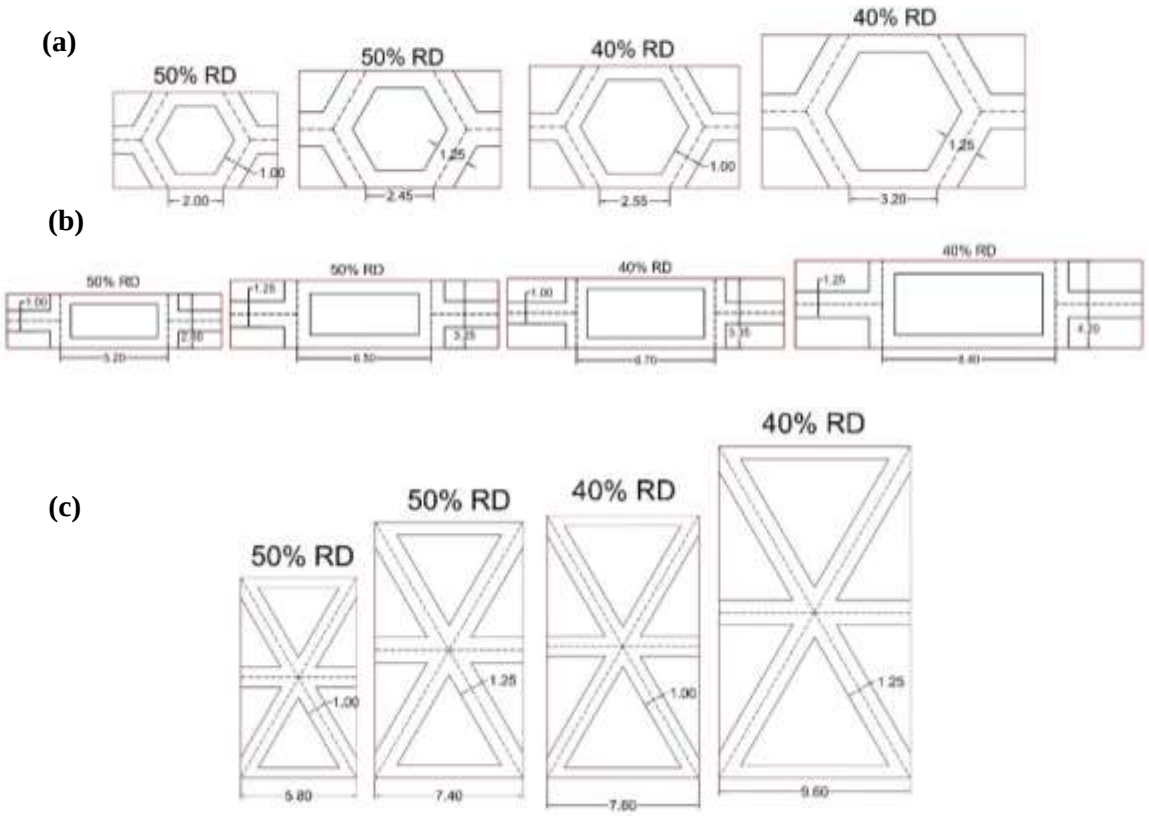

Fig. 2. Details of design of core structures; a) Hexagonal, b) Rectangular and c) Triangular unit cells.

To comprehensively evaluate the mechanical properties of these tailored structures, each configuration underwent 12 distinct 3-point bending simulations. This widely accepted testing method involves subjecting standardized specimens to controlled bending forces, enabling the extraction of key parameters such as flexural modulus and strength. By analyzing the responses of each geometry under these standardized loading conditions, the study aims to:

- Identify the geometry that offers the optimal balance between structural integrity and weight efficiency.
- Understand how core configuration influences the overall functionality of sandwich panels under various loading scenarios.

The expected outcomes of this investigation hold significant implications for various engineering fields, including:

- Aerospace structures: Optimizing the performance of lightweight and robust materials for aircraft components.
- Automotive industry: Developing fuel-efficient vehicles by utilizing sandwich panels with superior weight-to-strength ratios.
- Civil engineering: Creating high-performance building materials with improved structural integrity and thermal insulation.

By delving into the intricate interplay between core configuration and mechanical properties, this study paves the way for more informed design decisions and ultimately contributes to advancements in various engineering fields.

C. *Modeling and simulation in ANSYS*

This investigation explores how materials respond to flexural loading, focusing on minute details that influence their behavior. It uses the established ASTM D790-10 standard to ensure consistent and accurate testing. By analyzing how the core-shell sandwich panels with various core structures react under 3-point bending conditions, the research aims to improve our understanding of its properties and how they impact engineering design and performance. This will ultimately lead to more robust and efficient practices in fields like aerospace, automotive, and structural engineering.

Based on ASTM D790-10 standard, this study simulates a 3-point bending test, ensuring accurate testing conditions. This widely accepted method evaluates the mechanical properties of materials under bending loads by subjecting standardized specimens to controlled forces. This controlled bending induces deformation, allowing measurement of key parameters like flexural modulus and strength. Each specimen is designed to meet ASTM specifications with the dimensions of 127×12.7×3.2 mm and a span-to-depth ratio of 16:1 with a support span distance of 51 mm to ensure consistency and accuracy in the experimental setup. The specimen undergoes simulated testing with a displacement of the loading nose to induce a reaction force at the position of loading that results in force-displacement graphs of tested core-shell structures [30]. Dimensions and loading conditions of the modeled specimens according to the standard ASTM D790-10 are represented in Figure 3. The boundary conditions were applied as displacement/rotations for the constraint points represented in this figure, with the displacement degrees of freedom restricted at three points except the y-direction at point A.

In analyses, the equal distribution of the mesh, the piece size, and the correct number of pieces are very critical. To prevent a potential error in the results of simulation due to the incorrect selection of mesh size, a mesh size analysis was conducted for the core-shell structure of honey comb core by analyzing the level of maximum force developed in the reference point A, as shown in Figure 3b, in response to the displacement of 6 mm. To this end, the maximum load versus mesh size was graphed and the mesh size was determined as the developed force did not represent a significant change beyond this threshold of the mesh size. Accordingly, the mesh size was set to 1 mm as the default value for all the core structures. Additionally, based on the complexity of the core designs, tetrahedron meshes were adopted for all the models to satisfy a good meshing of the models.

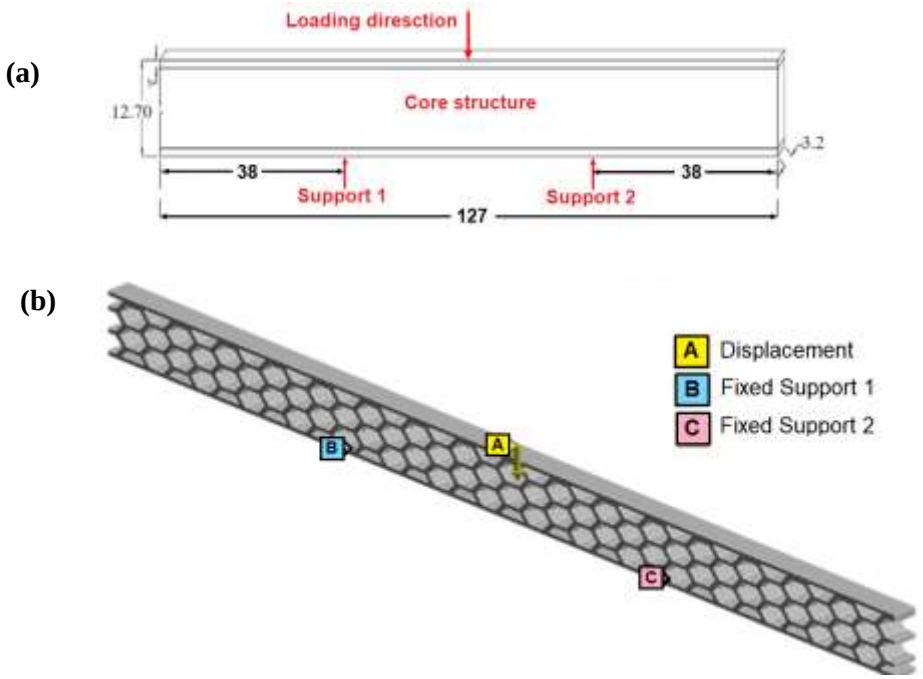

Fig. 3. Configuration of the core shell structure under 3-point bending analysis; a) dimensions, supports and loading condition and b) specifying the loading and boundary conditions in ANSYS.

III. RESULTS AND DISCUSSION

A typical results of core shell structure with honeycomb core under 3-point bending condition are represented in Figure 4. The equivalent stress and strain fields in this figure correspond to the result of finite element analysis in which the mid-pin displaced for 6 mm under 3-point bending condition. The results of these analyses, including the resultant reaction force at the mid-pin, maximum stress and strain developed in the core structure and the flexural response of the core shell structure have been represented and discussed in details with core structures of different configurations as the results of simulations.

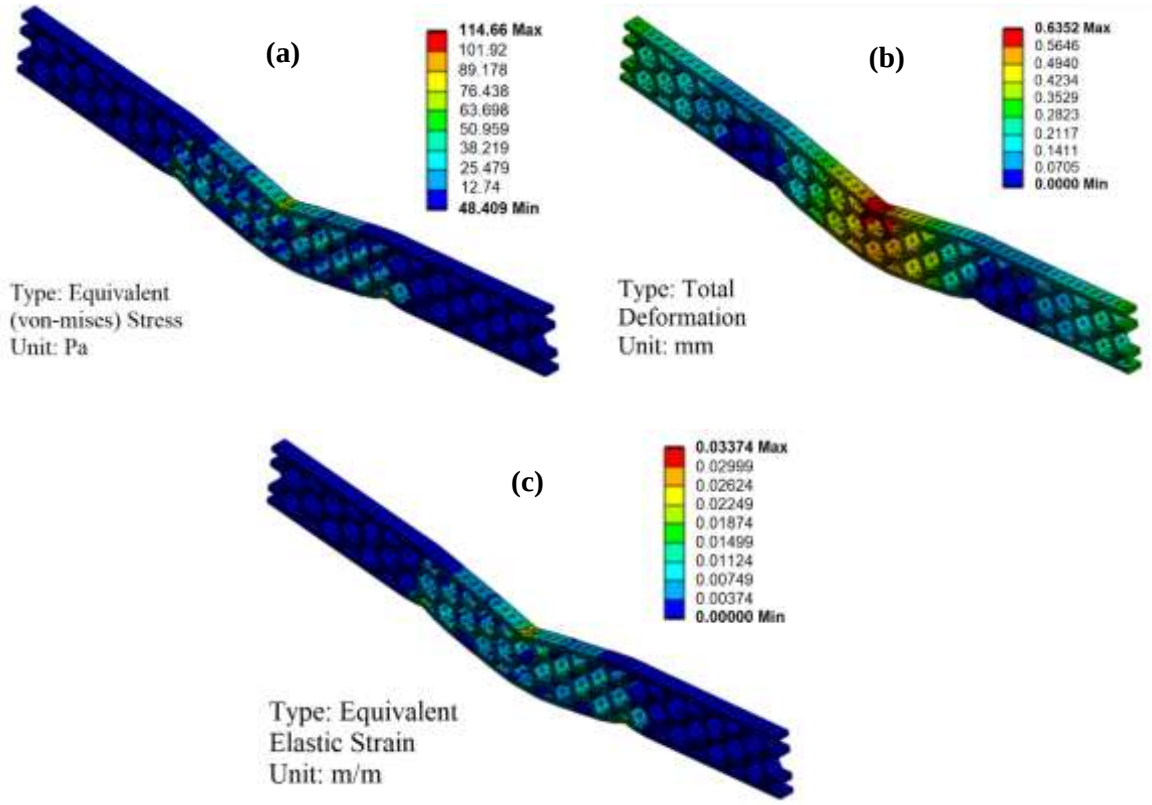

Fig. 4. Typical 3-point bending simulation results of core shell structure with hexagonal core of 0.4 relative density and 1.25 mm wall thickness; a) Equivalent von-Mises stress, b) Total deformation, and c) Equivalent elastic strain.

The details of the resuls of simulations are provided as graphs that depict the deformation forces as resultant forces, developed equivalent von-Mises stress in the core shell structure and the flexural modulus of the beams of diffirent configurations under 3-point bending conditions. |Each data point represents a specific combination of relative density (0.4-0.5) and wall thickness (1-1.25 mm) for the three core geometries (hexagonal, triangular, rectangular), represented by different colors.

Figure 5 shows the resultant forces for the different core configurations: hexagonal, rectangular, and triangular, under varying conditions of relative density and wall thickness. The data in this figure reveal significant differences in the mechanical performance of the various core geometries. Notably, the hexagonal core consistently shows the highest resultant forces across different configurations. This superior performance is attributed to the hexagonal geometry's efficient stress distribution, which enhances its load-bearing capacity under bending loads. For instance, at a relative density of 0.5 and a wall thickness of 1.25 mm, the hexagonal core achieves a significant resultant force of 178 N, surpassing both rectangular (78 N) and triangular (149 N) cores under similar conditions.

Conversely, the rectangular core exhibits lower resultant forces compared to the hexagonal core. For example, at 0.4 relative density and 1 mm wall thickness, the rectangular core achieves a resultant force of 44.69 N, highlighting its comparatively lower load-bearing capacity. The triangular core also shows varied

performance across configurations, demonstrating higher resultant forces compared to the rectangular core but lower than the hexagonal core in most cases.

Wall thickness and relative density play crucial roles in determining core performance. Increasing wall thickness generally enhances resultant forces across all core geometries. For instance, the hexagonal core at 0.4 relative density experiences an increase in resultant force from 107.96 N with 1 mm wall thickness to 178 N with 1.25 mm wall thickness, indicating improved structural integrity and load-bearing capacity. Moreover, higher relative densities typically result in higher resultant forces, indicating greater capacity to distribute and withstand applied loads. This trend is evident in the performance of the hexagonal and triangular cores, which show increased resultant forces at higher relative densities compared to lower densities.

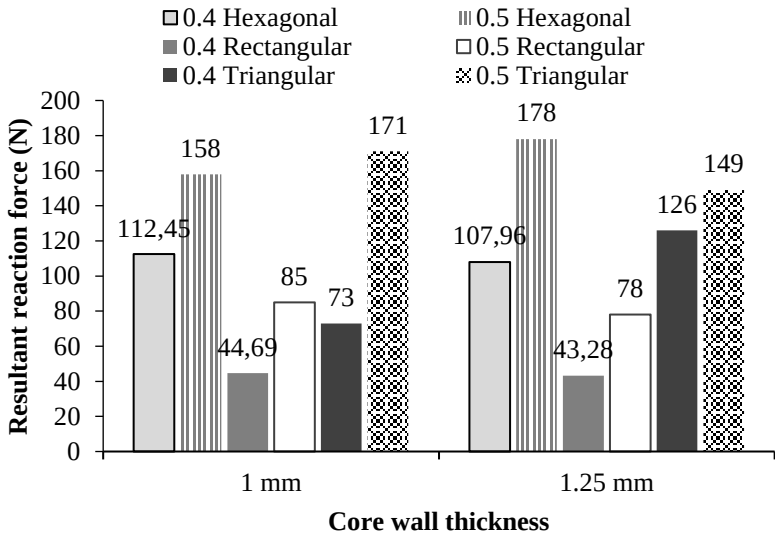

Fig. 5. Resultant force for core geometries under different configurations of relative density and wall thickness.

The maximum levels of von-Mises stresses developed on the core shell structures of different core designs are represented in Figure 6. The equivalent von-Mises stress analysis provides crucial insights into the mechanical behavior of core structures subjected to 3-point bending conditions, highlighting variations influenced by relative density and wall thickness. Among the core geometries studied (hexagonal, rectangular, and triangular) distinct stress distribution patterns emerge that reflect their structural responses under applied bending loads.

Starting with the hexagonal core structure, at 1 mm wall thickness and 0.4 relative density, the equivalent von-Mises stress measures 77.95 MPa, indicating effective stress distribution and structural stability under moderate loading conditions. Increasing the relative density to 0.5 reduces the stress to 61.18 MPa, suggesting improved stress management with denser material configurations. However, at 1.25 mm wall thickness and 0.5 relative density, the stress significantly increases to 146 MPa, indicating potential stress concentration areas due to increased stiffness and reduced deformation capacity.

The rectangular core structure consistently exhibits lower von-Mises stress levels across different configurations. At a wall thickness of 1 mm and relative density of 0.4, the stress measures 37.90 MPa, indicating effective stress distribution under moderate loading conditions. Increasing the relative density to 0.5 results in a slight increase in stress to 50.11 MPa, reflecting the core's ability to handle stress adequately with denser material but showing a minor rise in stress levels. When the wall thickness is further increased to 1.25 mm at 0.5 relative density, the stress rises to 63.14 MPa, indicating potential localized stress concentration areas due to the thicker structural profile. The lower von-Mises stress levels in the rectangular core structure correspond to its greater susceptibility to deformation under applied loads, as depicted in Figure 5. This higher deformability contributes to reduced von-Mises stress compared to hexagonal and triangular cores, which exhibit higher stress concentrations due to their more intricate geometries and

potentially less uniform stress distribution patterns. Thus, the rectangular core's ability to deform more readily underpins its lower stress levels and highlights its suitability for applications requiring controlled stress distribution and deformation characteristics.

The triangular core structure demonstrates a different stress response. At 1 mm wall thickness and 0.4 relative density, the stress is notably higher at 125.60 MPa, indicating less optimal stress distribution and potential concentration areas under bending loads. Increasing the relative density to 0.5 reduces the stress to 78.75 MPa, showing improved stress management with denser material configurations. With thicker walls of 1.25 mm, stress distribution improves further, dropping to 65.28 MPa at 0.4 relative density, but increases slightly to 124.30 MPa at 0.5 relative density, highlighting challenges with stress concentration in denser triangular core structures.

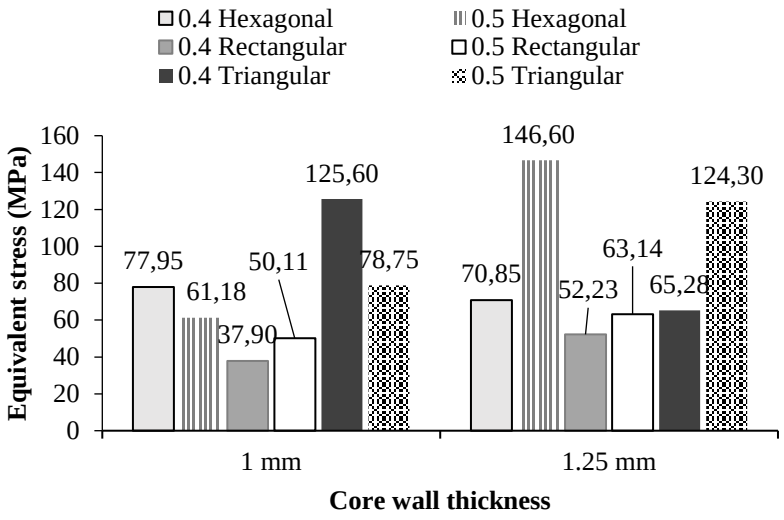

Fig. 6. Maximum equivalent von-Mises stress distribution across core geometries with varying relative densities and wall thicknesses.

The flexural modulus, also known as the modulus of elasticity in bending, was calculated using the formula:

$$E = \frac{F.L^3}{4.b.d^3.\Delta} \quad (1)$$

where E is the flexural modulus, F is the applied force at mid-span, L is the span length between supports, b is the width of the specimen, d is the thickness of the specimen, Δ is the deflection at the mid-span.

The data in Figure 7 illustrates the flexural modulus values for core structures of varying geometries (hexagonal, rectangular, and triangular) across different relative densities (0.4 and 0.5) and wall thicknesses (1 mm and 1.25 mm).

Upon analysis, the hexagonal core consistently demonstrates the highest flexural modulus values across all configurations. This is attributed to its geometric efficiency in distributing and resisting applied bending forces, resulting in enhanced stiffness. For instance, at a relative density of 0.5 and wall thickness of 1.25 mm, the hexagonal core achieves a flexural modulus of 150.09 MPa, significantly higher than the values observed for rectangular and triangular cores. Conversely, the rectangular and triangular cores exhibit lower flexural moduli, with values generally lower than those of the hexagonal cores. The rectangular core, for example, reaches a flexural modulus of 71.67 MPa at 0.5 relative density and 1 mm wall thickness, whereas the triangular core reaches 144.19 MPa under the same conditions.

Relative density plays a critical role in determining the flexural properties of these core structures. Higher relative densities generally result in higher flexural modulus values, indicating greater stiffness and resistance to deformation. For example, increasing the relative density from 0.4 to 0.5 in the hexagonal core significantly improves its flexural modulus, highlighting the direct correlation between material density and structural performance. In the case of the rectangular core, the flexural modulus increases from approximately 37.68 MPa at a relative density of 0.4 to 71.67 MPa at a relative density of 0.5. Similarly, the triangular core shows an increase in flexural modulus from around 61.55 MPa to 144.19 MPa with the same increase in relative density. These findings suggest that denser core configurations are more capable of distributing and withstanding applied loads, thereby enhancing their overall stiffness.

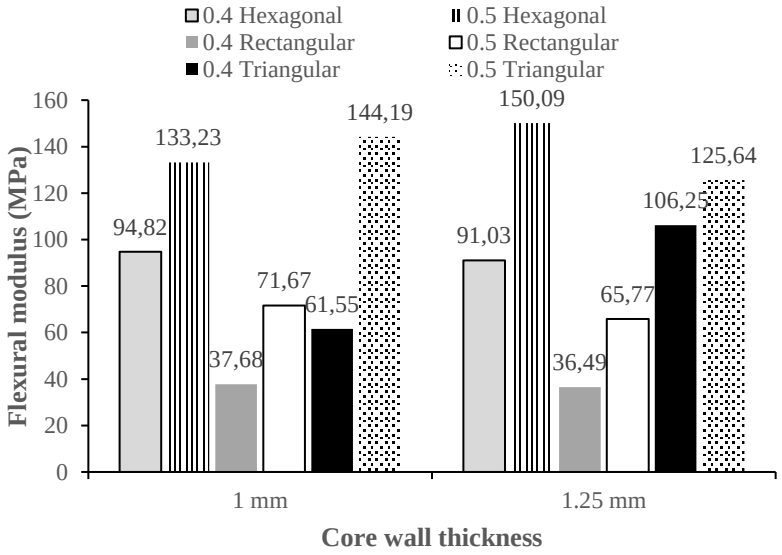

Fig. 7. Flexural modulus of core structures with varying relative densities and wall thicknesses.

IV. CONCLUSION

This study provides a comprehensive analysis of the impact of core geometry and relative density on the mechanical performance of sandwich panels fabricated from ABS material using the Fused Deposition Modeling (FDM) process. The design and analysis of these core structures were meticulously carried out using ANSYS to simulate 3-point bending conditions. By adhering to the ASTM D790-10 standard, the specimens were modeled with precise dimensions and subjected to controlled bending forces. This method allowed for accurate extraction of key mechanical parameters such as flexural modulus and von-Mises stress, ensuring the reliability of the results.

By meticulously examining three distinct core configurations—hexagonal, rectangular, and triangular—under varying conditions of wall thickness and relative density, we have gained valuable insights into their structural behavior and efficiency. The hexagonal core structure consistently demonstrated superior performance in both resultant force and flexural modulus, attributed to its geometric efficiency in stress distribution and load-bearing capacity. This configuration showed the highest flexural modulus values, particularly at higher relative densities, making it an ideal choice for applications requiring high stiffness and resistance to bending loads.

Conversely, the rectangular core, while exhibiting lower von-Mises stress levels and ease of deformation, did not match the stiffness and load-bearing capacity of the hexagonal core. The triangular core, despite having a higher resultant force in some configurations, displayed higher stress concentrations, indicating less optimal stress distribution compared to the hexagonal core. The study also highlighted the critical role of relative density in enhancing the mechanical properties of core structures. Higher relative densities generally led to increased resultant forces and flexural modulus values, underscoring the importance of material density in achieving superior structural performance.

An additional advantage emphasized in this study is the flexibility of the FDM process in engineering the core design parameters of core structures. The FDM process allows for precise control over geometry, relative density, and wall thickness, enabling the optimization of mechanical properties tailored to specific applications. This versatility is crucial for the development of customized, high-performance sandwich panels in various engineering fields.

ACKNOWLEDGMENT

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Işıklı Gölü'nün (Çivril, Denizli) Hidrojeokimyasal İncelemesi

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Özet – Işıklı Gölü, Ege Bölgesi'nde bulunur ve Denizli İli Çivril İlçesi'nin güneydoğusunda, Akdağ ile Bozdağ kütleleri arasında uzanan tektonik bir depresyonun en alçak noktasında konumlanmıştır. Işıklı gölü yaklaşık 36 km^2'lik alan kaplamaktadır. Günümüzde gözlenen iklim değişikliği etkisiyle yaşanan su kayıpları sebebiyle Işıklı Gölünün su kalitesinde bozulmalar, gözlenmektedir. Bu çalışmada, göl sularının fiziksel ve kimyasal özelliklerinin belirlenmesi amacıyla Mayıs-2024 döneminde su örnekleri alınmış ve kimyasal analiz sonuçları kullanılarak hidrojeokimyasal değerlendirmeler yapılmıştır. Göl sularının hidrojeokimyasal fasiyelerini belirlemek ve su tiplerini tanımlamak amacıyla Piper diyagramı kullanılmıştır. Işıklı Gölünden alınan su örnekleri, Piper diyagramında, zayıf asitlerin (CO_3^- + HCO_3^-) güçlü asitlerden (SO_4^- + Cl^-) daha fazla olduğu bir su tipini temsil ettiği belirlenmiştir. Ayrıca sular kimyasal açısından Schoeller diyagramına göre değerlendirilmiştir. Göl suyu genellikle diyagramda paralel bir dağılıma sahiptir ve özellikle Mg, Ca ve HCO_3 iyonlarının baskın olduğu görülmektedir. Chadha diyagramı sınıflandırmasına göre incelenen su örnekleri 5 numaralı bölgeye düşmektedir. Bu durum, suyun hidrojeokimyasal yapısında alkali toprak elementlerinin ve zayıf asidik anyonların sırasıyla alkali metalleri ve güçlü asidik anyonları aştığını göstermektedir. Bu tür sular geçici sertliğe sahiptir. Chadha diyagramdaki veri noktalarının konumları, Ca^{2+}– Mg^{2+}– HCO_3^- tipi, sular olduğunu göstermektedir. Ayrıca suların kimyasal analiz sonuçlarına göre kullanılabilirliği değerlendirilmiş ve pH ve As bakımından içme suyu olarak kullanıma uygun olmadığı sonucuna varılmıştır.

Anahtar Kelimeler – Işıklı Gölü, hidrojeokimya, su kalitesi, su kimyası, Denizli

I. GİRİŞ

Sulak alanlar, biyolojik üretimde son derece verimli sistemler olarak bilinir. Nehir kanalları, dere kenarları, göller ve taşkın düzlüklerinde oluşabilen bu alanlar, yaşamsal öneme sahip ekosistemler oluştururlar [1], [2]. Özellikle su ihtiyacının karşılanmasında en yoğun kullanılan su kaynakları arasında göller önemli bir yer tutar [3]. Türkiye'de su potansiyeli ve kullanılabilirlik özellikleri bakımından kısıtlı miktarlarda sahip olduğumuz göller, belirli bölgelerde toplanmıştır. Bunlar Göller Yöresi (Eğirdir, Burdur, Beyşehir ve Acıgöl), Güney Marmara (Sapanca, İznik, Ulubat, Kuş Gölleri), Van Gölü çevresi ve Tuz Gölü çevresidir. Bu göller, büyük arazi parçalarının drenaj sularını toplar ve göl ile çevresi arasında sürekli bir etkileşim sağlar. Yüzey ve yeraltı akışları göle giriş yapar ve gölden çıkar. Bu akışlar, çeşitli fiziksel, kimyasal ve biyolojik bileşenler ile organik maddeleri, tortu ve diğer maddeleri götürürler. Bu akışların hızı, gölün coğrafi yapısına, iklim ve mevsimsel şartlara bağlı olarak değişiklik gösterebilir. Akarsulara göre sınırlı akışı olan göllerdeki kirlilik potansiyeli farklılık gösterebilir.

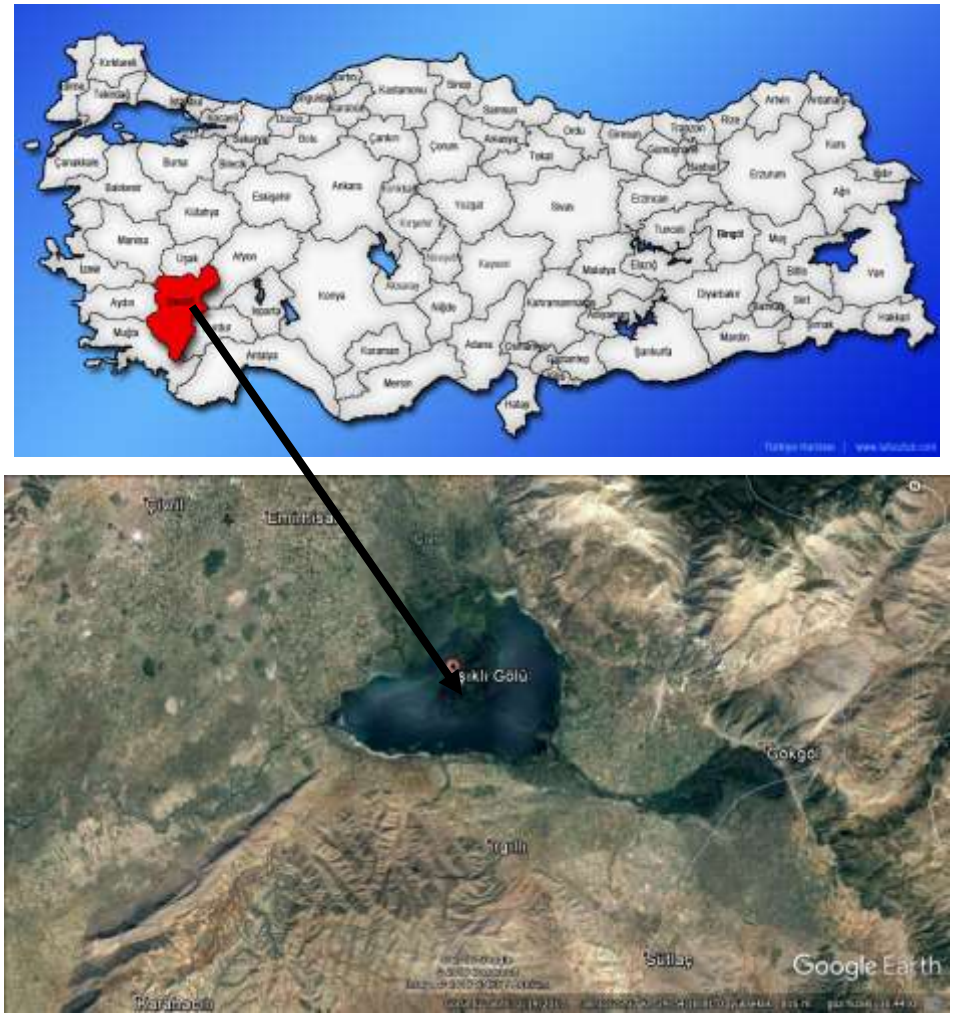
Bir gölün drenaj alanındaki kayaç türü, göl suyunun inorganik bileşimini belirleyen en önemli faktördür. Özellikle dışarıya akışı olmayan göllerde, ağır metaller gibi bozunmayan kirleticilerin ve zor parçalanabilen pestisitlerin birikimi, yüzeysel sularda kirlenme riskini artırabilir. Bu durum, göllerin korunması açısından büyük önem taşır, çünkü göller genellikle yüzeysel sularda en hassas su sistemlerini

oluşturur [4]. Bu çalışmada, Işıklı Gölü (Çivril, Denizli) havzasının jeolojik ve hidrojeolojik incelemesi yapılarak göl sularının hidrojeokimyasal özellikleri ve kullanılabilirlik durumu araştırılmıştır.

II. MATERYAL VE YÖNTEM

A. Çalışma Alanı

Işıklı Gölü Ege Bölgesinin İç Batı Anadolu Bölümünde Denizli İli Çivril İlçesinin 12 km. güneydoğusunda, Akdağ ile Bozdağ kütleleri arasında GB-KD doğrultusunda uzanan tektonik kökenli bir depresyonun en çukur kesiminde yer almaktadır. Işıklı Gölü, Büyük Menderes Nehri'ni besleyen kaynakların üzerinde Akdağ'ın güneyinde yer alan yaklaşık 36 km^2 yüzey alanına ve maksimum 7 m derinliğe sahip tatlı su gölüdür. Göl; Kufi Çayı, Akdağ, Işıklı kaynakları ile yeraltısuları ve Büyük Menderes'in yukarı havzadaki iki büyük kolu ile beslenmektedir [5]. Işıklı Gölü'nün orta kesimlerinde kuvvetli rüzgarlarla yer değiştiren saz adacıkları olup bu adacıklarda su kuşlarının barınma ve üreme yerleri bulunmaktadır.



Şekil 1. Çalışma alanının yer bulduru haritası

B. *Analiz Yöntemleri*

Çalışma kapsamında göl sularının kimyasal yapısı ve kalitesini belirlemek için gölü en iyi şekilde temsil edebilecek lokasyonlardan su örnekleri alınmıştır. Su örneklerin kimyasal analizleri Süleyman Demirel Üniversitesi Jeotermal Enerji, Yeraltısuyu ve Mineral kaynakları Labaratuvarları'nda yaptırılmıştır. Ayrıca, suların sıcaklık (T), elektriksel iletkenlik (EC), çözünmüş oksijen (DO) ve hidrojen iyonu konsantrasyonu (pH) değerleri YSI marka çok parametreli portatif su kalitesi ölçüm cihazı kullanılarak yerinde ölçülmüştür. Analiz sonuçları ilgili diyagram ve haritalar üzerinde yorumlanarak, suların kimyasal yapısı ve hidrojeokimyasal süreçleri ayrıntılı olarak yorumlanmıştır.

III. BULGULAR

A. *Çalışma Alanının Jeolojisi*

Çalışma alanı ve yakın çevresinde temel birimleri oluşturan otokton kayaç birlikleri en altta Paleozoyik yaşlı Afyon Metamorfitleri, Kestel formasyonu ve Jura-Kretase yaşlı Erginlik kireçtaşları ve Akdağ Kireçtaşları'dır. Bölgede yüzeyleyen allokton birimler ise Karaova formasyonu, Ortadağ formasyonu, Derealanı formasyonu, Gökgöl, Denizpınarı ve Cerityayla Üniteleri, Adlanmamış mermer, Kızılcadağ ofiyolitik melanjı ve Bozoğlan formasyonudur. Bu birimler üzerine gelen Oligosen yaşlı Acıgöl Grubu paraallokton yerleşime sahip olup Miyosen'den itibaren örtü kayalar olarak Gebeciler, Erdemir, Çameli ve Kepeztepe formasyonları gözlenmektedir. Çalışma alanında Büyük Menderes nehrinin fluviyal kanal dolgusu ve taşkın düzlüğünü meydana getiren alüvyon birimler, Işıklı Gölü etrafındaki bataklık ve ince taneli gölsel kırıntılılar, temel kayaçların önünde birikinti konileri oluşturan yamaç molozları ve yine bunlardan beslenen alüvyon yelpazeleri Kuvaterner yaşlı birimlerdir [6].

B. *Litolojik birimlerin hidrojeolojik özellikleri*

Çalışma alanındaki litolojik birimler hidrojeolojik özelliklerine göre sınıflandırılmış olup buna göre, Afyon Metamorfikleri , Kestel Formasyonu , Adlanmamış Mermer Geçirimsiz Birim 1 (Gz1) ; Kızılcadağ Melanj Geçirimsiz Birim 2 (Gz2) ;Derealanı Formasyonu , Deniz pınarı ünitesi Az Geçirimli Birim (Gça) ; Karaova Formasyonu , Cerit yaylası Ünitesi , Ergenlik Resifal Kireçtaşı Formasyonu , Aksu Formasyonu , Gebeciler Formasyonu , Erdemir Formasyonu Yarı Geçirimli Birim (Gçy) ; Gökgöl Üyesi Karstik Geçirimli Birim (Gç-2) ; Acıgöl Grubu Geçirimli Birim 3 ; Akdağ Formasyonu , Ortadağ Formasyonu , Bozoğlan Formasyonu Geçirimli Birim 2; Alüvyon , Yamaç Molozu Geçirimli Birim 1 ; Çameli Formasyonu , Kepeztepe Formasyonu , Pliyo- Kuvarterner Ayırtlanmamış Kırıntılı Birimler Geçirimli Birim olarak sınıflandırılmıştır.

C. *Göl sularının hidrojeokimyası*

Piper ve Schoeller'e göre suların sınıflaması

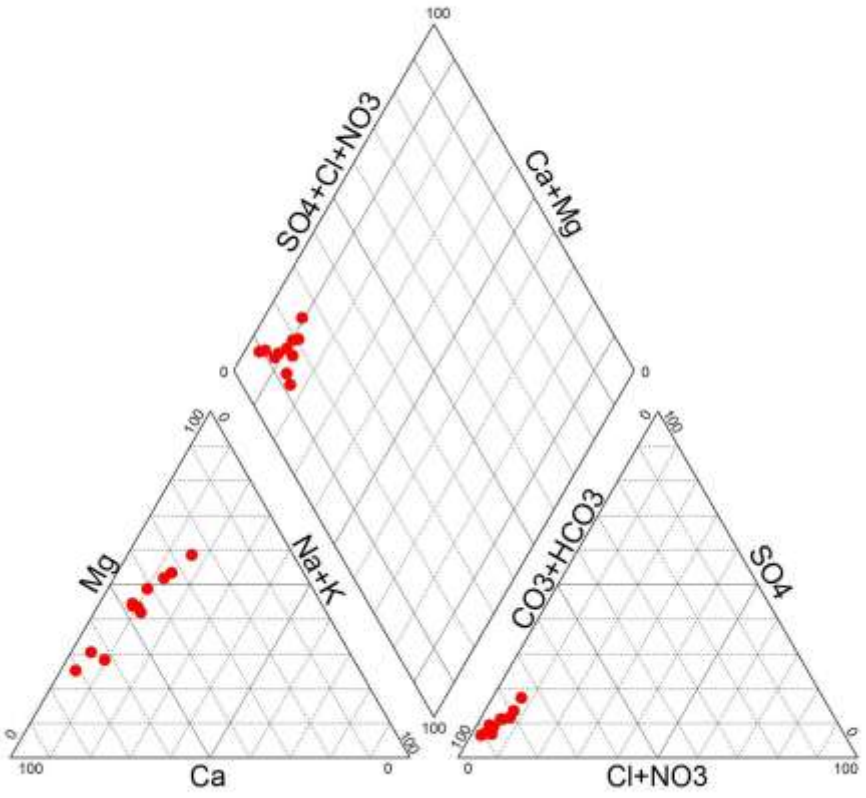
Analiz sonuçlarının grafiksel olarak gösterimi, hidrojeokimyasal fasiyelerin doğru bir şekilde tanımlanmasını ve yeraltısularının niteliksel özelliklerinin anlaşılmasını sağlamak için kullanılan faydalı bir yöntemdir. Bu çalışmada, yeraltısularının hidrojeokimyasal fasiyelerini belirlemek ve su tiplerini tanımlamak amacıyla Piper diyagramı kullanılmıştır. Piper diyagramı, anyonları ve katyonları toplam iyonlara göre oransal olarak gösteren iki üçgeni içeren bir grafik temsilidir [7]. Su karakterinin tanımlanması için bu diyagram, dokuz alt bölüme ayrılmıştır, her biri aşağıda belirtilen su tiplerini ifade etmektedir [7] (Şekil 2).

- Alkali toprak elementleri (Ca+Mg), alkali metallerden (Na+K)'nin üstünde bulunur.
- Alkali metaller (Na+K), alkali toprak elementlerinden (Ca+Mg) daha fazladır.
- Zayıf asitler (CO_3+HCO_3), güçlü asitlerden (SO_4+Cl) daha fazladır.
- Güçlü asitler, zayıf asitlerden daha fazladır.
- Karbonat sertliği (ikincil alkalinite) %50'den fazladır.
- Karbonat olmayan sertlik (ikincil tuzluluk), %50'den fazladır.
- Karbonat olmayan alkali metaller (birincil tuzluluk), %50'den fazladır.
- Karbonat alkali metaller (birincil alkalinite), %50'den fazladır.
- Hiçbir katyon-anyon çifti %50'den fazla değildir.

Bu analitik yöntem, yeraltı suyunun kimyasal bileşimini ayrıntılı olarak değerlendirmek ve farklı su tiplerini belirlemek için önemlidir.

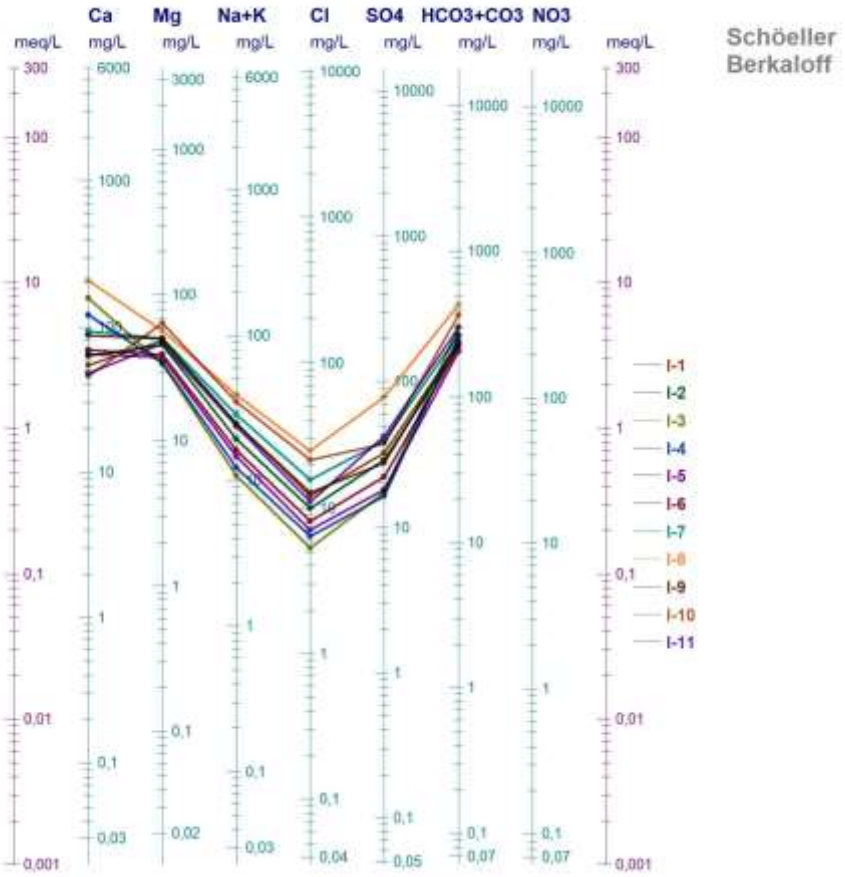
Bu diyagram, su örneklerinin mineralizasyon seviyelerinin artışıyla birlikte suyun yüzey fasiyelerinin gelişimini incelemek için özellikle uygundur. Ayrıca, örneklerin gruplar halinde karşılaştırılması ve baskın katyon ve anyon türlerini belirlemek için kullanılır. Işıklı Gölünden alınan su örnekleri, Piper diyagramında 3. bölgeye yerleşmiştir (Şekil 1). Bu bölgede bulunan su örneklerinin, zayıf asitlerin (CO_3^{-} + HCO_3^{-}) güçlü asitlerden (SO_4^{-} + Cl^{-}) daha fazla olduğu bir su tipini temsil ettiği görülmektedir. Ayrıca, 5. bölgede bulunan su örnekleri için karbonat sertliğinin %50'den fazla olduğu bir su tipi ile özdeşleştirilir. Farklı katyon ve anyon değerlerine dayanarak yapılan Piper diyagramına göre sınıflandırma sonucunda, çalışma alanındaki sularda Ca-Mg-HCO_3 su tiplerinin baskın olduğu tespit edilmiştir.

Örneklerdeki Ca ve Mg iyonlarının varlığı, çalışma alanında bulunan kireçtaşı ve kalkerli kayaçlarla ilişkilendirilir ve bu iyonlar kayaç-su etkileşiminin bir sonucu olarak meydana gelmektedir.



Şekil 2. Işıklı göl suyu örneklerinin Piper diyagramına göre sınıflaması

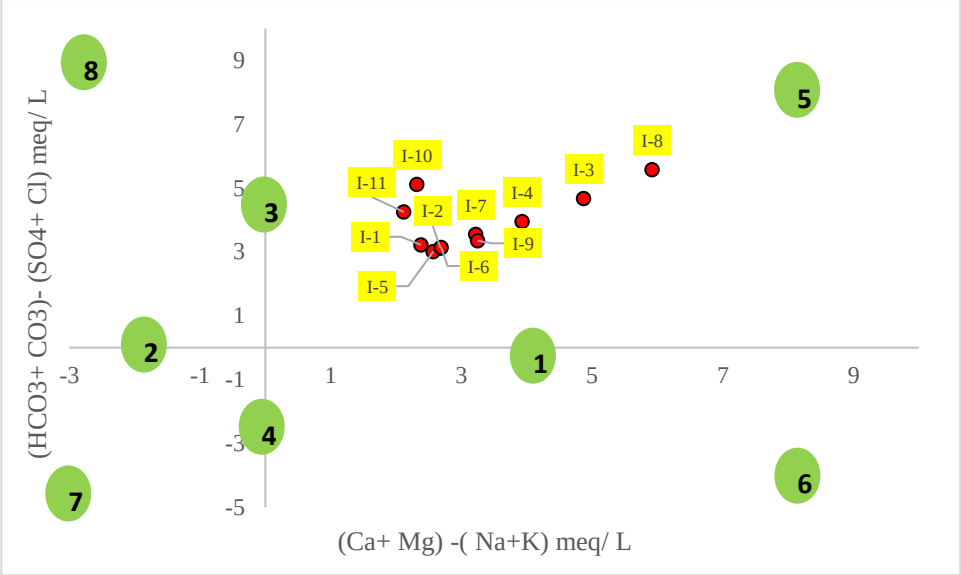
Ek olarak, sular kimyasal açısından Schoeller-1965 diyagramına [8] göre değerlendirilmiştir. Suyu genellikle diyagramda paralel bir dağılıma sahiptir ve benzer zirveleri gösterilmiştir. Suda özellikle Mg, Ca ve HCO_3 iyonlarının baskın olduğu görülmektedir (Şekil 3).



Şekil 3. Işıklı göl suyu örneklerinin Schoeller diyagramına göre sınıflaması

Chadha'e göre suların sınıflaması

Çalışma alanındaki yeraltı sularının hidrojeokimyasal sınıflandırılması ve ana jeokimyasal süreçlerin yorumlanması için Chadha diyagramı kullanılmıştır ve bu diyagram Şekil 4'de sunulmuştur [9]. Chadha diyagramı, suların kimyasal özelliklerini tanımlamak için dörtgen bir şekilde oluşturulmuş ve sekiz alt bölüme ayrılmıştır. Bu düzenleme, hidrokimyasal süreçlerin evrimini daha açık bir şekilde göstermeye yardımcı olur. Suyun temel su tipini belirlemek amacıyla, diyagramın dikdörtgen alanı, su tiplerini karakterize eden sekiz alt bölüme ayrılmıştır [9].



Şekil 4. Işıklı göl suyunun Chadha diyagramına göre sınıflaması

Chadha diyagramı sınıflandırmasına göre (Şekil 4), bu çalışmada incelenen su örneklerinin 5 numaralı bölgeye düşmektedir. Bu durum, suyun hidrojeokimyasal yapısında alkali toprak elementlerinin ve zayıf asidik anyonların sırasıyla alkali metalleri ve güçlü asidik anyonları aştığını göstermektedir. Bu tür sular geçici sertliğe sahiptir. Önerilen diyagramdaki veri noktalarının konumları, Ca^{2+}– Mg^{2+}– HCO_3^- tipi, Ca^{2+}–Mg^{2+} baskın HCO_3^- tipi veya HCO_3^- baskın Ca^{2+}– Mg^{2+} tipi suları temsil etmektedir. Bu bilgi, Chadha diyagramında incelenen veri noktalarının konumlarıyla uyumludur ve su örneklerinin hidrojeokimyasal yapısını daha iyi anlamamıza yardımcı olur.

IV. TARTIŞMA

Göl su örneklerinin majör iyon analiz sonuçları detaylı bir şekilde incelenmiştir. Örneklerin Cl^-/ HCO_3 oranı 1'den büyükse, bu klorür iyonlarında bir artış olduğunu gösterirken, oran 1'den küçükse, bikarbonat iyonlarında bir artış olduğunu ifade etmektedir. Ayrıca, Ca^{+2}/Mg^{+2} oranı, 1'den büyük değerler gösterdiğinde kalsiyumda bir artış olduğunu, 1'den küçük bir değer gösterdiğinde ise magnezyumda bir artış olduğunu göstermektedir. Su örneklerinin kimyasal bileşenlerinin analizi, özellikle klorür ve sülfat iyonlarının oranlarını ve kalsiyum ile magnezyum oranlarını dikkate alarak, suyun kimyasal evrimini ve olası jeokimyasal süreçleri değerlendirmek için kullanılır. Elde edilen sonuçlara göre, su örneklerinde baskın su fasiyeleri kalsiyum (7 su örneği), magnezyum (4 su örneği) ve bikarbonat olarak belirlenmiştir.

Göl suyunun pH değerleri 8.03 ile 9.4 arasında değişmektedir ve I-1, I-2, I-5, I-6, I-10 ve I-11 numuneleri standartların üzerindedir. Bu durumda, göl suyu numuneleri içme suyu olarak kullanılmak için uygun değildir. Kalsiyum açısından, diğer tüm örneklerdeki kalsiyum içeriği, Dünya Sağlık Örgütü [10] ve Türk Standartları [11] tarafından belirlenen sınırların altındadır. Ancak I-8 numunesinin kalsiyum içeriği sınırların üstündedir. Ayrıca, I-7, I-8 ve I-10 numunelerinin arsenik bakımından belirlenen sınırların üzerinde olduğu gözlemlenmiştir. Göl suyu genel olarak Al, Mn, Cu, Zn, Pb, Hg, Cd, Se, S, Fe ve Cr parametreleri açısından standartlara uygun bir şekilde görünmektedir. Bu nedenle, Işıklı göl suyun genel olarak içme suyu olarak kullanılabilmektedir.

V. SONUÇLAR

Ülkemizin önemli su kaynaklarından biri olan Işıklı Gölü'nün hidrojeokimyasal özelliklerinin incelenmesi bu çalışmanın ana konusunu oluşturmaktadır. Göl suları genel Ca-Mg-HCO_3 tipi sular sınıfında olup Ca ve Mg baskın katyonları, HCO_3 ise baskın anyonu oluşturmaktadır. Örneklerdeki Ca ve Mg iyonlarının varlığı, çalışma alanında bulunan kireçtaşı ve kalkerli kayaçlarla ilişkilendirilir ve bu iyonlar

kayaç-su etkileşiminin bir sonucu olarak meydana gelmektedir. Ayrıca, göl sularının pH ve As bakımından içme suyu limit değerlerinin üzerinde olduğu belirlenmiş olup içme suyu olarak kullanımı uygun değildir.

TEŞEKKÜR

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Gıda ve Kozmetik Ürünlerinde İçerik Bilgisi ve Anlaşılırlığı Sunan Mobil Uygulama

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Özet – İnsanoğlunun var oluşundan beri en temel ihtiyaçlarından birisi olan beslenme gereksinimi günümüz dünyasında da oldukça önemlidir. İnsanların sağlıklı bir yaşam sürdürebilmeleri için doğru ve dengeli beslenmeleri gerekmektedir. Ancak, günümüzde market raflarında bulunan ürünlerin içeriği hakkında yeterli bilgiye sahip olmamamız ve doğru seçimler yapmamamız kötü sonuçlara sebebiyet verebilmektedir. İşte bu noktada, bu proje önemli bir rol üstlenmektedir.

Bu proje, bireylerin sağlıklı yaşam bilincini artırmak ve sağlıklı ürün seçimlerini desteklemek amacıyla geliştirilen önemli bir çalışmadır. Proje, gıda ve kozmetik ürünlerindeki içerik bilgilerinin anlaşılırlığını değerlendirmek, kullanıcıların bilinçli tüketim davranışlarını teşvik etmek ve sağlıklı beslenme alışkanlıklarını yaygınlaştırmak için kapsamlı bir platform geliştirmeyi hedeflemektedir. Projenin temel amacı, tüketicilerin market ürünlerinin etiketlerindeki içerik bilgilerini doğru bir şekilde okuyup yorumlayabilmelerini sağlamaktır. Bu doğrultuda, besin değerleri, besin içerikleri, kozmetik ürün bileşenleri gibi konular anlaşılır bir şekilde açıklanacak ve kullanıcılara yönelik bilgilendirme materyalleri hazırlanması sağlanacaktır. Sağlık açısından potansiyel risk taşıyan bileşenlerin belirlenmesi ve tüketicilere sağlıklı ve güvenli ürün seçiminde rehberlik desteği sağlanacaktır.

Projede, platformu kullanacak bireylerin bilimsel anlamda bilgiler kazanmasının yanı sıra, sağlıklı yaşam için bilinçli tüketimde de pozitif bir artış meydana gelecektir.

Sonuç olarak, "Market Ürünlerindeki İçerik Bilgilerinin Anlaşılırlığı ve Kullanıcılar İçin Sağlıklı Yaşam Bilinci" adlı proje, tüketicilerin market ürünlerinin içerik bilgilerini anlamalarını ve sağlıklı ürün seçimlerini yapabilmelerini desteklemeyi amaçlamaktadır. Projede, etiketlerin anlaşılırlığı, kullanıcıların bilgi düzeyi, risk yönetimi ve bilimsel paylaşım gibi önemli hedefler doğrultusunda çalışmalar yürütülecektir. Bu proje, sağlıklı yaşam bilincini artırmak, bilinçli tüketim davranışlarını teşvik etmek ve daha sağlıklı bir gelecek için bilgi ve farkındalık oluşturmak adına büyük bir adımdır.

Anahtar Kelimeler – Gıda Etiketi, Ürün İçeriği, Mobil Uygulama, Sağlıklı Yaşam, Bilinçli Tüketim

I. GİRİŞ

Ürün içeriğini bilmek, bireylerin yeterli ve dengeli beslenme alışkanlıkları geliştirmelerinde önemli bir rol oynar ve sağlıklı gıda seçimleri yapmalarını teşvik eder. Bu şekilde, sağlıklı beslenme alışkanlıklarını benimseyerek daha iyi bir beslenme durumuna ulaşabilirler. Ülkelerin refah düzeylerindeki artışla beraber tüketiciler, tükettikleri gıdaların besin öğesi içeriğine, güvenilirliğine ve sağlıklı olmasına daha çok önem

vermiştir. Bu bağlamda üreticiler, kalite kontrolünün göstergesi olarak ürünlerini sertifikalandırmaya ve etiketlemeye başlamıştır [1]. Kalite göstergesi olarak kullanılan sertifikasyon, etiketleme ve marka vs. özellikle tüketicinin anlamasının zor olduğu kalite niteliklerini (ürünün ilaç kalıntısı içermesi gibi) ifade ettiği için ayrıca önemlidir [2]. Bu bilgilerin ışığında bireylerin doğru besinleri tercih etmelerini sağlamak için geliştirilen stratejilerden biri de besin etiketi bilgilerinin etkin bir şekilde kullanımına yönelik yapılan çalışmalardır [3].

Konu ile alakalı yapılan literatür çalışmaları incelendiğinde, Türkiye'nin 26 farklı ilinde yaşayan, tesadüfi örneklem yöntemi ile seçilen 12–56 yaş arası 1536 bireyin besin etiketlerinde yer alan bilgileri kullanım düzeyleri ve etiket bilgilerini kullanmama nedenlerinin incelendiği bir çalışmada; besin etiketinde yer alan bilgileri kullanma durumu %76,5 olarak belirlenmiştir.Besin etiketi okuma durumu yaş, cinsiyet, medeni durum,eğitim seviyesi ve sosyoekonomik durum ile anlamlı olarak ilişkilidir. ($p<0,001$).Ayrıca, bu çalışma ile terim, sembol ve değerlerianlamama, bilgi sunumunun zayıf olması, bilginin doğruluğu hakkında endişe duyulması, yazıların küçük olmasıgibi sebeplerin besin etiketlerinin okunması için engel olduğu ortaya konulmuştur [4].BirleşikKrallık'ta bulunan 37 üniversiteden rastgele seçilen 500 öğrenci (375 kadın, 125 erkek) üzerinde yapılan kesitselbir araştırmada, beslenme bilgisinin ve sağlıklı beslenmeye yönelik ilginin besinetiketlerindeki bilgileri kullanmaya etkisi olup olmadığı incelenmiş, katılımcıların beslenme bilgilerinin yaş, cinsiyet ve ırka göre farklılık gösterdiği saptanmıştır. Ayrıca, bu çalışma ile beslenme bilgisinin ve sağlıklı beslenmeye olan ilginin besin etiketleri üzerinde yer alan bilgilerin kullanılmasında pozitif etkisi olduğu sonucuna varılmıştır [5].

Çeşitli araştırmalar, genel olarak, etiketlerin okunmasının amaçlandığı ve bu sayede besin değerleri hakkında bilgi sahibi olmayı ve ürünün içeriğindeki belirli bileşenlerin varlığını öğrenmeyi hedeflediğini göstermektedir. Bireyleri besin etiketlerini okumaktan alıkoyan belli başlı faktörler ise yapılan araştırmalardan özetle; ambalaj üzerindeki bilgilerin okunamayacak kadar küçük olması ve çabuk silinmesi, ürünün içeriği hakkındaki bilgilerin yetersiz olması, ürünlerin anlaşılır olmaması, kullanma ve saklama bilgilerinin yetersizliği şeklinde sıralanabilir. Ayrıca yapılan bazı çalışmalarda etiketlerde çok fazla bilgi verildiğinde, tüketicilerin akıllarının karışabildiği ortaya konmaktadır. Etiket okumayan bir kısım tüketicinin ise yeterli zamanları olmadığı, tanımları anlayamadıkları, anlamaları zor olduğu ya da beslenme konusu ile ilgilenmedikleri için etiket bilgisi okumadıkları görülmektedir [6].

II. MATERYAL VE YÖNTEM

A. *Etiket Bilgileri ve Kullanıcı Rehberliği*

Bu projede, bir mobil uygulama aracılığıyla etiket bilgilerinin anlaşılırlığını ve kullanıcılar için sağlıklı yaşam bilincini artırmayı hedeflemekteyiz. Yöntem olarak, aşağıdaki adımlar takip edilecektir:

- Uygulama Geliştirme: Uygulama, kullanıcı dostu bir arayüz ve etiket bilgilerini kolayca okuyabilecekleri bir yapıya sahip olacaktır. Kullanım kolaylığı ile her yaşa hitap etmesi en önemli hedeflerimizden olacaktır.

- Veri Tabanı Oluşturma: Ürünlerin etiket bilgilerini içeren bir veri tabanı oluşturulacak. Bu veri tabanı, çeşitli gıda ve kozmetik ürünlerinin bilgilerini içerecek ve kullanıcılara anlaşılır bir şekilde sunulacak.

- Barkod Okuma Teknolojisi: Mobil uygulama, ürünlerin barkodlarını okuyarak doğrudan etiket bilgilerine erişim sağlayacak bir barkod okuma teknolojisiyle entegre olacak. Kullanıcılar, uygulama üzerinden ürünleri tarayarak hızlı bir şekilde içerik bilgilerine ulaşabilecekler. Bu sayede uygulama içerisindeki karmaşıklıktan uzak durularak kullanım kolaylığı sağlanacaktır.

• Bilgilendirme ve Rehberlik: Uygulama, kullanıcılara sağlıklı beslenme ve kozmetik ürün seçimi konusunda bilgilendirme ve rehberlik materyalleri sunacak. Besin değerleri, besin içerikleri bu besinlerin içindeki maddelerin sağlık açısından günlük kullanım miktarları gibi unsurlar açıklayıcı bir şekilde kullanıcılara aktarılacaktır.

• Kullanıcı Geri Bildirimi: Uygulama kullanıcılarından geri bildirimler toplanacak ve kullanıcı deneyimi iyileştirmeleri yapılacaktır. Kullanıcıların uygulama kullanımıyla ilgili memnuniyetleri ve önerileri dikkate alınacak ve uygulama sürekli olarak güncellenerek iyileştirilecektir. Bu sayede eksik veya yanlış bilgi olduğu takdirde en kısa sürede dönüş alınarak ürünlerin kontrolü sağlanacaktır.

• Veri Analizi ve Değerlendirme: Uygulama üzerinden toplanan veriler, kullanıcıların etiketleri nasıl kullandıkları, hangi ürünlerde daha fazla etiket kontrolü yaptıkları ve sağlıklı ürün seçimine yönelik tercihlerini içeren istatistiksel analizlere tabi tutulacaktır. Bu analizler, kullanıcı davranışlarını anlamak ve uygulamanın etkinliğini değerlendirmek için kullanılacaktır. Elde edilen sonuçlar, projenin başarı kriterleri ve hedeflerine ne kadar yaklaşıldığını belirlemek için kullanılacak ve raporlanacaktır. Bu sayede yapmak istediğimiz proje ile ulusal ve uluslararası insan sağlığının önemine, bilinçsiz tüketim ve kullanımın önüne geçilmiş olunacaktır.

B. Parametreler

• Besin Etiketleri: Gıda ürünlerinin etiketlerinde yer alan besin değerleri, içerik listesi gibi bilgiler değerlendirilmesi.

• Kozmetik Ürün Etiketleri: Kozmetik ürünlerin etiketlerinde yer alan bileşenler, kullanım talimatları, uyarılar gibi bilgilerin incelenmesi.

• Kullanıcı Geri Bildirimleri: Kullanıcıların deneyimleri, memnuniyetleri, önerileri ve sorunlarına yönelik geri bildirimlerin toplanması.

• Etiket Anlaşılırlığı: Ürün etiketlerinin anlaşılırlığı, dil ve bilgi düzeyine uygunluğun değerlendirilmesi.

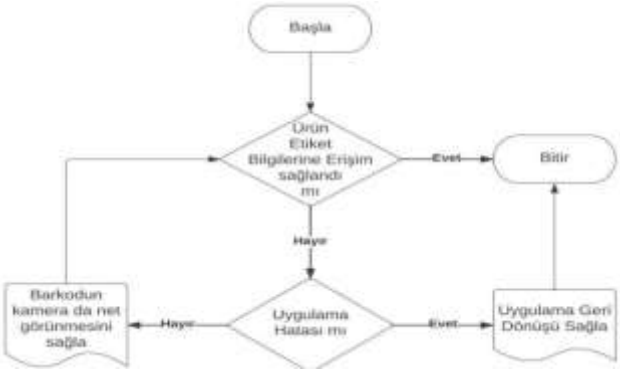
• Sağlık Etkileri: Ürün bileşenlerinin insan sağlığı üzerindeki potansiyel etkilerinin günlük kullanım miktarının sağlık açısından önerilerin verilmesi.

C. Model Mimarisi

Şekil 1'de de gösterildiği gibi gıda veya kozmetik ürünlerinin telefon uygulamasında oluşturduğumuz barkot ile okutulması hedeflenip bu doğrultuda uygulama içerisinde bilgiler yer alması sağlanacaktır.

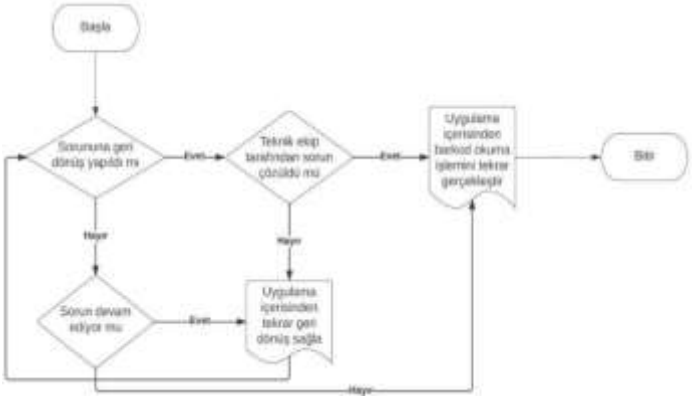
Şekil 1:Uygulama Taslağı

Şekil 2’de veri tabanı ve barkod okuması ile akış şeması oluşturulmuştur. Kullanıcının uygulama arayüzünü kolaylıkla kullanabilmesi için basit ve anlaşılır şekilde tasarlamamız gerekmektedir.



Şekil 2: Veri Tabanı Akış Şeması

Şekil 3’te kullanıcın geri dönüşünü sağlayan bir akış şeması oluşturulmuştur. Kullanıcının kolay bir şekilde bir sorunla karşılaştığında teknik ekibe kolay dönüş sağlaması gerekmektedir. Bu prototip ile akış şemaları ile kullanıcının rahatlıkla uygulamaya erişmesi, kolay şekilde kullanılması hedeflenmiştir.



Şekil 3: Kullanıcı Geri Dönüş Akış Şeması

III. BULGULAR

1- Uygulama Ana Ekranı

Kullanıcı odaklı, kullanışlı bir arayüz ile tüm yaş kitlelerine hitap etme de kolaylık sağlayacaktır.

2- *Barkod ile Ürün Okuma Ekranı*

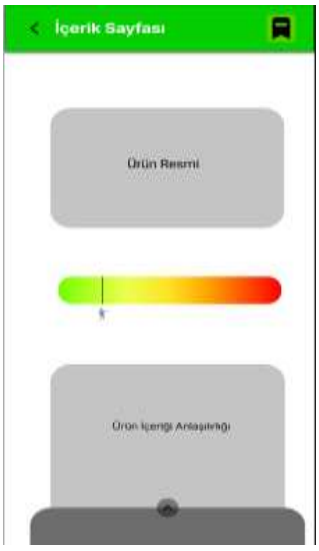
Mobil uygulama, ürünlerin barkodlarını okuyarak doğrudan etiket bilgilerine erişim sağlayarak bir barkod okuma teknolojisiyle entegre olacak. Kullanıcılar, uygulama üzerinden ürünleri tarayarak hızlı bir şekilde içerik bilgilerine ulaşabilecekler. Bu sayede uygulama içerisindeki karmaşıklıktan uzak durularak kullanım kolaylığı sağlanacaktır.

3- *Uygulama Geri Bildirim Ekranı*

Önerilen Yöntemler kısmında da belirtildiği gibi, uygulama kullanıcılarından geri bildirimler toplanarak, kullanıcı deneyimi iyileştirmeleri yapılacaktır. Kullanıcıların uygulama kullanımıyla ilgili memnuniyetleri ve önerileri dikkate alınacak ve uygulama sürekli olarak güncellenerek iyileştirilecektir. Bu sayede eksik veya yanlış bilgi olduğu takdirde en kısa sürede dönüş alınarak ürünlerin kontrolü sağlanacaktır.

4- *Ürün İçerik Ekranı*

Bu sayfa da projemizin ana kısmını ele alan unsurlar ele alınmaktadır. Okunan ürünlerin anlaşılırlık noktasında bu kısım çok önemlidir. Kullanıcıların doğru ve ürünlerin dönüştürülmüş adlarının daha anlaşılır olunmasında ki detaylar ön plana çıkmaktadır.



API isteği ile bu sayfa de oluşturulan kısımların içerikleri de beraberinde değişmektedir.

IV. TARTIŞMA

Hedeflerin önceliklerini belirleyerek ve öncelik sırasına göre kaynakları elde edilir. Bir veri doğrulama süreci oluşturarak verileri periyodik olarak doğrulanır. Proje ekibini kaynak tahsisini düzenlemek için yetkilendirilebilir. Her bir kaynağın becerileri ve yetkinlikleri doğrultusunda uygun görevlere atanması sağlanır.

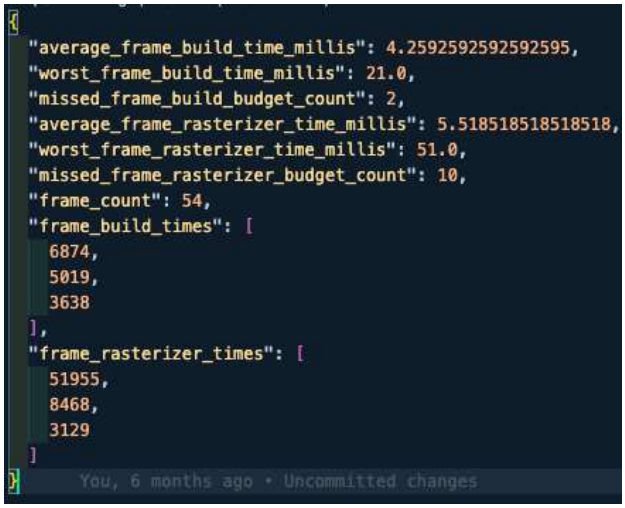
Eksik verilerin nerede olduğunu tespit etmek için veri setinizi analiz edilir. Eksik verileri tamamlamak için uygun veri toplama yöntemleri kullanılır. Veri giriş sürecinde, veri doğrulama kontrolleri uygulanır. Bu kontroller, hatalı veya tutarsız veri girişlerini tespit etmek için kullanılır. Hatalı veri girişinin nedenlerini tespit etmek için geriye dönük denetimler yapılır. Bu şekilde, hatalı veri girişlerinin tekrarlanmasını önlenebilir.

Hata raporlama mekanizması oluşturularak ve kullanıcıların hataları bildirebilmeleri için geri bildirim kanalları açık tutulacaktır. Uyumluluk testleri farklı platformlar ve cihazlar üzerinde yapılacak ve uyumsuzluklar tespit edilecektir. Performans testleri düzenli olarak yapılacak ve uygulamanın kaynak kullanımı, yanıt süreleri vb. performans metrikleri izlenecektir.

V. SONUÇLAR

1- Worstcase içeren Performans Test Sonuçları

Performans testi uygulama hakkkında ayrıntılı bilgiler içeren bir json dosyası kaydeder. Yazılım test ile belirli bir öğenin görüntülenmesini sağlayarak öğeler listesinde gezinen bir işlev sağlar. Bu işlev tamamlandığında kullanılan metod test senaryolarının detaylı bir şekilde raporlanmasını sağlar.



TEŞEKKÜR

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Towards Smart Cooking Technologies: Machine Detection of Onion Burn During Cooking

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Abstract – The rapid development of technology makes human life easier in many ways. Especially in the last century, the fact that many operations were carried out by machines eased the workload of people. However, technology is constantly advancing, and thanks to smart machines, many operations can now be performed unmanned, making human life even easier. One of the prominent innovations among these technological advances is "electronic nose" devices. These devices can detect certain events or situations by detecting the odours taught to them, and appropriate interventions are made by the machines in line with this information. Thus, advanced detection and intervention systems make daily life even simpler and more comfortable. In this study; Using the electronic nose developed with 11 gas sensors, the doneness of the onion was detected while cooking. Onion odours such as "cooking", "about to burn" and "burnt" were taught to the system, and then measured by using test data how accurately the system could detect these odours. The prepared system can perform this distinction with 92.15% accuracy using Random Forest Classification Algorithm. Robots that cook the meals themselves are not far away from humanity today.

Keywords – Gas sensors, electronic nose, classification, onion burn, burn detection

I. INTRODUCTION

With developing technology, odours can be learned and recognized by devices called electronic noses (e-noses). These devices consists of basically; an odour chamber containing gas sensors, a circuit that operates these sensors, a card that converts the electrical data obtained from the sensors to digital, and a computer system that learns and then recognizes this data through machine learning [1]. In the last 30 years, electronic noses have been made by many scientists and studies have been carried out with them in almost every field of human life. In the field of health; diagnosis of many diseases such as respiratory system diseases [2,3], lung diseases [4,5], diabetes [6,7] and heart diseases [8,9] has been done through the electronic nose from the breath. Environmental practices such as farming by scent were monitored [10,11]. It has also been used in the cosmetic industry [12,13]. A lot of work has been done in the food industry. In the food industry, electronic noses (e-noses) can be used to determine the quality or aroma of various foods such as tomatoes [14], peaches [15], and beverages like fruit juice [16], wine [17], and tea [18]. Additionally, numerous studies in the literature have employed e-noses to assess the shelf life of milk [19] and the species or freshness of foods like fish [20], peaches [21], and eggs [22]. Regarding onion, spoilage and rot infection of onion was studied with e-nose [23,24].

In this study, the doneness of the onion was determined using an electronic nose while cooking. "Cooking", "about to burn" and "burnt" onion odours were introduced to the electronic nose developed

with 11 gas sensors. The electronic nose system was able to detect these conditions with 92.15% accuracy using the Random Forest Classification Algorithm.

II. PERFORMED STUDY

In this study, the electronic nose used to detect onion odors was made with 11 gas sensors. These 11 gas sensors and the target gases they detect are given in Table 1.

Table 1. List of sensors

No	Sensor's Name	Sensed Gas
1	MQ-2	Butane, Methane, LPG, Smoke
2	MQ-3	Ethanol, Alcohol, Smoke
3	MQ-4	CNG Gas, Methane
4	MQ-5	Natural Gas, LPG
5	MQ-6	LPG, Butane Gas
6	MQ-7	Carbon Monoxide
7	MQ-8	Hydrogen Gas
8	MQ-9	Carbon Monoxide, Flammable Gasses
9	MQ-131	Ozone
10	MQ-135	Air Quality (CO, Benzene, Ammonia, Alcohol, Smoke)
11	MQ-137	Ammonia

In this study, MQ gas sensors were utilized along with their kits. These sensors were mounted on a 6x10 cm board to form a sensor array. Figure 1 shows the constructed electronic nose system. Here, the sensor array was put inside the storage container depicted in the figure, and the cables were routed through an airtight hole. The sensors were powered by a power supply, and their analog outputs were connected to the analog inputs of two Arduino Uno boards. The electrical signals emitted by the sensors were digitized by the Arduinos. Than, the data were transmitted to the computer by USB port.

Figure 1. Customized electronic nose system

Data from the sensors were captured using a data collection program created in LabView. When the onion placed in the sample box was cooked and burned, the presence and amount of the relevant gases in

its odour were sensed and recorded by the relevant sensors. Figure 2. shows the images of the 3 types of onions used in the study.

onion while cooking | onion starting to burn | burnt onion

Figure 2. Stages of onion used in the study

A total of 63 records obtained from different onion cooking were included in the research. In the study, 21 onion smell during cooking, 20 freshly burnt onion smell, and 22 burnt onion smell were used getting different times in 5 days under conditions of 60%-70% humidity and 22-25 oC temperature. The recording duration was set to 60 seconds, with each sensor collecting 10 data points per second. During each sniffing cycle, 11x601 data were captured, producing a 3-dimensional matrix with dimensions of 63x11x601 at the end of the study.

While extracting the attributes of this data in the classification algorithm, 3 statistical methods given below were applied.

$$x_{mean} = \sum_{x=1}^{s} \frac{x_1 + x_2 + \cdots + x_s}{s} \quad (1)$$

$$x_{std} = \sqrt{\frac{(x_1 - x_{mean})^2 + \cdots + (x_s - x_{mean})^2}{s-1}} \quad (2)$$

$$x_{sum} = x_1 + x_2 + \ldots + x_s \quad (3)$$

Following the extraction of attributes from the sensor-obtained data, the dataset was split into for training-validation- testing clusters as 60-20-20% randomly. In this way, classification was made with the classifiers given below. In order to increase the reliability of the performance of the classifiers, classifications were made repeatedly with 100 different training-validation-test sets randomly selected from the data. The averages of the accuracy-sensitivity-specificity scores obtained as a result of these 100 different classification processes were calculated and are given in Table 2 below.

Table 2. Classification Results According to Classifiers

	Accuracy (%)	Sensitivity (%)	Specificity (%)
Random Forest	92.15	92.23	93.54
Gradient Boosting	88.00	88.08	90.72
Decision Tree	85.00	85.13	87.91
kNN-3	72.54	73.05	75.22

The frequency of use of the features used by the Random Forest classification algorithm in 100 classifications for different training-validation-test sets is shown in percentage form in Figure 3. Features and frequency of use in percentage are listed in Table 3.

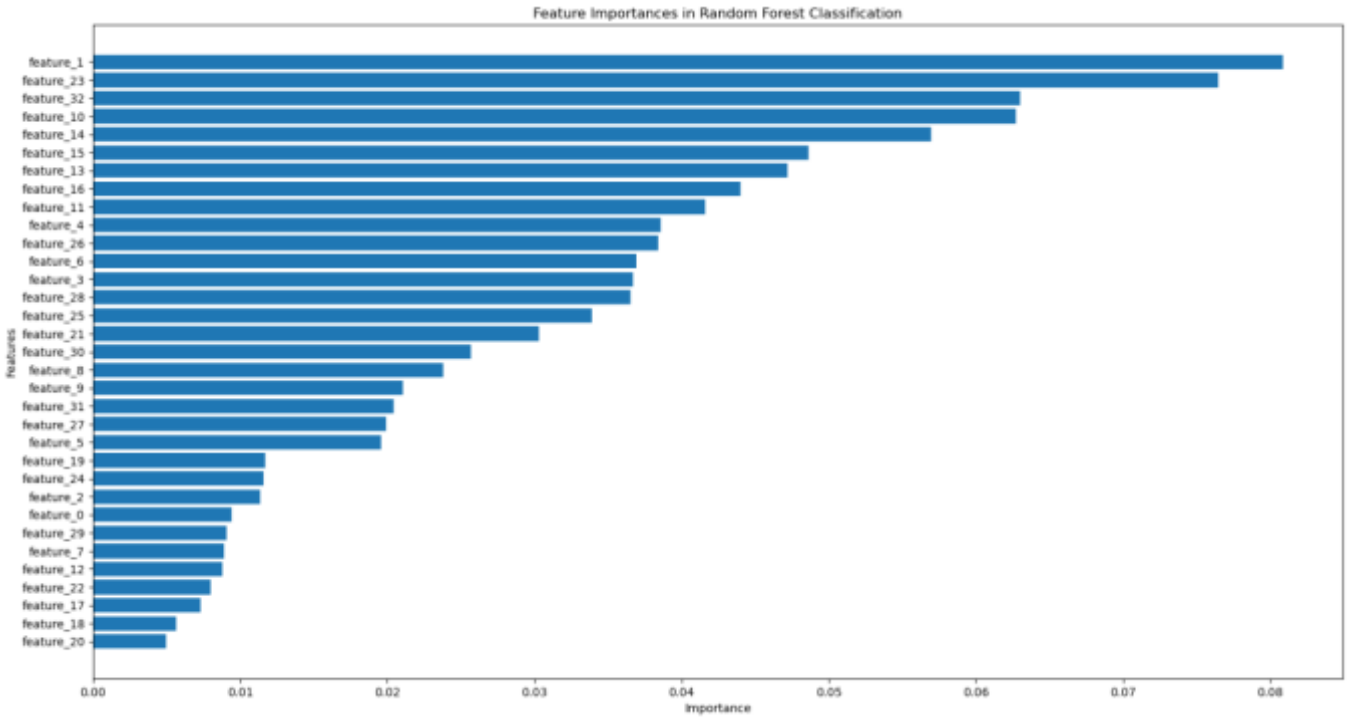

Figure 3. Feature Importance in Random Forest Classification

Table 3. Features and Percentage of Usage Frequency

Sensor\Method	Mean	%	Std	%	Sum	%
MQ-2	Feature 0	0,8075	Feature 1	8,1609	Feature 2	1,2024
MQ-3	Feature 3	3,8012	Feature 4	3,6747	Feature 5	2,1454
MQ-4	Feature 6	3,7514	Feature 7	0,8591	Feature 8	2,2863
MQ-5	Feature 9	1,846	Feature 10	6,4624	Feature 11	4,1838
MQ-6	Feature 12	0,8092	Feature 13	4,4509	Feature 14	5,589
MQ-7	Feature 15	4,4805	Feature 16	4,2044	Feature 17	0,7082
MQ-8	Feature 18	0,6169	Feature 19	1,2225	Feature 20	0,5808
MQ-9	Feature 21	3,3942	Feature 22	0,8774	Feature 23	8,0422
MQ-131	Feature 24	1,168	Feature 25	3,7427	Feature 26	3,8274
MQ-135	Feature 27	2,0972	Feature 28	3,6443	Feature 29	0,8555
MQ-137	Feature 30	2,2202	Feature 31	1,7857	Feature 32	6,5016

In the classification process; 100 different training, validation and test clusters were formed to avert the possibility of obtaining high success by selecting appropriate data accidentally. An average of 92.15 %

CA (classification accuracy), 92.23 % SE (sensitivity) and 93.54 % SF (specificity) success was obtained at the end of 100 cycles. The 5 most effective features are Feature 1, Feature 23, Feature 32, Feature 10 and Feature 14, respectively. These features are extracted from the data of MQ-2, MQ-9, MQ-137, MQ-5 and MQ-6 sensors.

III. CONCLUSION

In this study, an electronic nose with 11 metal oxide gas sensors was used to determine the burning level of onions during cooking. For this purpose, a total of 63 odor records were taken for 3 different conditions of the onion. Then, the recorded data was randomly selected as training data (60%), validation data (20%), and test data (20%). In the classification model; firstly the algorithm was trained by the training, than the hyperparameter settings were adjusted by using the validation set, and finally the generalization performance of the model was evaluated by the test set. The average classification success was found to be 92.15% after 100 different classifications performed.

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Küreselleşme Sürecinin Demokrasi Üzerine Etkisine Yönelik Bir Değerlendirme

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Özet – 1980'lerin sonu, 1990'ların başına damgasını vuran yeni bir gelişme trendi küreselleşme kavramı dünyada büyük bir değişim süreci başlatmıştır. Bu değişim ekonomi başta olmak üzere siyasi, sosyal, kültürel alanı derinden etkilemiştir. Küreselleşmenin çok boyutlu etkisi demokrasi sisteminde de kendini göstermiş ve bu değişim sürecinde demokrasi payına düşeni almıştır. Küreselleşmenin demokrasiye etkisinin olumlu olup olmadığı tartışma konusudur. Bu çalışmada "küreselleşme demokrasi için bir fırsat mıdır yoksa tehdit midir?" sorusuna cevap aranmaya çalışılmıştır.

Anahtar Kelimeler – Demokrasi, Yönetim, Küreselleşme, Globalleşme, Değişim,

I. GİRİŞ

Günümüzde küreselleşme ve demokrasinin birbiriyle ilişkili kavramlar olduğuna şahit olmaktayız. Küreselleşmenin demokrasiye nasıl bir yön verdiğini incelemeden önce demokrasinin ne gibi aşamalar geçirdiğini açıklamak konuyu kavramamıza yardımcı olacaktır. Huntington demokratikleşme dalgalarını üçe ayırmaktadır: 1828-1926 tarihleri birinci dalgayı, 1943-1962 tarihleri ikinci dalgayı, 1974'ten sonrası üçüncü dalgayı oluşturmaktadır. II. Dünya savaşı sonrası uygulanan Keynesyen iktisat politikaları demokratikleşme sürecini hızlandırırken, 1973 ekonomik krizi ise demokratikleşmede ters dalga etkisi yapmıştır. Yani otoriter rejimlere geri dönüşler yaşanmıştır (Huntington, 2011: 27-82). Küreselleşmenin etkisinin hissedildiği 1990'lı yıllarda demokratikleşme süreci tekrar hızlanmıştır. Ancak bu süreçte demokrasinin temel ilkeleri olan özgürlük, eşitlik, halk egemenliği, çatışma, uzlaşma, katılım, işlevsel demokrasi gibi kavramların büyük çapta ihlal edildiği gözlenmiştir. Küreselleşme sürecinin demokratikleşme üzerindeki etkisinin ele alınacağı bu çalışmanın ilk bölümünde, küreselleşme kavramından, küreselleşme sürecinden ve bu kavramın tarihsel boyutundan bahsedilecektir.ikinci bölümde; demokrasi kavramı üzerinde durulacak ve bu kavram, türleri ve değerleri yönüyle ele alınacaktır.Son bölümde ise çalışmamızın esas konusunu oluşturan küreselleşmenin demokrasi üzerindeki etkisi ve bunun eleştirel boyutu tartışılacaktır.

II. GENEL OLARAK KÜRESELLEŞME: TANIMI, ORTAYA ÇIKIŞI, TARİHÇESİ

Küreselleşme herkesin tek bir dünyada yaşaması gerektiğini ortaya atan bir kavramdır (Giddens, 2000: 20). Aynı zamanda küreselleşme, ekonomi, sanayi, tarım, iletişim, sanayi, teknoloji ve kültür hayatını içine alıp bu alanlarda yaşanan değişim ve dönüşümleri konu edinmektedir (Timur, 2000: 20).

Küreselleşmeyi subjektif ölçütler dikkate alarak tanımlamak da mümkündür. Buna göre küreselleşme, dünyanın, ekonomik, siyasi ve teknolojik güçler tarafından sosyal ilişkilerin mesafe ve sınırların kısıtlamalarına bağımlılığının azaldığı bir sosyal alana dönüştüğü hissini ve bir bölgedeki değişiklik ve olayların diğer bölgelerdeki insanların ve toplumların yaşamı üzerinde önemli değişikliklere yol açtığı görüşünü yansıtır. Başka bir ifadeyle, küreselleşme günümüzdeki ekonomik ve sosyal değişimlerin ulus

devlet ve bireylerin kontrolü dışındaki değişiklikleri kapsayan kronik bir güvensizlik ve siyasi bir kadercilik hissi ile ilişkili bir kavramdır (Held v.d., 1999: 1).

Özetle, bugün dünya neyi tartışıyor? Sorusuna küreselleşme olarak cevap verebiliriz. Çünkü küreselleşme kavramı 21. yüzyılın bir mitolojisidir (Taşkın, 2011: 1). Timur'a göre; küreselleşme sözcüğü kendine bir yandan tutkulu yandaşlar öte yandan da alerjik karşıtlar yaratmıştır (Timur, 2000: 7). Bir başka ifadeyle; küreselleşme için hem lehte hem de aleyhte olan görüşlere rastlanmaktadır.

Giddens, küreselleşme ile ister iyi isterse kötü olsun, hiç kimsenin tam olarak anlayamadığı, ama etkisini hepimizin hissettirdiği bir küresel düzene doğru sürüklenmekte olduğumuzu ifade etmektedir. Küreselleşme konusunda farklı düşünürler zıt fikirlerle karşımıza çıkmaktadır. Giddens, bunları şüpheciler ve radikaller olarak ikiye ayırmaktadır. Şüpheciler: küreselleşmenin önceki dönemden farklı olmadığını dünyanın eskisi gibi döndüğünü savunmaktadırlar. Radikallere göre ise küreselleşme; gerçek bir olgudur ve etkisi her yerde hissedilmektedir. Bunun gerekçesi olarak da ulusların egemenliklerini kaybettikleri, siyasetçilerin ise yaptırım güçlerini yitirdiklerini iddia etmektedirler (Giddens, 2000: 20-21).

Küreselleşme taraftarları, küreselleşmeyi özgürleştirici bir güç olarak görürler ve herkese hayallerini gerçekleştirebilmek için daha fazla fırsat ve tercih hakkı sağlayan bir süreç olarak bakarlar. Küreselleşme mobiliteyi, esneklik ve uyumu, değişim kapasitesini ve bağlantıları artırır. Küreselleşme, üretimin uluslararasılaşmasını, sermayenin daha fazla mobil hale gelmesini, güneyden kuzeye göç hareketlerini, rekabetin küresel düzeyde artmasını, devletlerin küreselleşen dünyanın birer aracı haline gelmesini içerir ve dünyayı daha fazla bağlantı ve sosyal ilişkiye sahip olan küresel bir köye dönüştürür. Bu görüşe göre globalleşme, ekonomik kararların gittikçe artan oranlarda devletin kontrolü dışında alınabilmesini sağlayan ve tüm dünyayı global düzeyde ve kalitedeki ürünlerin piyasası haline dönüştüren bir süreçtir. Şüpheci ve kötümser görüşler ise küreselleşmeyi kültürlerin tekdüzeleşmesi ve siyasi özerkliklerin ortadan kalkmasına yol açan bir süreç olarak algılar. Bu çerçevede, globalleşme Batı kaynaklı ve özellikle ABD'den gelen bilgi ve bireycilik, materyalizm, tüketim kültürü ve sekülerleşme gibi değerleri dünyanın her yanına yayar. Sonuçta global kültür gittikçe artan bir düzeyde Batı ya da Amerikan kültürü haline gelir ve kültürel emperyalizm ortaya çıkar. Bu açıdan bakıldığında küreselleşme Üçüncü Dünyanın uzun yıllardır içinde bulunduğu ve kolonileştirme olarak adlandırılan sürecin günümüzde moda haline gelen karşılığından başka bir şey değildir. Kötümserlere göre küreselleşme yerel kültürlerin tahribine, farklı kimliklerin ve değerlerin yok olmasına, ulus devletlerin gücünün azalmasına, zengin ve yoksul arasındaki uçurumun artmasına ve eko-sistemlerin yok olmasına yol açan bir süreçtir (Aktan ve Vural, 2003: 7).

Görüldüğü gibi küreselleşme çemberine her alan dahil olmak durumunda kalmıştır. Bu durum, küreselleşmenin çok boyutlu bir süreç olma özelliğini karşımıza çıkarmaktadır. Ürünlerin değişimi, ticaretin gelişmesi, bilimin ilerlemesi, bilgi ve teknolojilerin uygulanması ve yeni metotların geliştirilmesi, bilginin hızla yayılması küreselleşmenin ilk aşamalarını oluştururken; İnternet, 24 saat anlık haber veren merkezler, büyük ekonomik şirketler, iletişim ve ulaşım sisteminin gelişmesi, şimdiye kadar benzeriyle karşılaşmadığımız uluslararası aktörler, bizi, küreselleşmenin gelişmeye başladığı süreçten daha farklı bir aşamaya götürmektedir (Hebron ve Stack, 2008: 2).

Küreselleşmeyi ortaya çıkaran en önemli faktör mal ve sermaye hareketlerinin hızlanması sonucu kar elde etme faaliyetlerinin artması olmuştur. Şirketler bu amaçla yola koyulmuş ve teknolojinin gelişmesinden de yararlanarak ticaret ve yatırım faaliyetlerini uluslararası alanlara yaymaya çalışmışlardır (Somel, 2011: 196-197). Dolayısıyla da her seferinde küreselleşmenin siyaset, kültür vs. alanındaki dönüşümlerine vurgu yapılsa da küreselleşmeye yön veren pusula esasen iktisadi konular olmuştur (Timur, 2000: 8).

1980'li ve 1990'lı yıllar dünyanın yeniden biçimlendiği ve bu yeni biçimin 21.yüzyıla da şekil verdiği zaman dilimidir. İki kutuplu sistemin var olduğu dünya, Sovyetler Birliği'nin dağılmasına mütakiben tek kutuplu bir yapıya dönüşmüş ve bunun öncülüğünü Amerika Birleşik Devletleri

üstlenmiştir (Özkul ve Akça, 2007: 83). Dolayısıyla tarihsel süreci siyasal açıdan değerlendirecek olursak; küreselleşen dünyada, uluslararası boyutta egemen güç Amerika Birleşik Devletleri olmuştur. Amerika Birleşik Devletleri, askeri gücüne dayanarak ilerleyen ve aynı zamanda bu ilerleme sürecinde dünyayı da arkasına alan bir başka deyişle onlara şekil veren bir ülke konumuna gelmiştir (Şaylan, 2003: 216).

III. DEMOKRASİ KAVRAMI

Demokrasi kelime olarak Yunanca "kratos" kelimesinden gelmektedir, anlamsal olarak ise "demos tarafından yönetim" yani halk tarafından yönetimi ifade etmektedir. Demokrasi kavramı 19. Yüzyılın "ayak takımının yönetimi" olarak ifade edilmekteyken, 20. yüzyılda ise ideal bir yönetim biçimine dönüşmüştür (Heywood, 2012: 101-102).

Tarihsel süreç içerisinde demokrasiye farklı anlamlar yüklenmiş ve bu kavram çeşitli türlere ayrılmıştır. Demokrasi anlamsal olarak; batı toplumlarında genel oy ve rekabete dayalı seçimlerin yapıldığı bir sistemdir, bu durumdan farklı olarak bazen de "liberal demokrasi" olarak açıklanmaya çalışılır (Heywood, 2012: 106). Yeni dünya düzeni adı altında küreselleşen çağ liberal demokrasi ideolojisine vurgu yapmaktadır. Liberal demokrasi, ulus devlet içerisinde gelişmiştir. Ulusa ait bireyler demokratik siyasal sistemde temsilciler seçmişler ve bu temsilciler halk adına siyasal gücü kullanmışlardır. Yani demokratikleşme süreci, sınırlı bir alanda temsil, seçim, genel ve eşit oy vb. ilkelere bağlı olarak varlığını sürdürmüştür (Şaylan, 2008: 394-397).

Demokrasi için gerekli unsurlar hususu da önem arz etmektedir. En başta, demokrasi için ilk ve vazgeçilmez koşul "siyasal özgürlükler"in mevcut olmasıdır. Demokrasi için gerekli ikinci en önemli unsur "hukuk devleti"dir. Hukuk devleti aynı zamanda iktidarın sınırlandırılmasını gerektirdiğinden demokrasi için gerekli üçüncü koşul "iktidarın sınırlandırılması"dır. Yine hukuk devleti ve iktidarın sınırlandırılması ile yakından alakalı olan ve demokrasi için gerekli dördüncü unsur ise "kuvvetler ayrılığı"dır. Demokrasi için gerekli olan beşinci unsur ise kamu yönetiminde "şeffaflık"tır. Çünkü demokrasi açık bir toplum düzenidir. Demokrasi için din ve devlet işlerinin birbirinden mutlaka ayrı olması gerekmektedir. Bu nedenle "laiklik" demokrasi için gerekli bir diğer unsurdur. Bir toplumda mevcut olan kültür, değer yargıları ve ahlak da demokrasi için önem arz etmektedir. Bu anlamda "demokrasi kültürü"nün oluşması demokrasi için gereken yedinci unsurdur. Son olarak demokrasinin oluşması ve kurumsallaşması için sivil toplumun güçlü ve etkin olması gerektiğinden, demokrasi için gerekli son unsur "sivil toplum"dur (Aktan, 2010: 20-22).

Demokrasi türleri ise en genel şekliyle; doğrudan demokrasi, temsili demokrasi, katılımcı demokrasi olarak üçe ayrılır. Bu türler, birçok kaynakta anlamsal olarak aynı şeyleri ifade etmekle beraber farklı isimlerle de adlandırılmaktadır. Örneğin, Heywood demokrasiyi "klasik demokrasi", "koruyucu demokrasi", "gelişmeci demokrasi" ve "halk demokrasisi" olmak üzere dörde ayırmaktadır (Heywood, 2012: 107-112):

- *Klasik demokrasi:* Eski Yunan'daki Atina yönetiminde uygulanan bir sistemdir. kitle toplantılarıyla yani halkın doğrudan yönetime katılabileceği ortamların oluşturulduğu yönetim biçimidir.
- *Koruyucu demokrasi:* Birey demokrasi kavramını kendini hükümetin ani saldırılarından korumak amacıyla kullanmıştır.
- *Gelişmeci demokrasi:* Bu teorinin amacı birey ve topluluğun gelişmesine katkı sağlamaktır ve bunu geliştirmek içinde bir takım yeni değerler ortaya atılmıştır.
- *Halk demokrasisi:* Bu kavram komünist rejimler tarafından ortaya atılmıştır. Marx'ın öncülüğündeki bu sistem liberal demokrasiye karşı çıkar ve sosyal demokrasiyi savunur.

Demokrasi özünde bireyi seyirci konumundan alıp sahneye koyan ve ona aktörlük rolü veren değerler sistemidir. Bir başka deyişle birey, nesne konumundan yani etkilenmekten (yönetilmekten), özne konumuna (yönetmek) geçiş yapmıştır. Demokrasi, bireye önem vermenin yanında bir sistemi

oluşturmaktadır. Bu sistemi güçlendirecek olan hususlar hakkında da çok sayıda görüş ileri sürülmüştür. Bu konuda Huntington'ın ortaya attığı, demokrasiye katkıda bulunan değişkenlerden bazıları şunlardır (Huntington, 2011: 51-52): "Yüksek bir ekonomik refah düzeyi", "piyasa ekonomisi", "güçlü bir burjuvazi", "yüksek eğitim düzeyi", "sosyal çoğulculuk", "siyasetle ilgili olan sosyal gruplar" ve "demokrasiye bağlı siyasal liderler" (Huntington, 2011: 51-52).

Son olarak kanaatimizce her ne kadar yüzyıllar boyunca adeta kutsallaştırılan demokrasinin uğruna verilen eşsiz ve değerli mücadeleler küçümsenmeyecek kadar büyük olsa da ne yazık ki insanlık halen kelimenin gerçek değerine yakın bir siyasal rejim ile tanışabilmiş değildir. Demokrasi birçok unsurdan ("eksik enformasyon", "siyasal bilgisizlik", "siyasal ilgisizlik" vs.) dolayı imkansızdır. Bu noktada Aktan'ın şu görüşlerinin önemini vurgulamak gerekmektedir (Aktan, 2017: 8):

"Modern demokrasilerde ilgisiz ve bilgisiz seçmenlerin iradesini yansıtan ve çıkar gruplarının hakimiyetine dayalı, iktidarın güç ve yetkilerinin etkin bir biçimde sınırlandırılmadığı bir siyasal yönetim hüküm sürmektedir. Demokrasi kelimesine daha fazla tapmak yerine bu kelimenin gerçek manasını kavramak ve uygulamadaki eksikliklerini ortaya koymak gereklidir."

IV. KÜRESELLEŞME VE DEMOKRASİ İLİŞKİSİ

Kişilerin, örgütlü topluluk ve kuruluşların yönetime mümkün olan en üst düzeyde katılması olarak tanımlanabilecek demokrasi gittikçe artan oranda modern yönetim tarzı ve meşru yönetim şekli haline gelmekte ve tüm dünyada yaygınlaşmaktadır. Küreselleşen dünyada demokrasi konusunda iki önemli gelişmeden bahsedilebilir (Baylis ve Smith, 1997:26):

1. Küreselleşme, demokrasiyi geliştirecek olanaklar ortaya koymaktadır. Egemenliğe aşırı vurgu yapan yönetim anlayışında egemenlik devredilemez, kapsamlı, üstün, sorgulanamaz ve toplumu oluşturan herkese açık olmayan bir yapı varken demokrasi genel olarak kısıtlı, dağıtılmış, koşullara bağlı ve kolektif bir yetki ve güce dayanır. Hükümetler seçimle işbaşına gelseler bile gücün bir ya da birkaç elde toplanması söz konusu olabilir. Bu nedenle küreselleşme sürecinde egemenlik anlayışındaki değişme ve egemenliğin ulus devlet, yerel yönetimler, ulus üstü yönetimler, piyasa güçleri ve hükümet dışı örgütler arasında dağılmaya başlanması demokrasinin gelişmesi olanaklarını artırabilir.

2. Küreselleşme, küresel yönetim tarzlarını demokratik eksikliklerden kurtaramamaktadır: devletler, küresel yönetim kurumları, piyasa ve küresel sosyal hareketler halkın katılımı ve erişim, danışma ve müzakere, herkesi kapsama ve temsil ve anayasallık ve hesap verilebilirlik açılarından yetersizliklere sahiptir.

Habermas'a göre dünya ticareti, çok milletli ortaklıklar, yeni medya, yeni iletişim, yeni kültür biçimleri, iktisat ve kültür alanları arasında sınırların ortadan kalkması gibi yapılanmalar küreselleşme adı altında ortaya çıkmıştır. Böyle bir ortamda demokraside kendi payına düşeni almıştır. Ulusal boyuttan uluslararası boyuta geçilmesiyle birlikte demokrasinin değer ve düşünceleri etkisiz bir hale bürünmüştür. Çünkü devlet, dünyadaki iktisadi sistemin ve toplumun karşılıklı bağımlılığı arasında kalmış ve demokratik değerlerini, özerkliğini, yeteneğini yitirmeye başlamıştır. Piyasa ekonomisine geçilmesiyle beraber, mal ve sermaye sınır ötesine ulaşmış, uluslararası şirketler güçlenmiş, sermaye küreselleşmiş, ulusal ölçekte etkisini sürdüren parlamentolar prestij kaybetmiştir. Kısacası, para, siyasal yaptırımın yerini almıştır (Habermas, 2008: 24-25).

Küreselleşme bir taraftan demokrasinin aktörlerini pasifleştirirken, diğer tarfatanda yeni muhalif grupların ve sosyal hareketlerin oluşmasına da zemin hazırlamıştır. Sivil toplum örgütlerinin etkin olmaya başlamasıyla birey karar almanın her sürecinde yer almaya başlamıştır.yine son dönemde de etkisini gördüğümüz sosyal medyanın alt yapısını küreselleşme oluşturmuştur diyebiliriz. Günümüzde kamuoyunda ve yönetimde en etkin faktör olan bu sosyal hareketler sayesinde birey kurum veya kuruluşlar her konuda doğrudan görüş, öneri elde etme fırsatı yakalamışlardır (Tuncel, 2010: 499).

Eklemek gerekirse, küreselleşme, geleneksel yönetim sürecini köklü bir değişime uğratmıştır. Devlet, toplum ve iktisat bir arada gelişmiştir. Geçmişte ticari ilişkileri devlet kontrol ederken, şimdi küresel ilişkiler devletleri pazarların içine yerleştirmiştir (Anderson, 2004: 78).

Ekonominin gelişmesi ve haberleşmenin hızlanmasıyla birlikte, ülkelerin birbiriyle etkileşimi artmıştır. Ancak, dünyanın bir kısmı demokratik, bir kısmı yarı demokratik, diğer bir kısmı ise otoriter olarak varlığını sürdürmektedir. Dolayısıyla da küreselleşme ile ortaya çıkan yeni dünya düzeni insanlığa birçok fırsat sunarken, eşitsizlikler de hızla artmaya devam etmiştir.

Küreselleşme ile birlikte artan iletişim ve bilişim teknolojileri yalnızca demokrasi ile yönetilen ülkelerin sayılarını arttırmakla kalmayıp, mevcut demokrasi ile yönetilen ülkelerin demokrasi standartlarının da yükseltilmesine de olanak sağlamaktadır. İletişim teknolojilerinde başta internetin yaygın olarak sosyal hayatta yer almasıyla birlikte bazı kamu hizmetleri internet üzerinden verilmeye başlanmıştır. Bu yeni süreç aynı zamanda işlem maliyetlerini ve kırtasiyeciliği azaltmakta, halkın yönetime doğrudan ulaşabilmesi gayesi ile siyasal katılımın artırılmasına ve demokrasinin imkan sağlanmaktadır (Erdağ ve Peker, 2014: 217).

Küreselleşmenin demokrasi üzerindeki etkilerini kısaca şu başlıklar altında değerlendirmek mümkündür:

Küreselleşmenin Demokrasi Üzerindeki Olumlu Etkileri

- *Bilgi Erişimi ve Haberleşme:* İnternet ve diğer iletişim teknolojileri sayesinde bireyler daha fazla bilgiye ve farklı düşüncelere erişebilirler. Bu, demokratik katılımın artmasına ve bilinçlenmiş bir seçmen kitlesine yol açabilir.
- *İnsan Hakları ve Hukukun Üstünlüğü:* Küresel normlar ve uluslararası hukuk, demokrasiyi destekleyen insan haklarının ve hukukun üstünlüğünün yayılmasına katkıda bulunabilir.
- *Ekonomik Gelişim:* Serbest ticaret ve yatırımın artması ekonomik büyümeyi teşvik edebilir ve bu da demokrasinin sürdürülebilirliğine katkıda bulunabilir.

Küreselleşmenin Demokrasi Üzerindeki Olumsuz Etkileri

- *Eşitsizliklerin Derinleşmesi:* Küresel ekonomik entegrasyon, gelir eşitsizliklerini artırabilir ve bu da demokratik süreçlere olan güveni azaltabilir.
- *Demokratik Hesap Verebilirlik Zorlukları:* Küresel şirketler ve uluslararası kuruluşlar, ulusal demokratik süreçleri etkileyebilir ve bu da yerel halkın demokratik karar alma süreçlerine olan güvenini zedeleyebilir.
- *Kültürel Homojenizasyon Tehlikesi:* Küresel medya ve kültürel etkileşimler, yerel kültürel çeşitliliği azaltabilir ve demokratik süreçler üzerinde standartlaşmış bir etki yaratabilir.

V. SONUÇ VE DEĞERLENDİRME

Küreselleşme, ekonomik, sosyal, kültürel ve siyasi alanlarda dünyanın farklı bölgeleri arasındaki etkileşimi artıran bir süreç olarak tanımlanabilir. İletişim teknolojilerindeki ilerlemeler, sermaye hareketliliğindeki artış, ticaretin serbestleştirilmesi gibi faktörler küreselleşmeyi tetiklemiştir. Bu süreç, ulusal sınırların ötesindeki bağlantıları ve etkileşimleri artırarak dünya üzerinde birçok alanda derin değişimlere yol açmıştır. Küreselleşmenin demokrasi üzerindeki etkileri, genellikle karmaşıktır ve birden fazla faktöre bağlıdır. Küreselleşmenin demokrasiyi güçlendirici ya da zayıflatıcı etkileri olabilir. Ancak, demokrasinin sürdürülebilirliği için önemli olan nokta, demokratik kurumların güçlendirilmesi, katılımın teşvik edilmesi ve demokratik değerlerin korunmasıdır. Küreselleşmenin getirdiği zorluklara rağmen, demokrasinin güçlenmesi için ulusal ve uluslararası düzeyde çaba sarf edilmesi gerekmektedir.

Hiç şüphesiz küreselleşme, ekonomik, siyasal, sosyal ve kültürel alanı şemsiyesi altına alarak, demokratik sistemin işleyişini derinden etkilemiştir. Bu etki, her dönem aynı çizgide ilerlememiş, inişli çıkışlı bir yol izlemiştir. Çalışmanın bulgularından anlaşılacağı üzere, küreselleşmenin demokrasinin gelişmesine olumlu bir etkide bulunduğunu söylemek pek mümkün değildir. Küreselleşmeyle birlikte demokrasinin aktörleri (siyasi partiler, parlamento, ideoloji…) geri plana itilmiş ve buna ek olarak; demokrasinin temel değerleri (özgürlük, eşitlik, katılım, çatışma, uzlaşma) sınırlandırılmıştır. Bu bağlamda, küreselleşmenin etkisiyle demokrasi de krizler meydana gelmekte ve ülkeler arasında demokrasi açıkları ortaya çıkmaktadır. Sonuç olarak uluslararası arenada ülkeler karşılaştırıldığı zaman, demokrasi düşüncesi açısından, küreselleşmeyle oluşan uçurumlar daha da belirgin bir hal almaktadır. Büyük dönüşümler yaşamak zorunda kalan bu toplumların büyük bir çatışmaya doğru sürükleneceği de akıldan çıkarılmamalıdır.

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Analyses of X-Ray Diffraction and Hirshfeld Surface of complex (di-aqua) bis (pyridine-3-carboxamide) di (2 nitrobenzoato) zinc(II) monohydrate

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Abstract – This study involves elucidating the structure of a Zinc II metal derivative complex named (di-aqua) bis (pyridine-3-carboxamide) di (2-nitrobenzoato) zinc(II) monohydrate ($C_{26}H_{28}N_6O_{14}Zn$). These types of compounds are used in a variety of scientific and industrial applications, including the pharmaceutical industry, materials science and chemical research. A single crystal of the complex was meticulously prepared and mounted in the diffractometer for X-ray diffraction (XRD) analysis. Thanks to meticulous analysis, the structure was successfully solved and refined using the resulting diffraction data. Following these steps, precise geometric parameters of the structure were calculated using advanced software tools and methodologies. The cif (crystallographic information file) prepared for the Hirshfeld surface (HS) analysis of the structure was also used in the CrystalExplorer program.

This crystal ($C_{26}H_{28}N_6O_{14}Zn$) crystallizes in the monoclinic crystal system. Unit cell parameters are a= 7.8521 (5) Å, b= 19.2940 (13) Å, c= 11.3164 (7) Å, α=90°, β = 120.456 (4)°, γ=90°, and Z=2 in the $P2_1/c$ space group. It has an octahedral geometry and hexacoordination. In the complex, there are strong O–H…O, N–H…O and C–H…O hydrogen bonds, and thanks to these intramolecular and intermolecular bonds, a three-dimensional (3D) crystal structure is formed. Hirshfeld surface (HS) analysis reveals that the main contributions to crystal packing come from O···H (42.2%), H···H (25.9%), C···H (16.6%) and C···C (5.2%) interactions.

This study, in addition to the existing knowledge in the literature, provides new information about the structural properties of the complex.

Keywords – X ray diffraction analysis, Zinc(II) complex, Crystal structure, Hydrogen bonds, Hirshfeld surface analysis

I. INTRODUCTION

Zinc is an important element found in the human body and acts as a catalyst in enzymes that are vital for DNA synthesis and repair [1], [2], [3], [4]. Zinc also plays an important role in protecting cells. It is necessary for cell survival and tissue protection by affecting processes such as cell proliferation, renewal, reproduction and immunity in the body [6], [7]. As a transition metal, zinc is known for its versatile physical and chemical properties that are of biological importance. Zn^{+2} ion is diamagnetic due to its electron configuration and acts as a strong Lewis acid.This property enables zinc to effectively stabilize various coordination geometries, making it compatible with biological environments where rapid ligand exchange processes are required for functional activities [8]. Many studies mention the possibility that disruptions in zinc homeostasis may cause cancer. Chelation therapy has been proposed as a treatment for cases of excess cellular zinc [9], [10] . Zinc complexes, akin to various other metal (II) complexes, have garnered attention as potential new anticancer agents, offering a promising alternative to traditional platinum-based therapies. The appeal of Zinc(II) complexes lies in their markedly lower toxicity at elevated doses compared to other metal-based treatments. This lower toxicity profile, coupled with their potential efficacy, makes Zinc(II) complexes a particularly attractive option in the development of new

cancer therapies [11], [12], [13]. Moreover, zinc complexes have anticancer properties. They can undergo rapid ligand exchange, allowing them to interact dynamically with a variety of biological molecules. In addition, these complexes can facilitate Lewis acid activation, increasing their reactivity and binding to target sites. Perhaps most importantly, zinc complexes have the capacity to inhibit cancer cell proliferation and catalyze DNA division. These versatile actions highlight the potential of zinc complexes as potent anticancer agents. [14], [15], [16].

Recently, there has been increasing interest in the ability of metal complexes to form multidimensional structures through hydrogen bonds. The main goal in this field of research is to establish a connection between the structural features of these complexes and intermolecular interactions. This will provide a direct understanding of how these interactions affect the physical and functional properties of the complexes. Such studies offer significant potential for the development and applications of new materials.

In the this paper, we report the X ray diffraction analysis and Hirsfield surface analysis study of one zinc(II) complex has a hexacoordination.

II. Materials and Method

The data collected from the diffractometer were processed using several software programs, resulting in visual representations. These programs include X-AREA, X-RED32 [17], SHELXT2018/3 [18], SHELXL2018/3 [19], OLEX2 [20], WinGX [21], PLATON [22], and publCIF [23]. They were employed to determine the positions, bond lengths, bond angles, and torsion angles of the atoms within the molecule. Furthermore, Hirshfeld surface analysis of the molecule was conducted using Crystal Explorer program version 21.5 [24].

III. Structural Commentary

A. *X- Ray Diffraction Analysis*

The line formula of the crystal we examined is as follows (Fig. 1).

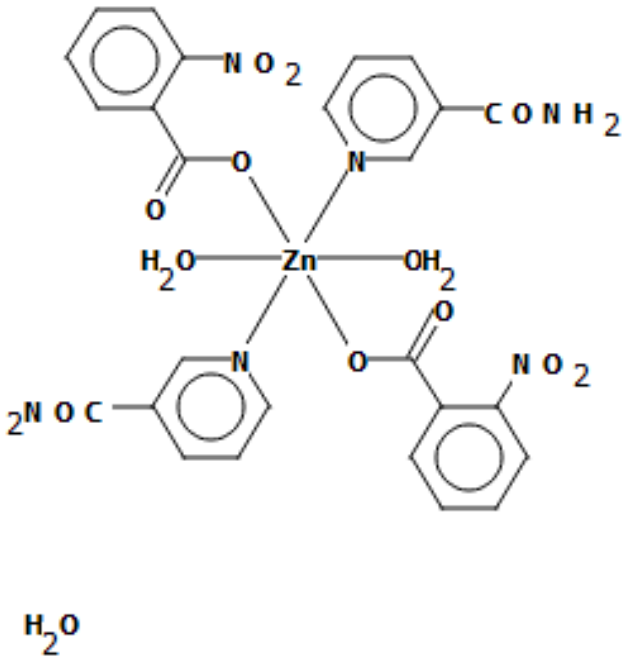

Fig. 1 Crystal Scheme

Some information regarding crystal data, data collection, and structure refinement is listed in Table 1.

Table 1. Experimental details

Empirical formula	($C_{26}H_{28}N_6O_{14}Zn$)
Formula weight	713.91
Temperature (K)	293
Crystal system	Monoclinic
Crystal shape	Prism
Crystal colour	Colorless
Space group	$P2_1/c$
a (Å)	7.8521 (5)
b (Å)	19.2940 (13)
c (Å)	11.3164 (7)
α (°)	90
β (°)	120.456 (4)
γ (°)	90
Volume ($Å^3$)	1477.86 (17)
Z	2
Dx ($Mg.m^{-3}$)	1.604
μ (mm^{-1})	0.91
F(000)	736
Crystal size (mm^3)	0.68 × 0.50 × 0.34
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection (°)	4.2 to 51.8
Index ranges	$-9 \le h \le 9$, $-23 \le k \le 23$, $-13 \le l \le 13$
Measured reflections	7637
Independent reflections	2847
Reflections with $I > 2\sigma(I)$	2428
R_{int}	0.04
S	1.04
Reflections/Restraints/Parameters	2847/0/218
$wR(F2)$	0.076
$\Delta\rho$max / $\Delta\rho$min ($e\ Å^{-3}$)	0.31/-0.25

X-ray diffraction studies show that ($C_{26}H_{28}N_6O_{14}Zn$) crystallizes in the monoclinic space group $P2_1/c$ (Table 1). This complex forms a six-coordinate octahedral geometry. Two water molecules are positioned axially to each other. The pyridine-3-carboxamide and 2-nitrobenzoate molecules occupy the basal plane of the distorted octahedral structure in a trans configuration (For the same type of ligands) (Fig. 2 and Fig. 3). The bond lengths in the six coordinations between the central zinc II atom and the surrounding atoms are (Zn−N; 2.143(15) Å), (Zn−$O_{carboxylate}$; 2.182(12) Å) and (Zn−O_{aqua}; 2.119(12) Å) (Fig. 2 and Table 2). Reference [25] and reference [26] in the literature are examined, the results in our study are similar to them.

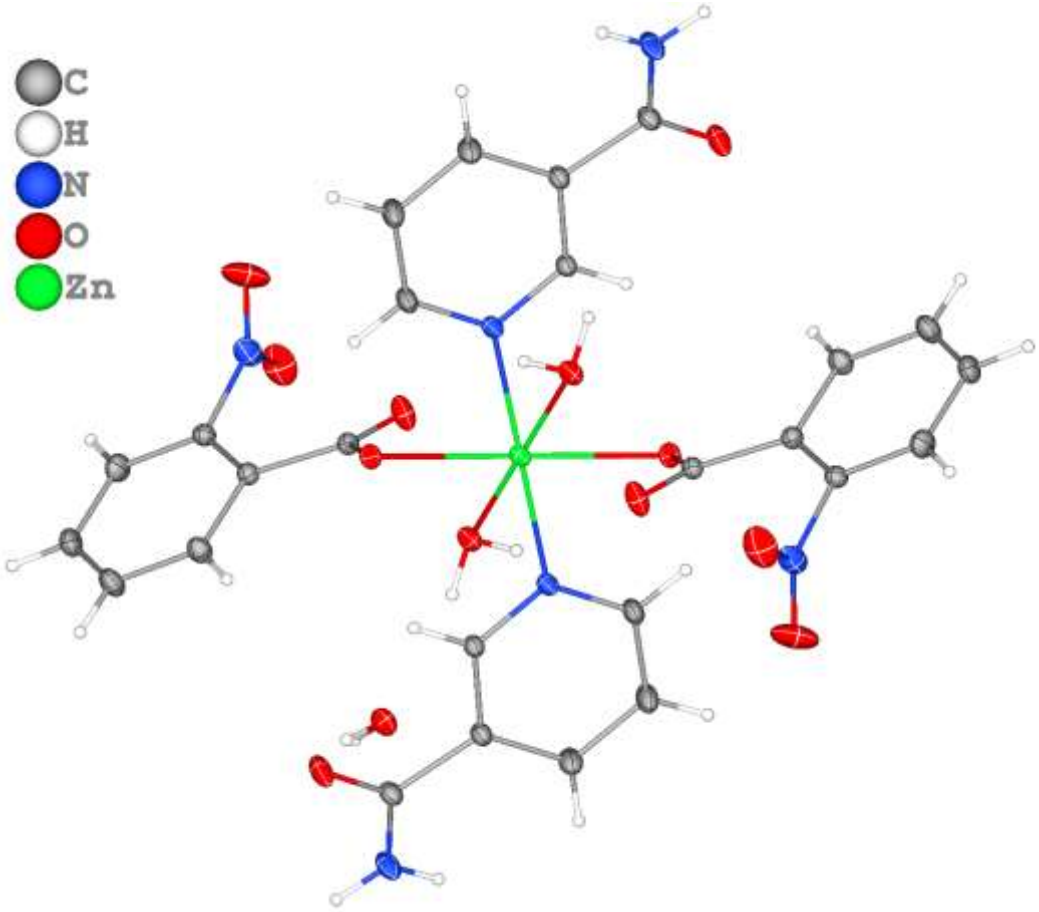

Fig. 2 Crystal structure of the complex

Table 2. Some selected bonds

Bond	**Bond Length**
Zn1—O6	2.119 (12)
Zn1—O6^{i}	2.119 (12)
Zn1—N2^{i}	2.143 (15)
Zn1—N2	2.143 (15)
Zn1—O1^{i}	2.182 (12)
Zn1—O1	2.182 (12)
O1—C1	1.264 (2)
N1—O3	1.208 (3)
N1—O4	1.209 (3)

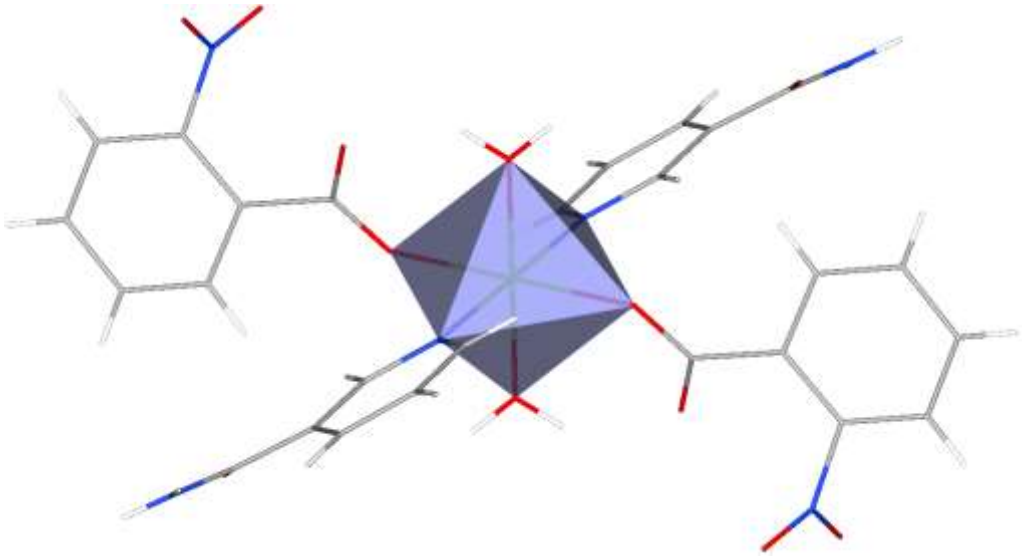

Fig. 3 Special geometry inside the crystal structure

From Fig. 4 and Table 3, it is evident that strong hydrogen bonds permeate the complex, linking the mononuclear units into a three-dimensional supramolecular network. There are both intramolecular and intermolecular hydrogen bonds in the complex.

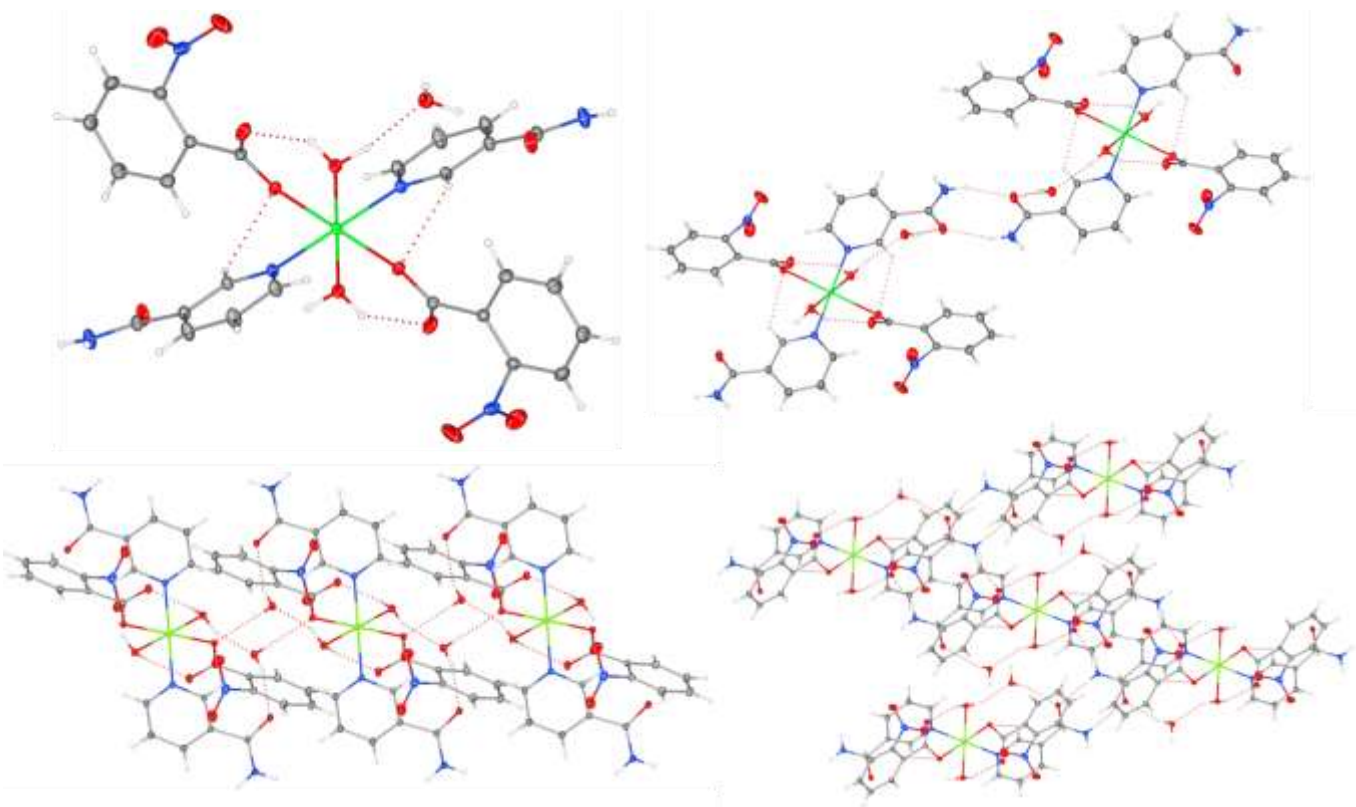

Fig. 4 Formation of crystal structure trough hydrogen bonds

Table 3. Hydrogen-bond geometry

D—H···A	D—H	H···A	D···A	D—H···A
O6—H6A···O2	0.85 Å	1.92 Å	2.647 (19) Å	143°
O6—H6B···O7	0.85 Å	2.00 Å	2.805 (19) Å	157°
C12—H12···O1^{i}	0.93 Å	2.46 Å	3.043 (2) Å	121°
N3—H3A···O5^{ii}	0.86 Å	2.04 Å	2.865 (2) Å	162°
N3—H3B···O2^{iii}	0.86 Å	2.19 Å	2.990 (2) Å	156°
C4—H4···O7^{iv}	0.93 Å	2.54 Å	3.386 (3) Å	151°
C9—H9···O3^{v}	0.93 Å	2.54 Å	3.221 (3) Å	130°

Symmetry codes: (i) −*x*, −*y*, −*z*; (ii) −*x*−2, −*y*, −*z*−1; (iii) *x*−1, *y*, *z*−1; (iv) *x*+1, −*y*−1/2, *z*+1/2; (v) *x*, −*y*−1/2, *z*−1/2.

B. Hirshfeld Surface Analysis

Fig. 5 presents non-covalent interactions of the complex. These visual representations utilize color schemes to illustrate different properties, including normalized contact distance (dnorm), shape index variations, and curvedness. The three-dimensional dnorm surfaces are meticulously generated with high surface resolution, ensuring an accurate portrayal of these properties [27], [28]. The color scale ranges from -0.5605 to 1.0974 Å for the complex.

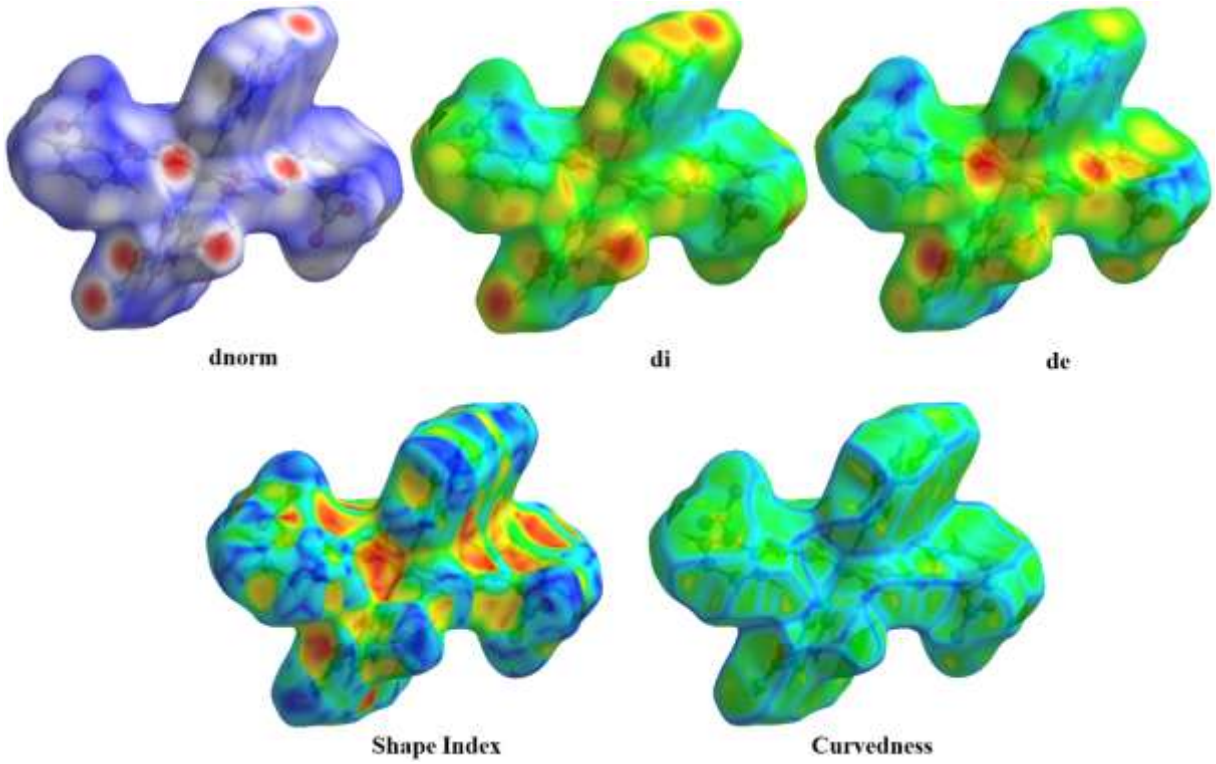

Fig. 5 d_{norm}, d_i, d_e, Shape index and Curvedness maps

In particular, it is noteworthy that H···O contacts account for 42.2% of the total surface area, emphasizing the significance of hydrogen bonding interactions in stabilizing this crystal arrangement. A few of these oh interactions and the molecular binding model with the dnorm surface map are shown in Fig. 6.

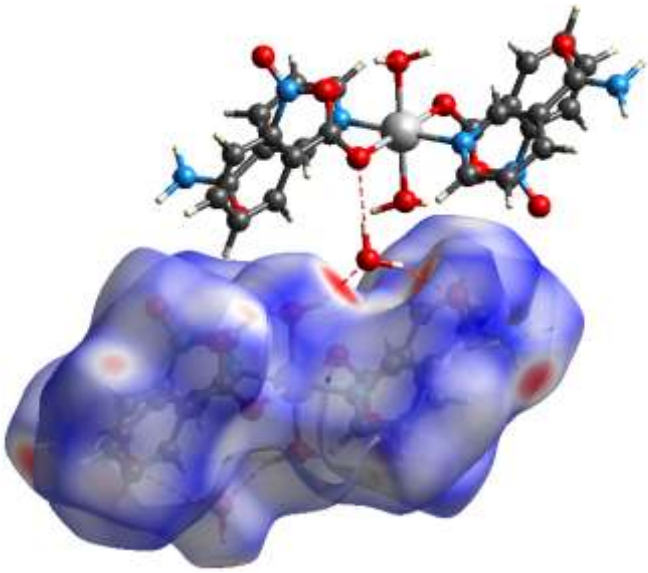

Fig. 6 A few (H···O) interactions in the crystal structure

Additionally, H···H make up 25.9% of the contribution, while H···C contacts contribute 16.6%. Furthermore, C···C are responsible for 5.2% of the total surface area and C···O contribute 4.7%. Minor contributions from H···N (2.1%), O···O (1.5%), C···N (1.1%) and N···O (0.8%) are observed. 2D Fingerprint graphs of these interactions are given in Fig. 7.

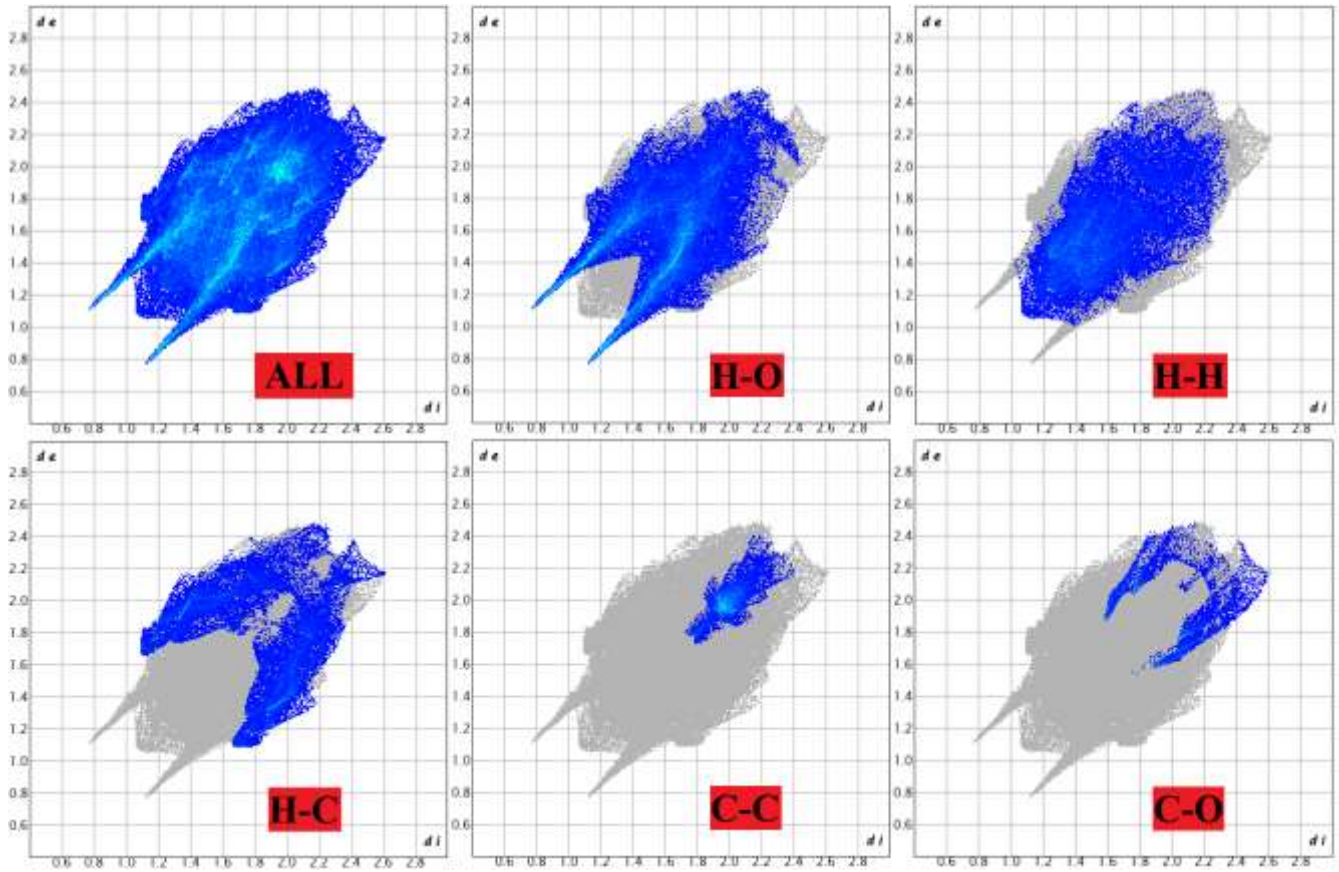

Fig. 7 Two-dimensional fingerprint plots

IV. RESULTS

Complex crystallizes in the monoclinic crystal system, with unit cell parameters a= 7.8521 (5) Å, b= 19.2940 (13) Å, c= 11.3164 (7) Å, α=90°, β = 120.456 (4)°, γ=90°, and Z=2 in the $P2_1/c$ space group. And İt has an octahedral geometry and hexacoordination. In addition, according to the Hirshfeld surface analysis results, H···O contacts constitute 42.2% of the total surface area.

V. DISCUSSION

In summary, HS analysis shows that the compound examined in this study exhibits significant intermolecular interactions, with the H···O interactions being the most prominent, accounting for 42.2% of the total interactions observed. These results align with XRD crystal analysis. Such comprehensive analyses are essential for gaining a deeper understanding of molecular structure and properties, which are critical in various scientific and industrial applications, including drug design, materials science, and chemical research.

VI. CONCLUSION

In this study, the structural properties and intermolecular interactions of ($C_{26}H_{28}N_6O_{14}Zn$) were investigated using the X-ray diffraction method and Hirshfeld surface analysis. According to XRD and HS results, an infinite crystal structure emerges, mainly due to hydrogen bonds and intermolecular interactions. The findings from XRD and HS analyzes are consistent and mutually reinforcing, providing a comprehensive understanding of the structural properties of the complex.

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Sınıf Öğretmeni Adaylarının Matematik Eğitiminde Örüntülerin Önemine İlişkin Görüşlerinin İncelenmesi

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Özet **–** Örüntüler, günlük hayatımızın birçok alanında karşımıza çıkan ve bir bilim alanı olarak matematiksel bilginin temelini oluşturan unsurlardan biridir. Sınıf öğretmeni adaylarının örüntülerin önemini kavraması ve matematiksel düşüncenin gelişimindeki önemini bilmesi, örüntülerin öğretimiyle ilgili pedagojik bilgiyi anlamaları son derece önemlidir. Bu araştırmada sınıf öğretmeni adaylarının matematik eğitiminde örüntülerin önemine ilişkin düşüncelerini incelenmesi amaçlanmaktadır. Bu doğrultuda araştırmanın çalışma grubunu Ondokuz Mayıs Üniversitesi Eğitim Fakültesi Sınıf Öğretmenliği 3. sınıfta öğrenim gören 47 öğretmen adayı oluşturmaktadır. Araştırma nitel araştırma yöntemlerinden durum çalışması yöntemi kullanılarak yapılmış olup, veri toplama aracı olarak yarı yapılandırılmış görüşme formu kullanılmıştır. Veri analizi içerik analizi ile yapılmıştır. Araştırmanın sonuçlarına göre öğretmen adaylarının örüntülerin önemine ilişkin bilgi ve farkındalık sahibi oldukları görülmüştür. Özellikle örüntülerin genelleme yapabilme, problem çözme, çıkarım yapma, mantıklı düşünme ve muhakeme yetilerini geliştirmede önemli bir rol oynadığını vurgulamışlardır. Ayrıca, öğrencilerin yaş ve bulundukları gelişim döneminin özelliği doğrultusunda örüntülerin somut ve soyut düşünme becerilerini geliştirmede de etkili olduğunu ifade etmişlerdir. Bu bulgular sınıf öğretmeni adaylarının genel olarak örüntülerin önemini anladıklarını ve matematik eğitiminde bu unsurların değerinin farkında olduklarını göstermiştir. Araştırmada, öğretmen adaylarının örüntülerin matematik eğitimindeki ve günlük hayattaki rolünü anlamalarının gelecekteki öğrencilerine temel matematik eğitimi vermeleri bakımından kritik öneme sahip olduğunu sonucuna varılmıştır.

Anahtar Kelimeler – Genelleme, Matematik eğitimi, Matematiksel düşünce, Örüntü, Sınıf öğretmeni adayları.

I. GİRİŞ

Matematik, günlük hayatımızın her alanında etkili bir biçimde var olan bir araçtır. Hayatın her yerinde ve hayatın her anında karşımıza çıkan matematik, evrensel ve tüm bilimlerin ortak dilidir [1]. Günlük rutinimizde zamanı ölçmekten alışveriş yaparken fiyatları hesaplamaya, yemek tariflerini ölçülere göre hazırlamaktan trafik ışıklarında sıra beklemeye, bir otomobilin hızını hesaplamak için matematiksel formülleri kullanmaktan bütçemizi dengelemeye kadar birçok durumda matematiksel hesaplamalar yaparız matematiği kullanırız. Eğitim düzeyi yüksek olan toplumun ülkesinde gelişmişlik düzeyi de artacağından bireylerin gerekli bilgi birikimine sahip olması ve bu bilgileri etkili kullanabilmesi özellikle son yüzyılda eğitim ve bilginin öneminin hızla artmasıyla daha da önemli hale gelmiştir [1]. Ayrıca teknolojinin ve yaşam standartlarının kalitesi ile doğrudan ilişkisi olan matematik eğitimine vurgu yapılmakta, matematik eğitimi olmadan ülkelerin gelişmeleri, kalkınmaları, bilim ve teknolojide ilerlemelerinin zor olacağı belirtilmektedir [1]. Bu nedenlerden dolayı matematik basit sayma ve ölçme işlemlerinden başlayarak toplumun ihtiyacı doğrultusunda diğer bilim dallarıyla iş birliği içinde ilerleyerek yaşamın her alanında yerini alarak yaşamımızın ayrılmaz bir parçası konumundadır.

Matematiğin net bir tanımı tam olarak yapılamamasına rağmen araştırmacılar tarafından farklı tanımlar yapıldığı görülmektedir. "İnsan zihni ve kültürünün örüntüleri tanımlamak, sınıflandırmak ve kullanmak için geliştirmiş olduğu formal düşünce sistemi" matematik tanımlarından biridir [2]. Farklı bir tanımda matematik şöyle ifade edilmiştir; matematik, örüntüler ve ilişkiler üzerine odaklanan bir düşünme biçimidir [3]. Matematik, insanlara bilgiyi düzenleme, analiz etme ve sentezleme stratejileri sunar. Gerçek hayattaki problemleri matematiksel prosedürlere dönüştürerek daha anlaşılır hale getirir. Matematik, dikkatle tanımlanmış terimler ve semboller kullanan bir dildir ve geniş bir araç yelpazesine sahiptir. Bu nedenle, matematiği anlamak sadece matematikçiler için değil, herkes için önemlidir. Çocuklar da matematiği soyut ve pratik problemleri çözmek için günlük ve iş hayatlarında kullanabilecekleri bir araç olarak görebilmelidirler. Dolayısıyla matematiğin akıl ve mantıkla ilgili bir disiplin olduğu, düşünmeyi teşvik ettiği söylenebilir [1].

Öğrencilerin matematiğe olan ilgisini artırmak, her okulda ve sınıf düzeyinde matematik öğretimini etkinleştirebilmek için herkes çabalamalı, matematik öğrenmeleri teşvik edilmeli, desteklenmeli, başarıları takdir edilmeli ve ödüllendirilmelidir [4]. Buna ek olarak matematik öğretimi sırasında birtakım prensiplere uyulması gerekmektedir. Bu prensipler; problemleri anlamak ve çözmek için kararlılıkla çalışmak, soyut ve nicel olarak akıl yürütmek, geçerli argümanlar oluşturmak ve diğerlerinin akıl yürütmesini eleştirmek, matematiksel modelleme yapmak, uygun araçları stratejik olarak kullanmak, hassasiyete dikkat etmek, tekrarlayan akıl yürütmede düzenlilik aramak ve ifade etmektir [5].

Matematik tanımlarında geçen örüntüleri tanımlamak, sınıflandırmak ve kullanmak ifadesinde görüldüğü üzere matematiğin önemli bir konusu da örüntülerdir. Matematiğin temel taşlarından olan örüntü öğrencilerin matematik öğrenimini eğlenceli hale getirir ve matematiksel düşünme süreçlerini görmelerine yardımcı olurken genellemeler yapılmasını ve matematiksel kavramları derinlemesine anlamayı sağlar [6]. Bu nedenle örüntüler hem günlük hayatta hem de matematiksel kavramların anlaşılmasında önemli bir rol oynar; örüntüleri oluşturma, tanıma ve genişletme yeteneği, ilişkileri görme ve matematiğin düzen ve mantığını anlamaya katkıda bulunur [7].

Doğanın örüntülerini ve doğal süreçleri yöneten kuralların önemli bir parçası olan örüntü ilkokul ve ortaokul matematik dersi öğretim programında yer almaktadır. Türkiye'de ilkokul matematik dersi öğretim programında dört öğrenme alanı bulunmaktadır [2]. Bu öğretim alanları; sayılar ve işlemler, geometri, ölçme ve veri işlemedir. Örüntüler geometri öğrenme alanında yer almaktadır. Bu alt öğrenme alanında öğrenciler, 1. sınıfta belirli bir geometrik örüntüyü deneyimleriyle bulur, nesneler, geometrik şekiller veya cisimlerden oluşan örüntülerdeki ilişkileri anlamaya çalışarak eksik olan ögeleri belirlemeye çalışır. 2.sınıf düzeyinde, öğrenciler tekrarlanan örüntülerde eksik bırakılan ögeleri tespit edip tamamlama becerisi kazanır. 3. sınıf düzeyinde ise, öğrencilerin kaplama yapabilme yeteneğini geliştirir ve yaptıkları kaplama örüntülerini noktalı veya kareli kağıt üzerine çizebilecek beceriye sahip olur. Ortaokul matematik dersi öğretim programında ise sayılar ve işlemler, cebir, geometri ve ölçme, veri işleme ve olasılık olmak üzere beş öğrenme alanından oluşmaktadır. Cebir öğrenme alanında örüntüler bulunmaktadır ve cebir öğrenme alanındaki kazanımlar 6. sınıfta yer almaktadır [8].

Matematik eğitiminin öğrencilere kazandırdığı önemli becerilerden biri akıl yürütme yeteneğidir ve bu yetenek özellikle örüntü etkinliklerinde yoğun bir şekilde kullanılır [6]. Ayrıca erken çocukluk dönemindeki matematik öğretimi, örüntülerin keşfedilmesini cebirsel düşünme için önemli bir adım olarak öne çıkarır ve bu öğretim, çocukların çevrelerindeki dünyayla bağlantı kurmaları için bir araç olarak örüntülerin kullanılmasını teşvik eder ve cebirsel düşünmenin temellerini oluşturur [9]. Matematik öğreniminde örüntülere erken dönemlerde önem verilmesine rağmen örüntü kelimesi net olarak tanımlanamamıştır. Kökeninin "patron" (patteren) kelimesinin bir varyasyonu olduğu ve patron kelimesinin en eski anlamının da taklit edilecek bir mükemmellik modeli olduğu ifade edilirken birkaç yüzyıl sonra patron düzenli veya tekrar eden olarak tanımlanmıştır [8]. Günümüzde örüntü kelimesi hem gündelik kavramlar için hem de sanat, müzik, edebiyat, psikoloji, biyoloji ve matematik gibi disiplinlere özgü bağlamlarda kullanılan çok sayıda sözlük anlamı vardır. Matematikte ise örüntü terimi ile neyin kastedildiğini tanımlamanın kolay olmadığı ifade edilmektedir. Örüntünün ne olduğuna ilişkin bir anlayış olmadığını belirten Carraher, Martinez ve Schliemann durumu şöyle belirtmiştir: Bir örüntü matematiksel bir nesne değildir [10]. Matematikçilerin bile matematiğin örüntülerin bilimi olduğunu iddia ettiklerinde,

terimi matematik dışı, neredeyse şiirsel bir anlamda kullandıklarını kabul ederler. Matematikçiler arasında örüntülerin ne olduğu konusunda veya özellikleri ve işlemleri konusunda bir anlaşma yoktur (s. 4). Matematikte genellikle düzen arayışıyla, düzenlilikle ilişkilendirilir [11]. Sarama ve Clements örüntü oluşturma eyleminin görünüşte organize olmayan durumlara düzen, uyum ve öngörülebilirlik getirmek ve doğrudan mevcut bilgilerim ötesinde genellemeleri kolaylaştırmak için matematiksel düzenlilikler ve yapılar arayışı, bir süreç ve bir zihin alışkanlığı olduğunu öne sürmüştür [12]. Papic ve arkadaşları örüntüyü tekrarlanabilir herhangi bir düzenlilik olarak tanımlamış ve örüntülerin matematikte özellikle önemli olan üç bağlamda ortaya çıktığını belirtmiştir [13]. Bunlar; tek bir nesne içinde, bileşenlerinden bazıları sürekli olarak ilişkilidir; sıralı bir nesne kümesi içinde, her bileşen ile bir sonraki arasında sürekli bir ilişki bulunur; iki sıralı nesne kümesi arasında, karşılık gelen öğeler bir şekilde eşleştirilmiştir (s. 238). McGarvey örüntüyü; fiziksel, davranışsal, görsel veya sembolik fenomenler üzerinde yapısal düzenlilikleri algılama veya empoze etme eylemi olarak tanımlamıştır [9].

Örüntülerin tanımlanması, genişletilmesinin öğrenilmesi matematik yapmanın ve cebirsel düşünmenin bir parçası olarak yer alır [14]. Örüntülerdeki terimler arasında ilişkilerin genellenmesini ve sembolik kural veya formüllerle ifade edebilme becerisi cebirsel düşünmeyi sağlayabilir [15]. Dolayısıyla öğrencilerin örüntüleri tanıma, devam ettirme ve örüntüdeki ilişkileri gözlemleyerek genelleme yapma becerileri cebirsel düşünmeye teşvik ederek bu süreçte, matematiksel kavramları anlama ve sembolik olarak ifade etme yeteneklerini güçlendirir [16]. Bu nedenle, örüntülerle cebir arasında derin ve önemli bir bağlantı mevcuttur [15].

Örüntülerin tanınması, matematik kavramlarının gelişimini artıran temel bir beceridir ve günlük hayatın her alanında karşımıza çıkan örüntü, güneşin doğup akşamları ayın çıkması, sabahları yatağımızı toplarken yaptığımız işlemler, kahvenin hazırlanması gibi birçok yerde kural ve düzende mevcuttur [6]. Sayı örüntülerinden önce somut örüntülerle, alkışlamalarla, zıplamalarla, canlandırmalar, ip üzerinde renkli boncuklar dizmekle örüntülere başlangıç yapılabilir [17]. Başka bir örnek ise sözlü örüntülerle basit bir şarkı deseni "do, mi, mi, do, mi, mi,..." hazırlanabilir, böylece örüntü kavramı hızlı şekilde öğrenilebilir [14]. Örüntüler matematiğin önemli bir parçası olarak çocuklara dünyanın düzenlemelerine ve matematiği anlamalarına yardımcı olur [3]. Örüntüler içerdikleri unsurlara göre sayı örüntüleri ve şekil örüntüleri gibi gruplandırılabilir. Ayrıca, aralarındaki farklara göre doğrusal ve ikinci dereceden örüntüler şeklinde ayrılabilir. Buna ek olarak elemanlar arasındaki ilişkilere bağlı olarak yinelemeli örüntüler ve belirgin ilişkilere sahip örüntüler şeklinde kategorize edilebilirler [16]. Benzer gruplama; etiketli sayı örüntüleri, resimsel/geometrik örüntüler, hesaplama prosedürlerindeki örüntüler, doğrusal ve ikinci dereceden örüntüler, tekrar eden örüntüler ve benzeri şeklindedir [18]. Yaman ve Umay örüntülerin sunum biçimlerini; şekil (görsel), tablo veya grafik, sayı dizileri ve sözel problemler olarak ifade etmiştir [19].

Örüntülerin doğru bir şekilde tanınması ve öneminin bilinmesi ilköğretim düzeyindeki öğrencilerin matematik kavramlarını anlayıp genellemeleri, matematiksel düşüncenin gelişimi açısından önemli bir temel oluşturacaktır. Nathan ve Kim örüntülerin farklı şekillerde sunulduğunu, öğrencilerin örüntü genelleme performanslarının bu sunum şekillerinden etkilendiğini gözlemlemiştir [20]. Benzer şekilde Yaman ve Umay öğrencilerin sınıf düzeylerine göre örüntü sunum biçimlerine bağlı olarak matematiksel örüntülerdeki performanslarında anlamlı farklılıklar olduğunu ortaya koymuştur [19]. Bu bulgular, örüntülerin nasıl sunulduğunun öğrencilerin örüntüleri anlama ve uygulama becerilerini etkilediğini göstermektedir. Palabıyık yedinci sınıf öğrencilerinin cebirsel düşünme becerileri ve matematiğe karşı tutumları üzerinde örüntü temelli ve örüntü temelli olmayan cebir öğretiminin etkilerini incelemiştir [21]. Araştırma sonuçları öğrencilerin örüntü temelli öğretim sürecini verimli bulduklarını ve örüntü temelli etkinliklerin başka sınıflarda da uygulanmasını tavsiye ettiklerini göstermiştir. Benzer bir çalışmada Palabıyık ve Akkuş İspir örüntü temelli cebir öğretiminin gerçekleştirildiği çalışmada deney grubundaki öğrencilerin kavramsal cebir başarıları artmış ancak, işlemsel cebir başarıları açısından kontrol grubuyla karşılaştırıldığında anlamlı bir fark gözlenmemiştir [16]. Kılıç, matematik öğretmen adaylarının 6. sınıf öğrencilerinin örüntü problemlerini çözümlemelerine odaklanmıştır [22]. Araştırma sonuçlarına göre, öğretmen adayları öğrencilerin açık stratejilerini fark etme konusunda başarılı olmuş ancak öğrencilerin yaptıkları hataların altında yatan nedenleri belirleme konusundaki açıklamaları yeterli bulunmamıştır.

Doğan Temur ve Turgut ilkokul dördüncü sınıf düzeyinde sınıf öğretmenlerinin sayı ve şekil örüntülerini nasıl öğrettiğini incelemiştir [23]. Öğretim sürecinde öğretmenler, muhakeme gerektiren görevleri kullanmış olsalar da bazı durumlarda yetersiz kalmış ve etkili dersler işleyememişlerdir. Öğretmenler genellikle düşündürücü ve problem çözmeye dayalı sorular yerine rutin ve tablo okumaya dayalı sorular kullanmışlardır. Ayrıca, genelleme gerektiren görevleri iyi organize edememişlerdir. Bununla birlikte, tablolar ve örüntü içeren farklı görevlerin kullanılması öğrencilere genellemeler yapma fırsatları sunmuştur. Sulak ve Çavuşoğlu'nun yaptığı araştırmada matematik ders kitaplarında yer alan örüntü türlerinin sınıf kademesi ilerledikçe azaldığı ve bu örüntülerin günlük hayatla ilişkilendirilmediği tespit edilmiştir [6]. Ayrıca sınıf öğretmenlerinin örüntülerin öğretiminde soyut konuları daha somut hale getirmek için materyal ile nesnelerin kullandıkları, bunların yanı sıra drama ve animasyonların da örüntü öğretiminde kullanıldığı görülmüştür. Çilingir ve Yanpar Yelken'in çalışmasında sınıf öğretmeni adayları ve sınıf öğretmenleri örüntünün günlük yaşamla ilişkisi konusunda yorum yapmamışlardır [24]. Sınıf öğretmen adayları günlük yaşamda geleceği tahmin etme, çevre hesaplama, inşaat, hayatları planlarken, bir olay veya davranıştan sonra ne olabileceğini düşünmede örüntünün kullanılabileceğini belirtmişlerdir. Ayrıca öğretmenler örüntünün faydaları konusunda ileri görüşlülüğü artırdığını, çok yönlü düşünmeyi sağladığını, muhakeme gücünü kullanmayı gerektirdiğini, düşünme kapasitesini geliştirdiğini ileri sürerken sınıf öğretmeni adayları örüntülerin faydalarının günlük hayatta kullanıldığını, mantıksal akıl yürütmeyi geliştirdiğini, yaratıcı ve çok yönlü düşünme becerisi kazandırdığını, öngörü kazandırdığını ifade etmiştir. Başka bir çalışmada Topbaş Tat ortaokul matematik öğretmenlerinin örüntüler konusundaki görüşlerini incelemiş ve öğretmenlerin genel olarak örüntülerle ilgili olumlu bir bakış açısının olduğunu ortaya koymuş ancak, öğretmenlerin örüntü konusunun önemini yeterince açıklayamadıklarını ve örüntülerin öğretiminde örüntü kuralını harfle ifade etmede zorluklar yaşadıkları sonucuna ulaşılmıştır [25].

Örüntü ile ilgili yapılan araştırmalarda, örüntülerin matematik eğitimindeki önemi ve öğretim süreçlerindeki uygulamalarının çeşitli açılardan incelendiği görülmüştür. Ancak çalışmalar sınıf öğretmeni adaylarının örüntünün önemine ilişkin görüşlerine odaklanmamıştır. Bu nedenle bu araştırmada sınıf öğretmeni adaylarının matematik eğitiminde örüntülerin önemine ilişkin görüşleri tespit edilmeye çalışılmıştır.

II. YÖNTEM

Çalışmada nitel araştırma yöntemlerinden durum çalışması kullanılmıştır. Durum çalışması, bir durumu bütüncül bir yaklaşımla ele alarak etkenlerin nasıl etkilediğini ve aynı zamanda bu durumdan nasıl etkilendiğini inceleyen bir yöntemdir [26]. Durum çalışmalarında neden-sonuç ilişkileri kurulabilir [27]. Buradaki matematik eğitiminde örüntülerin önemine ilişkin öğretmen adaylarının nasıl düşündüğü incelendiğinden bu yöntem tercih edilmiştir.

A. Katılımcılar

Çalışmada olasılıksız örnekleme yöntemi olan amaçlı örnekleme yöntemi tercih edilmiştir. Amaçlı örneklemede stratejik ve amaçlı olarak bilgi açısından zengin vakalar seçilir; seçilen vakaların türü ve sayısı çalışmanın amacına ve kaynaklara bağlı olarak belirlenir [28]. Amaçlı örnekleme yöntemlerinden ise kolay ulaşılabilir durum örneklemesi seçilmiştir. Pratik ve ulaşılabilirliği olan örneklemlerle yapılan örnekleme yöntemidir [26]. Bu araştırmada, 2023-2024 eğitim öğretim bahar döneminde Ondokuz Mayıs Üniversitesi eğitim fakültesinde öğrenim görmekte olan sınıf öğretmeni adayları ile matematik öğretimi dersi kapsamında matematik öğretimi programının geometri kazanımlarından örüntülerin öğrenilmesine ilişkin gerçekleştirilmiştir. Araştırmanın örneklemini Matematik Öğretimi II dersini alan öğretmen adayları oluşturmuştur. Araştırmanın katılımcıları bu dersi alan 50 öğretmen adayı olarak belirlenmiştir, ancak 3 öğretmen adayı belirtilen soruya cevap vermemiştir. Bu nedenle araştırma sorusu 47 öğretmen adayının görüşleri doğrultusunda incelenmiştir. Araştırmaya 36 kadın ve 11 erkek öğretmen adayı katılmıştır.

Tablo 1. Sınıf Öğretmeni Adaylarının Demografik Bilgileri

Cinsiyet	**N**
Kadın	36
Erkek	11
Toplam	47

B. Veri Toplama Araçları

Sınıf öğretmeni adaylarının matematik eğitiminde örüntülerin önemine ilişkin görüşlerinin belirlenmesinde yarı yapılandırılmış görüşme yöntemi kullanılmıştır. Bu yöntem ile görüşmeler sırasında esneklik oluşturmak, konuşma süresince farklı konuları katılımcıların kişisel deneyimleriyle derinlemesine anlatmalarını ve açık uçlu sorular ile çeşitli konuları keşfetmeyi sağlar [29]. Yarı yapılandırılmış görüşme formu öğretmen adaylarının örüntülerin önemine ilişkin görüşlerini açığa çıkarmak için araştırmacılar tarafından geliştirilmiştir. Görüşme sorusu öğretmen adaylarının öğrencilerin bilişsel gelişimi ve matematiksel düşüncenin gelişimi açısından örüntülerin önemini ve matematik öğretim programının geometri kazanımlarından örüntülerin öğrenilmesine ve önemine ilişkin görüşlerini açık uçlu sorularla yazılı olarak sorulmuştur.

C. Veri Analizi

Öğretmen adayları ile gerçekleştirilen görüşmelerden elde edilen verilerin analizinde içerik analiz kullanılmıştır. Bir araştırmanın başlangıcında genel bir soruyla başlanarak elde edilen verilerin analiziyle derinlemesine analizler yapılarak analitik genellemelere ulaşılır. Bu süreç, mevcut kuramlara yeni perspektifler ekleyebileceği gibi önceden fark edilmemiş temaların ve boyutların ortaya çıkarılmasına olanak tanır [26]. Elde edilen veriler, tek tek okunarak analiz edilmiş ve kodlar oluşturulmuştur. Oluşan kodlar görüşme sorusundan oluşturulan temalara göre incelenmiş ardından uygun temaya yerleştirilmiştir. Araştırmaya katılan her katılımcı için, etik açıdan gizlilik sağlanmış ve her birine bir kod numarası (örneğin, Ö1, Ö2 vb.) verilmiştir. Öğretmen adaylarının yanıtları kodlanarak temalara yerleştirilmiş ve temalara göre sayılarak frekans sayıları belirlenmiştir. Öğretmen adaylarının görüşlerinden direkt alıntılarla desteklenmiştir.

III. BULGULAR

Araştırmanın verilerinden elde edilen bulgular doğrultusunda örüntülerin önemine ilişkin iki tema oluşturulmuştur. Bu temalar matematiksel düşüncenin gelişimi ve bilişsel gelişimdir. Elde edilen bulgular iki alt başlıkta incelenmiştir.

A. Öğretmen Adaylarının Örüntülerin Matematiksel Düşüncenin Gelişimindeki Önemine İlişkin Görüşleri

Öğretmen adayları matematik eğitiminde örüntülerin önemine dair verdikleri cevaplardan matematiksel düşüncenin gelişimine yönelik olanlar Tablo 2'de gösterilmiştir.

Tablo 2. Matematiksel düşüncenin gelişimine ilişkin kodlar

Kodlar	**Öğretmen Adayları**	**f**
Genelleme	Ö5, Ö6, Ö8, Ö10, Ö13, Ö15, Ö18, Ö25, Ö26, Ö29, Ö33, Ö35, Ö37, Ö40, Ö42, Ö43, Ö45	17
Somuttan soyuta doğru öğrenme	Ö7, Ö9, Ö11, Ö12, Ö17, Ö23, Ö24, Ö26, Ö27, Ö29, Ö30, Ö39, Ö42, Ö46	14
Problem çözme	Ö5, Ö9, Ö16, Ö22, Ö31, Ö48	6
Formüle edebilme	Ö2, Ö10, Ö18, Ö34	4
Zihinde canlandırma	Ö12, Ö31	2
Algoritmik düşünme	Ö10, Ö37	2
Cebirsel düşünme	Ö36, Ö44	2
Günlük hayatla ilişkilendirme	Ö3, Ö8	2
Üst düzey sayı dizilimlerini anlama	Ö3	1
Tamamlama	Ö12	1

Matematiksel zekanın gelişimi	Ö5	1

Öğretmen adayları örüntülerin önemini matematiksel düşüncenin gelişimi açısından değerlendirmişlerdir. Örüntüler, öğrencilerin genelleme becerilerini geliştirmelerini ve somuttan soyuta doğru öğrenme süreçlerini desteklemelerini sağladığı belirtilmiştir. Ö29 *"Dördüncü sınıf kazanımı ile kural genellemesi yapabilir, böylece matematiksel düşünmeyi kavramış olur."* diyerek genelleme becerilerini geliştirmeye vurgu yaparken Ö26 "*Öğrenciler bu dönemde somuttan soyuta olacak şekilde dönüşümleri iyi kavrayıp uygulayabilmektedir."* diyerek öğrencilerin somut matematiksel kavramları soyutlamayı öğreneceğini göstermiştir. Öğrencilerin örüntüleri kullanarak problem çözme ve formüle edebilme yeteneklerini geliştirebileceklerini ifade eden öğretmen adaylarından Ö5 *"Öğrenci örüntüde mantık yürüterek problem çözme yeteneğini arttırabilir"* derken Ö18 *"Örüntüyü formüle ederek problem çözmede kolaylık sağlanabilir."* diyerek formüle edebilmeyi kolaylaştıracağını ifade etmiştir. Buna ek olarak öğretmen adayları tarafından örüntülerin zihinde canlandırma yeteneğini artırdığı ve öğrencilere matematiksel kavramları görsel olarak anlama becerisi kazandırdığı, algoritmik ve cebirsel düşünmeyi teşvik ettiği matematiksel kavramların gerçek dünyadaki durumlarla ilişkilendirilmesine yardımcı olduğu, üst düzey sayı dizilimlerini anlama yeteneğini artırdığı, örüntülerin tamamlama, eksik parçayı tanımlama ve örüntüdeki bağlantıları kurma becerilerini geliştirdiği ve matematiksel zekanın gelişimine katkıda bulduğu belirtilmiştir.

B. Öğretmen Adaylarının Örüntülerin Bilişsel Gelişimdeki Önemine İlişkin Görüşleri

Öğretmen adaylarının örüntülerin önemine ilişkin verdiği diğer cevaplar bilişsel gelişime ilişkindir ve bu temaya göre sınıf öğretmeni adaylarının görüşleri Tablo 3'te sunulmuştur.

Tablo 3. Bilişsel gelişime ilişkin kodlar

Kodlar	**Öğretmen Adayları**	**f**
Çıkarım yapma	Ö5, Ö6, Ö8, Ö13, Ö15, Ö20, Ö21, Ö25, Ö26, Ö27, Ö29, Ö32, Ö33, Ö35, Ö37, Ö41, Ö42, Ö43, Ö46	19
Muhakeme/akıl yürütme	Ö4, Ö5, Ö6, Ö9, Ö14, Ö24, Ö31, Ö40, Ö47, Ö48	10
Analiz etme	Ö6, Ö15, Ö31, Ö35, Ö39, Ö42, Ö43	7
Sentez becerisi	Ö10, Ö19, Ö30, Ö33, Ö42, Ö43	6
Analitik düşünme	Ö4, Ö14, Ö16, Ö28, Ö48	5
İlişkili öğrenme	Ö14, Ö17, Ö21, Ö23, Ö35	5
Çok yönlü düşünme	Ö3, Ö7, Ö35	3
Tahmin etme	Ö4, Ö15, Ö48	3
Eleştirel düşünme	Ö4, Ö14	2
Bilgisayarca düşünme	Ö1	1
Görsel hafıza gelişimi	Ö6	1
Sistematik düşünme	Ö18	1
Yaratıcılık	Ö31	1

Öğretmen adayları, örüntülerin kullanımının öğrencilerin çıkarım yapma, muhakeme ve akıl yürütme becerilerini geliştireceğine dikkat çekmiş, öğrencilere matematiksel yapıları analiz etme ve sentezleme yeteneklerini geliştirme fırsatı sağladığını ifade etmişlerdir. Ö5 *"Öğrenci örüntülerde çıkarım yapabilmesiyle beraber kuralı kavrayabilir ve mantık yürütebilir."* ve Ö8 *"Sınıf düzeylerinde örüntüler arasındaki ilişkileri fark etmesi, çıkarımlar yapması ve bunların kurallarını genelleyebilmesi matematiksel düşünmesine katkı sağlayıp bir sonraki öğrenmeleri için de temeller oluşturmaktadır."* ifadesiyle çıkarım yapmaya , Ö15 *"Örüntülerde bir sonrakinin ne olacağını tahmin etmek üst bilişsel becerilerden olan analiz yeteneğini geliştirir."* diyerek analiz etmeye, Ö43 *"Örüntüde değerlendirme ve genelleme yaparak da öğrencinin sentez yeteneğinin gelişmesine katkısı olur. Çözümlemeye yer verilmesiyle de analiz yeteneğinin gelişmeyi sağlanır."* cümlesiyle sentez becerisine vurgu yapmışlardır. Ayrıca görüşlerde örüntüleri kullanarak öğrencilerin analitik düşünme ve çıkarımda bulunma becerilerinin geliştirileceği, bu becerilerin, öğrencilerin bilgiyi analiz etmelerine yardımcı olurken, üst düzey öğrenme basamaklarına, senteze geçişlerini kolaylaştıracağı, örüntülerin genel yapısını analiz

ederek sonuçlara varma süreci, öğrencilerin diziler, cebir gibi matematiksel konulara hazırlanmalarına katkı sağlayacağı dile getirilmiştir.

IV. TARTIŞMA VE SONUÇLAR

Örüntüler, ilkokul öğrencilerinin matematiksel düşünme becerilerinin gelişiminde önemli bir rol oynar. Bu beceriler arasında cebirsel düşünme, akıl yürütme ve genelleme yer alır. İlkokul öğrencilerinin bilişsel gelişimde somut dönemde olmaları nedeniyle, örüntülerin öğretimi sınıf öğretmenleri tarafından dikkatli bir şekilde planlanması ve uygulanması gereken bir konudur. Yalnızca dersin bir konusu olarak görülmemesi gereken örüntüler öğrencilerin matematiksel düşünme süreçlerini güçlendirirken, ileriki yıllarda edinmeleri gereken daha karmaşık matematiksel becerilere sağlam bir temel oluşturur. Bu nedenle, sınıf öğretmeni adaylarının örüntülerin matematik öğretimi içindeki önemini kavramaları ve öğrencilerin bu konuda gelişimini desteklemek için uygun adımları izlemesi önem taşımaktadır.

Araştırma sonucunda sınıf öğretmeni adaylarının örüntülerin günlük hayatla ilişkilendirileceğini ve tahmin etme becerisini geliştireceğini düşündükleri ortaya çıkmıştır. Bu bulgu Çilingir ve Yanpar Yelken'in çalışmasındaki bulguyla desteklenmiştir [24]. Çalışmalarında günlük yaşamda geleceği tahmin edip hayatı planlama ve bir olay veya davranıştan sonra ne olacağına dair düşünce geliştirmede örüntülerin kullanılabileceği ifade edilmiştir. Bu sonuç çalışmamızdaki sonucu desteklemektedir. Ayrıca öğretmen adayları örüntülerin çok yönlü düşünmeyi sağladığını, muhakeme ve akıl yürütme becerisinin kullanıldığını yaratıcılığı sağladığını ifade etmişlerdir. Bu sonuç Çilingir ve Yanpar Yelken'in çalışmasının sonucu ile paralellik göstermektedir [24]. Lannin öğrencilerin genellemelerinin geçerliliğine ilişkin anlayışın geliştirilmesinin örüntü oluşturma etkinliklerinde önemli olduğunu vurgulamıştır [30]. Öğretmen adayları örüntünün genelleme becerisi geliştirdiğini ifade ettiği bulguyu desteklediği görülmektedir.

Yapılan araştırma sonucunda öğretmen adayları örüntülerin matematiksel düşünceyi ve bilişsel gelişimi destekleme açısından öneme sahip olduğunu vurgulamaktadır. Örüntüler öğrencilerin genelleme becerilerini geliştirmelerini ve gelişim düzeylerine uygun olarak somuttan soyuta doğru öğrenmelerini sağlamaktadır. Ayrıca örüntülerin analiz edilmesiyle örüntüde elde edilen kuralları formüle ederek genelleyebilirler. Bu becerilerin geliştirilmesi de analitik ve mantıksal düşünen, matematiksel zekası gelişen öğrencilerin problem çözmelerini kolaylaştırır. Ayrıca sonraki derslerde ve sınıf düzeylerinde görecekleri cebir konusunun da temelini atarlar. Günlük hayatla ilişkilendirilmesi sağlandığında bilgiler ezber bilgi olmaktan çıkarak günlük hayata aktarılabilir. Örüntülerin öğrenilmesiyle birlikte çıkarım yapabilen, akıl yürütebilen, muhakeme yapabilen öğrencilerin analiz yetenekleri sayesinde karmaşık matematiksel konuların üstesinden gelebilir. Sonuç olarak matematik eğitiminde örüntülerin önemi diğer beceriler ve yeteneklerle birlikte gelişimi sağlanır. Öğrenciler problem çözme, analiz etme, sentez yapma gibi üst düzey düşünme becerilerini kazanır. Öğretmen adaylarının görüşleri doğrultusunda matematik derslerinde örüntülerin önemi konusunda bilgi birikimine sahip oldukları, genel olarak örüntülerin önemini anladıkları ve matematikteki değerinin farkında oldukları görülmüştür. Araştırma sonucunda örüntülerin önemine ve sınıf içi uygulamalarına ilişkin farklı yöntemlerle farklı örneklemlerde yeni araştırmalar tasarlanması önerilebilir. Ayrıca sınıf öğretmenlerinin örüntülerin önemini anlama ve öğrencilerine öğretme süreçleriyle ilgili farklı araştırmalar yürütülebilir.

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Özet **–** Bilgi işlemsel düşünme uzun süredir bilgisayar bilimlerinde öğretilen bir problem çözme yaklaşımıdır. Son zamanlarda diğer disiplinlere de entegre edilmeye başlanan bilgi işlemsel düşünme algoritmaların kullanılarak çözümler üretilmesi avantajını sağlar. Her bireyin eğitiminde analitik yeteneğinin yanı sıra bilgi işlemsel düşünme becerisini de geliştirmesi gerekmektedir. Bu araştırmada Türkiye'de bilgi işlemsel düşünme konusunda yürütülmüş lisansüstü tezler incelenmiştir. Bu bağlamda YÖK Ulusal Tez Merkezi veri tabanında anahtar kelime taraması yapılmıştır. Tarama sonucunda bilgi işlemsel düşünme ve bilgisayarca düşünme üzerine 133 lisansüstü tez olduğu belirlenmiştir. Lisansüstü tezler doküman incelemesiyle incelenmiştir. Ulaşılan tezlerin incelenmesi amacıyla araştırmacılar tarafından "Tez inceleme formu" hazırlanmıştır ve ilgili lisansüstü tezler; yayın yılı, yayın dili, yayın türü, tezlerin yürütüldüğü üniversite, örneklem, çalışma grubu özellikleri, araştırmanın modeli, kullanılan veri toplama araçları olmak üzere çeşitli değişkenler açısından incelenmiştir. Veri çözümlenmesi sürecinde frekanstan yararlanılmıştır. Sonuçlar şekil ve tablolar üzerinde gösterilmiştir. Araştırmanın sonuçlarına göre bilgi işlemsel düşünme ve bilgisayarca düşünme konusunda 47 farklı üniversitede 133 tezin yürütüldüğü, yürütülen tezlerin çoğunluğunun yüksek lisans türünde olduğu, özellikle 2022 ve 2023 yıllarında bu konuda yürütülen tezlerde artış gözlemlendiği, 67 tezin nicel yöntemle yapıldığı, 42 tezin ise karma yöntem ile yürütüldüğü, tezlerde çalışma grubunun sıklıkla öğrencilerden oluştuğu ve öğrenciler arasında da en çok ortaokul öğrencileri ile çalışmaların yapıldığı ve veri toplama yöntemi olarak ölçeklerin sıklıkla tercih edildiği sonucuna ulaşılmıştır.

Anahtar Kelimeler – Bilgi işlemsel düşünme, Bilgi işlemsel düşünme becerisi, Bilgisayarca düşünme, Doküman İnceleme, Lisansüstü tez.

I. GİRİŞ

Bilgisayar bilimlerinde uzun zamandır öğretilen bilgi işlemsel düşünme becerisi, son zamanlarda diğer disiplinlere de entegre edilmeye başlanmıştır. Bilgi işlemsel düşünme bilgisayar programcıları tarafından kullanılan bir problem çözme yaklaşımıdır [1]. Bu yaklaşımın avantajı bilgisayar kodu kullanılarak algoritmalar aracılığıyla çözümler üretilebilmesidir. Bilgi işlemsel düşünme (Computational Thinking, CT) kavramı kodlama eğitimi bağlamında ilk kullanan Seymour Papert [2] olmasına rağmen bilgi işlemsel düşünmenin tanımını ilk defa Wing [3] yapmıştır. Wing'e [3] göre "bilgi işlemsel düşünme, bilgisayar biliminin kavramlarını kullanarak problem çözme, insan davranışlarını anlama ve sistem tasarlama üzerinde durur" (s. 33). Genel anlamda bilgi işlemsel düşünme "bilgisayar biliminin kavramlarından yararlanarak problem çözme, sistem tasarlama ve insan davranışlarını anlama" olarak ifade edilebilir [4]. Wing [3] bilgi işlemsel düşünmenin bilgisayar düşünmesini modellediğini ve bilgi işlem süreçlerinin gücü ve sınırlarına dayandığını, bu nedenle hiç kimsenin tek başına çözemeyeceği sorunları çözme olanağı sunduğunu söylemektedir. Bu anlamda bilgi işlemsel düşünme sadece bilgisayar

bilimcileri için değil, herkes için temel bir beceridir. Her çocuğun analitik yeteneğine okuma, yazma ve aritmetiğin yanı sıra bilgi işlemsel düşünme de eklenmelidir [3].

Bilgi işlemsel düşünme kavramının kökleri, Papert'in LOGO programlama dili üzerindeki çalışmalarına ve çocukların bilgisayarı manipüle etme fikrine dayanır, bu da onların programlama yoluyla işlemsel düşünce geliştirmelerine olanak sağlar [5]. Papert [5], çocukların bilgisayar programlamayı öğrenmeye başladıklarında, öğrenme sürecinin dönüştüğünü öne sürmüştür. Bu dönüşüm, öğrenmenin daha aktif, kişisel ve kendi kendine yönlendirilen bir sürece dönüşmesiyle karakterizedir. Başlangıçta programlamayı matematikle ilişkilendirmiş olsa da bilim ve edebiyat gibi çeşitli disiplinlerde düşünme ve öğrenmeyi kolaylaştırmaya yönelik bir araç olarak görmüştür. Bilgi işlemsel düşünmenin temeli bir sorunla karşılaşıldığında bilgisayar bilimcileri gibi düşünmektir [7]. ISTE [8]'e göre bilgi işlemsel düşünme, insanların yaratıcılık, mantıklı düşünme ve eleştirel düşünme becerilerini kullanarak dijital teknolojilerle problem çözme kapasitelerini artıran bir yaklaşımdır. Korkmaz ve arkadaşları [9] bilgi işlemsel düşünme, insanların problem çözme, sistem tasarımı ve bilgisayar biliminin temel kavramlarına odaklanarak insan davranışlarını anlama ve günlük yaşamdaki problemleri çözmek için bilgisayarları üretim aracı olarak kullanma becerisini ifade eder; gelecekte temel becerilerden (okuma, yazma ve aritmetik) biri olarak kabul edilerek herkes için önemli bir beceri haline gelebilir. Wing [3] bu görüşü destekleyerek okuma, yazma ve aritmetiğe bilgi işlemsel düşünme eklenmesi gerektiğini belirtmiştir. Voogt ve arkadaşları [10] bilgi işlemsel düşünmenin her çocuğun analitik yeteneğine eklenmesi gereken evrensel bir yetenek olarak ifade etmiştir. Bilgisayar bilimi kavramlarına dayanan ancak bilgisayar biliminin aynısı değildir. Bilgisayar bilimi bilgisayarları ve hesaplamalı sistemleri incelerken bilgi işlemsel düşünme karmaşık problemleri çözer ve çeşitli problemlere aktarır. ISTE [8]'a göre bilgi işlemsel düşünme, bilgisayar ve diğer araçları kullanarak verileri mantıklı bir şekilde organize etmeyi, analiz etmeyi, verileri modeller ve simülasyonlar gibi soyutlamalar aracılığıyla temsil etmeyi, algoritmik düşünmeyi, olası çözümleri tanımlamayı, uygulama ile en verimli adımlar aracılığıyla problem çözümlerini genellemeyi ve transfer etmeyi içermektedir. Bu nedenle teknoloji ve düşünce birleşimini güçlendiren bir problem çözme yaklaşımıdır. Bu açıdan bilgi işlemsel düşünme becerisi yaratıcı düşünme, algoritmik düşünme, eleştirel düşünme, problem çözme, işbirlikli öğrenmeyi kapsamaktadır [8].

Son zamanlarda 21. yüzyıl öğrenme becerileri arasında önemli bir yere sahip olan ve geniş bir disiplinler arası ilgi görmektedir ve bu beceriler sadece temel akademik bilgiyle sınırlı kalmayıp, eleştirel düşünme, etkili iletişim, problem çözme, iş birliği ve yaratıcı düşünme gibi becerileri de kapsamaktadır [11]. 21. yüzyılı anlamanın, bilgi işlemsel düşünme becerisini kavramayı gerektiği vurgulandığında [12] bilgi işlemsel düşünme, bilgisayar biliminin kavramlarından yararlanarak okuma, yazma ve aritmetik gibi temel becerilere ek olarak her çocuğun analitik yeteneğini, problem çözme, sistem tasarlama ve insan davranışlarını anlama süreçlerini içermelidir [3]. Bu düşünme biçimi, özellikle bilgi işleme süreçlerinin gücü ve sınırlarını anlama üzerine odaklanır ve karmaşık problemleri çözme yeteneği sunar. Günümüz eğitiminde, gelişen ve yaygınlaşan daha güçlü bilgisayar araçları ve mobil teknolojiler, bilgi işlemsel düşünme konusuna yönelik ilgi ile odağın artmasına yol açtı ve bilgi işlemsel düşünmenin önemi giderek artmaktadır çünkü sadece bilgisayar bilimcileri için değil, herkes için temel bir beceri olarak kabul edilmektedir. Nordby ve arkadaşları [13], literatür incelemesi sonucunda 2015-2020 yılları arasında bilgi işlemsel düşünmeye odaklanan çalışmaların arttığını belirtmektedir. Ayrıca matematik eğitiminde bilgi işlemsel düşünmenin dünya çapında yaygın olduğu sonucuna ulaşılmıştır. Özellikle bilgi işlemsel düşünme ile ilgili yapılan araştırmaların incelenmesi gelecekteki araştırmalara dair önemli ipuçları sunabilir.

Bu araştırmanın amacı bilgi işlemsel düşünme ve bilgisayarca düşünme alanında Türkiye'de yapılmış lisansüstü tezlerin çeşitli değişkenlerle analizinin yapılarak, yapılacak çalışmalara yeni bir bakış açısı ve farklı fikirlerle alana katkıda bulunmaktadır. Bu amaç doğrultusunda aşağıda belirtilen sorulara cevap aranmıştır. Bilgi işlemsel düşünme ve bilgisayarca düşünme hakkında yapılan tezlerin;

1. Tezler hangi yıllarda yazılmıştır ve dağılımları nasıldır?
2. Yayın dili bakımından dağılımı nasıldır?
3. Tezlerin türleri nedir?
4. Tezlerin yürütüldüğü üniversiteler hangileridir?

5. Tezlerde kullanılan araştırma türleri nelerdir?
6. Tezlerde hangi gruplarla çalışılmıştır?
7. Tezlerde kullanılan veri toplama yöntemleri nelerdir?

II. YÖNTEM

Araştırmada bilgi işlemsel düşünme ve bilgisayarca düşünme üzerine yazılmış lisansüstü tezlerin incelenmesi amacıyla nitel araştırma yöntemlerinden doküman incelemesi yapılmıştır. Doküman incelemesi, araştırmanın odaklandığı konularla ilgili yazılı materyallerin detaylı bir şekilde incelenmesini içerir [14].

A. Çalışma Materyali

Çalışmanın evrenini bilgi işlemsel düşünme ve bilgisayarca düşünme alanında hazırlanmış lisansüstü tezler oluşturmaktadır. Araştırmanın örneklemi amaçlı örnekleme yöntemlerinden ölçüt örneklemedir. Ölçüt örneklemede belirli niteliklere veya özelliklere sahip olan araştırmanın amacına uygun nitelikteki katılımcı veya belgeler seçilir [15]. Bu araştırmada lisansüstü tezlerin araştırmaya dahil edilmesindeki kriterler; bilgi işlemsel düşünme ve bilgisayarca düşünme anahtar kelimelerini içermesi, YÖK Ulusal Tez Merkezi veri tabanında yayımlanmış olmasıdır. Bu doğrultuda YÖK Ulusal Tez Merkezi veri tabanı kullanılarak anahtar kelimeler taratılmış ve tarama sonucunda 135 teze ulaşılmıştır. Ancak çalışmalardan 2 tanesinin erişiminin kısıtlandığı tespit edilmiştir. Bu nedenle 133 lisansüstü tez çalışma materyaline dahil edilmiştir.

B. Verilerin Toplanması

Bilgi işlemsel düşünme yöntemi, bilgi işlemsel düşünmenin özüdür ve genel olarak, iki ana tür bilgi işlemsel düşünme yöntemi bulunmaktadır. Bunlardan biri matematik ve mühendislikten gelir, diğeri ise bilgisayar bilimine özgü yöntemdir [16]. Bu nedenle araştırmanın ilk aşamasında YÖK'ün resmi internet sitesinde bulunan ulusal tez merkezi sayfasında bilgi işlemsel düşünme ve bilgisayarca düşünme anahtar kelimeleri aratılmış ve erişime açık olan tezler indirilmiştir.

C. Veri Analizi

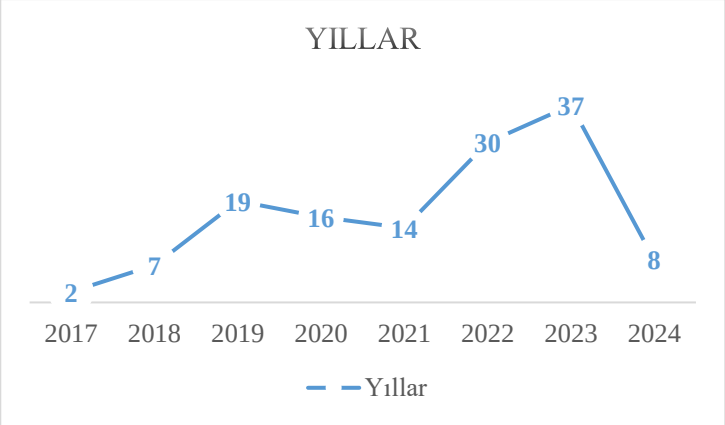
Araştırmacılar çalışmanın amacına uygun olarak tez inceleme formu geliştirmiştir. Bu form ilgili alanyazın taranarak benzer çalışmaların tez inceleme formu incelenerek hazırlanmıştır. Formda incelenen tezlerin yayın yılı, yayın dili, yayın türü, tezlerin yürütüldüğü üniversite, örneklem, çalışma grubu özellikleri, araştırmanın modeli ve kullanılan veri toplama araçları hakkında bilgiler yer almaktadır.

III. BULGULAR

Son yıllarda bilgi işlemsel düşünme ve bilgisayarca düşünme alanında hazırlanmış lisansüstü tezlerin ayrıntılı olarak incelenmesi amaçlanan bu araştırma kapsamında ulaşılan tezlerden elde edilen verilere yönelik bulgu ve yorumlar bu kısımda yer almaktadır.

A. Tezlerin Yayınlandığı Yıl

İncelenen tezlerin yayın yıllarına göre dağılımı Şekil 1'de yer almaktadır.



Şekil 1. Tezlerin yayınlandığı yıllar ve dağılımları

Şekil 1'de göre, bilgi işlemsel düşünme ve bilgisayarca düşünme alanındaki tezlerin sayısı yıllara göre artış göstermektedir. 2017 yılında çok az tez yapılmışken, 2018 yılından itibaren bu tezlerin sayısında belirgin bir artış gözlenmektedir. Özellikle 2022 ve 2023 yıllarında ise sıçrama niteliğinde büyük bir artış yaşanmıştır. Bu artışın nedeni, bilgi işlemsel düşünme ve bilgisayarca düşünmeye olan ilginin artması olabilir. 2024 yılında ise tezlerin sisteme yüklenmesinde yaşanan gecikmelerden dolayı bir düşüş gözlenmiş olabileceği düşünülmektedir.

B. Tezlerin Yayın Dili

Tezlerin yayın diline göre dağılımı Tablo 1'de gösterilmiştir.

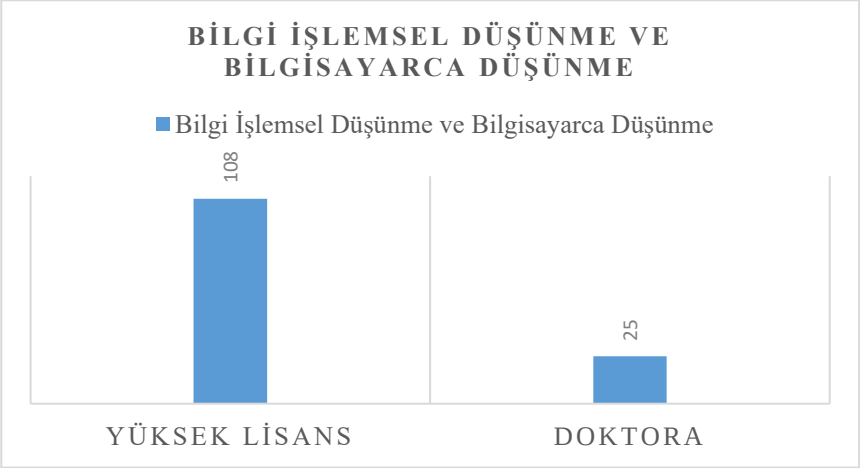
Tablo 1. Tezlerin yayın dili

Yayın Dili	Yüksek Lisans	Doktora	f
Türkçe	100	24	124
İngilizce	8	1	9
Toplam	108	25	133

Tablo 1'de toplam 124 tezin Türkçe ve 9 tezin İngilizce olduğu, İngilizce olan 8 tezin yüksek lisans tezi ve 1 tezin ise doktora tezi olduğu, Türkçe olan tezlerden ise 100 tezin yüksek lisans ve 24 tezin de doktora tezi olduğu tespit edilmiştir.

C. Tezlerin Yayın Türü

İncelenen tezlerin yayın türüne göre dağılımı Şekil 2'de sunulmuştur.



Şekil 2. Tezlerin türleri

Şekil 2 incelendiğinde, alanyazında mevcut tezlerin büyük çoğunluğu yüksek lisans tezlerinden (f=108) oluşmaktadır. Doktora tezlerinin sayısı ise sadece 25'tir. Çalışmada incelenen tezlerin yayın türü ve yayın yılına göre dağılımı Tablo 3'te verilmiştir.

Tablo 2. Tezlerin yayın yılı ve yayın türüne göre dağılımı

Yıllar	Yüksek Lisans	Doktora	f
2017	2	0	2
2018	4	3	7
2019	17	2	19
2020	10	6	16
2021	11	3	14
2022	26	4	30
2023	31	6	37
2024	7	1	8
Toplam	108	25	133

Tablo 2 verileri incelendiğinde 2023 yılında 31 yüksek lisans ve 6 doktora teziyle en çok lisansüstü tezin yapıldığı yıl öne çıkmakta; buna karşın 2017 yılında yalnızca 2 yüksek lisans tezi görülmektedir.

D. Tezlerin Yayınlandığı Üniversite

Tezlerin yayınlandığı üniversiteye göre listesi Tablo 3'te gösterilmiştir.

Tablo 3. Tezlerin yürütüldüğü üniversiteler

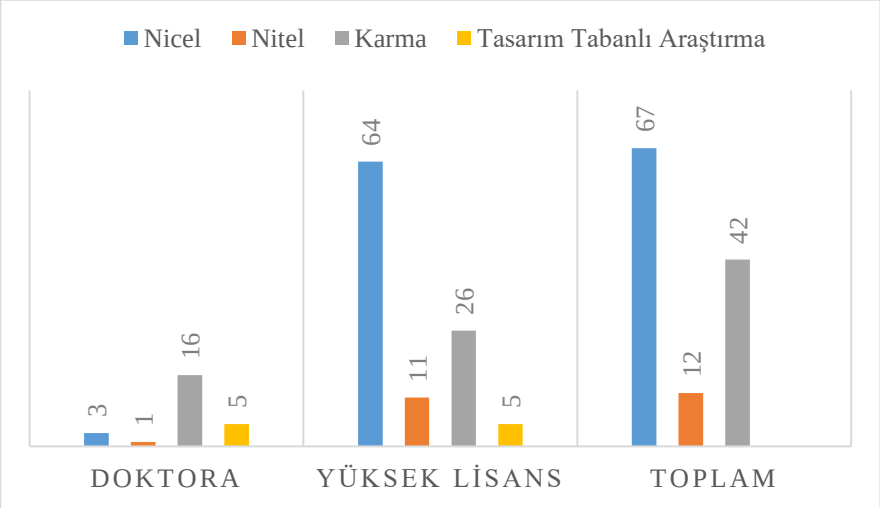
Üniversiteler	f
Mersin Üniversitesi	8
Atatürk Üniversitesi	7
Trabzon Üniversitesi	7
Boğaziçi Üniversitesi	6
Marmara Üniversitesi	6
Gazi Üniversitesi	6
Hacettepe Üniversitesi	6
Van Yüzüncü Yıl Üniversitesi	5
Ondokuz Mayıs Üniversitesi	4
Ankara Üniversitesi	4
Çanakkale Onsekiz Mart Üniversitesi	4
Gaziantep Üniversitesi	4
Sakarya Üniversitesi	4
Necmettin Erbakan Üniversitesi	4
Bolu Abant İzzet Baysal Üniversitesi	4
Aydın Adnan Menderes Üniversitesi	4
Yıldız Teknik Üniversitesi	4
Amasya Üniversitesi	3
Süleyman Demirel Üniversitesi	3
Afyon Kocatepe Üniversitesi	3
Bartın Üniversitesi	3
İstanbul Üniversitesi	2
Orta Doğu Teknik Üniversitesi	2
Bahçeşehir Üniversitesi	2
Çukurova Üniversitesi	2
Burdur Mehmet Akif Ersoy Üniversitesi	2
İnönü Üniversitesi	2
Ege Üniversitesi	2
Fırat Üniversitesi	2

Bursa Uludağ Üniversitesi	1
Düzce Üniversitesi	1
Aksaray Üniversitesi	1
Kırıkkale Üniversitesi	1
Pamukkale Üniversitesi	1
Kastamonu Üniversitesi	1
Giresun Üniversitesi	1
Ordu Üniversitesi	1
Trakya Üniversitesi	1
Niğde Ömer Halisdemir Üniversitesi	1
Okan Üniversitesi	1
Hatay Mustafa Kemal Üniversitesi	1
Balıkesir Üniversitesi	1
Muğla Sıtkı Kocaman Üniversitesi	1
Başken Üniversitesi	1
Tokat Gaziosmanpaşa Üniversitesi	1
Recep Tayyip Erdoğan Üniversitesi	1
Manisa Celal Bayar Üniversitesi	1

Tablo 3'e göre, bilgi işlemsel düşünme ve bilgisayarca düşünme alanında yapılan 133 tez çalışmasının 47 farklı üniversite tarafından yürütüldüğü ve bu alanda en fazla tez çalışması yapan üniversitelerin sırasıyla Mersin Üniversitesi, Trabzon Üniversitesi ve Marmara Üniversitesi olduğu belirlenmiştir.

E. Tezlerde Kullanılan Araştırma Türleri

Bilgi işlemsel düşünme ve bilgisayarca düşünme alanında yer alan tezlerin kullandığı araştırma türlerine göre dağılımı Şekil 3'te sunulmuştur.



Şekil 3. Tezlerde kullanılan araştırma türleri

Şekil 3 incelendiğinde yapılan araştırmalarda nicel araştırma yöntemleri (f=67) en sık tercih edilen yöntem olarak öne çıkmaktadır. Karma yöntemler (f=42) ise tez çalışmalarında ikinci sırada yer almaktadır. Nitel araştırma yöntemleri (f=12) ise bilgi işlemsel düşünme ve bilgisayarca düşünme konularında en az tercih edilen yöntemler arasındadır. Araştırma türlerinin dağılımı yayın türüne göre dağılımı incelendiğinde doktora tezlerinde (f=16) en fazla karma yöntem kullanılırken, en az ise nitel yöntem (f=1) tercih edilmiştir. Yüksek lisans tezlerinde ise nicel yöntemler (f=64) en fazla tercih edilen yöntem iken tasarım tabanlı araştırmalar (f=5) en az tercih edilen yöntemdir.

F. Tezlerde Yer Alan Çalışma Grupları

Araştırmada incelenen tezlerin çalışma grubu ve örneklem özelliklerine göre dağılımları Tablo 4'te verilmiştir.

Tablo 4. Tezlerin çalışma grubu ve örneklem özelliğine göre dağılımı

Çalışma Grubu/Örneklem	Tez		f
	Yüksek Lisans	Doktora	
Öğrenci	84	17	101
Öğretmen	12	3	15
Öğretmen adayı	9	2	11
Üniversite öğrencisi	3	1	4
Belge	3	1	4
Diğer	2	1	3

Tablo 4'teki çalışma grubu ve örneklemler bazı tezlerde birlikte incelemeye dahil edildiğinden verilen değerler tez sayısına karşılık gelmemektedir. Çalışma grupları ve örneklemlere göre incelenen tezlerde en çok tercih edilen grubun öğrenciler olduğu, öğrencilerden ise en fazla ortaokul öğrencileri (f=70) ve ardından lise öğrencileri (f=11) ile tezlerin yapıldığı görülmektedir. İlkokul öğrencileriyle (f=8) ve okul öncesi öğrencileriyle (f=3) yapılan çalışmalar ise en az olanlardır.

G. Tezlerde Kullanılan Veri Toplama Yöntemleri

Tezlerde kullanılan veri toplama araçlarının incelenmesi sonucunda elde edilen bilgiler Tablo 5'te gösterilmiştir.

Tablo 5. Tezlerin veri toplama araçlarına göre dağılımı

Veri Toplama Aracı	Yüksek Lisans	Doktora	f
Ölçek	85	17	102
Görüşme formu	34	15	49
Başarı testi	23	7	30
Test	25	0	25
Gözlem formu	13	8	21
Rubrik	7	5	12
Odak grup görüşmeleri	3	6	9
Belge taraması	5	3	8
Envanter	5	2	7
Araştırmacı notları	2	5	7
Anket	4	2	6
Gözlem notları	3	2	5
Bilge Kunduz Uluslararası Enformatik ve Bilgi İşlemsel Düşünme Etkinliği	4	0	4
Toplam	213	72	285

Tablo 5 verileri incelendiğinde en fazla tercih edilen veri toplama araçlarının ölçek (f=102) olduğu; yüksek lisans tezlerinde ve doktora tezlerinde de benzer şekilde ölçeklerin en fazla tercih edildiği görülmektedir. Ölçeklerden sonra en sık kullanılan veri toplama araçları görüşme formu ve başarı testidir. Doktora tez çalışmalarında testlerin hiç kullanılmadığı, yüksek lisans tezlerinde ise en az araştırmacı notlarının kullanıldığı görülmektedir.

IV. TARTIŞMA

Bilgi işlemsel düşünme ve bilgisayarca düşünme konusuyla ilgili olarak, 2017 ile 2024 yılları arasında lisansüstü tezlerin yazıldığı, 2017 yılından önce ise bu konuda herhangi bir tez bulunmadığı belirlenmiştir. Wing'in [3] 2013 yılı öncesini bilgi işlemsel düşünme açısından bir başlangıç aşaması olarak değerlendirmesi, bu alandaki farkındalığın son yıllarda arttığını gösterebilir.

İncelenen tezlerde, çalışma grubu ve örneklemlerin genellikle öğrencilerden oluştuğu belirlenmiştir. Ezeamuzie ve Leung [17], 2013 öncesinde inceledikleri çalışmaların çoğunun okul ortamında gerçekleştirildiğini ortaya koymuştur. Bu, bilgi işlemsel düşünmenin sınıfta öğretilebilir bir beceri olarak

olumlu bir şekilde değerlendirildiğini göstermektedir. Ayrıca, çalışmamızda ortaokul öğrencileriyle yapılan araştırmaların sıklıkla yapıldığı, ancak anaokulu ve lise öğrencileriyle yapılan çalışmaların daha az olduğu gözlemlenmiştir. Bu bulgular, Ezeamuzie ve Leung [17] çalışmasında da anaokullarında yapılan araştırmaların az sayıda olduğunu ve lise öğrencileriyle yapılan müdahalelerin sınırlı olduğunu göstermektedir. Benzer şekilde okullarda bilgi işlemsel düşünmeyi değerlendirmek üzere yapılan çalışmada en çok ortaokullarla çalışma yapıldığı görülmüştür [18].

V. SONUÇLAR

Bu araştırmada 2017-2024 yılları arasında bilgi işlemsel düşünme ve bilgisayarca düşünme üzerine yapılan tezlerin çeşitli değişkenlere göre incelenmesi amaçlanmıştır. Bu amaç doğrultusunda elde edilen bulgular ve bu bulgulara dayanarak yapılan sonuçlar maddeler halinde sıralanmıştır:

- Bilgi işlemsel düşünme ve bilgisayarca düşünme konusunda; 2017 ile 2024 yılları arasında 47 farklı üniversitede 108 yüksek lisans ve 25 doktora tezi yayınlanmıştır. Yayımlanan tezlerden 124 tez Türkçe olarak, 9 tez ise İngilizce olarak yazılmıştır.
- Bilgi işlemsel düşünme ve bilgisayarca düşünme konusunda en çok çalışma yapılan yıl 2022 ve 2023 iken 2017 yılından önce bu konu ile ilgili hiç çalışma yapılmadığı görülmüştür. Ayrıca 2023 yılında yapılan tez çalışmalarının diğer yıllara göre en yüksek değere ulaştığı dikkat çekmektedir.
- İncelenen tez çalışmalarında en çok tercih edilen yöntem nicel araştırma yöntemi olurken, bazı çalışmalarda karma yöntem ve nitel yöntem tercih edilmiştir.
- İncelenen tez çalışmalarında çalışma grubu/örneklemlerde daha çok öğrenciler üzerine yoğunlaşıldığı, öğrenciler arasında ise en çok ortaokul öğrencileri seçilmiştir.
- İncelenen tez çalışmalarında, veri toplama sürecinde en yaygın olarak tercih edilen aracın ölçek olduğu belirlenmiştir. Bu çalışmaların nicel araştırma yöntemleri kullanılarak yapılması, ölçek kullanımını artıran bir etken olarak görülmüştür.

Bilgi işlemsel düşünme ve bilgisayarca düşünme alanında yapılan bu çalışmanın sonuçlarına dayanarak, aşağıdaki öneriler sunulmuştur:

- Bilgi işlemsel düşünme ve bilgisayarca düşünme konusunda yapılan doktora çalışmalarının azlığı dikkat çekmektedir. Konu ile ilgili araştırma yapılması teşvik edilebilir.
- Bu çalışma Türkiye'de bilgi işlemsel düşünme ve bilgisayarca düşünme üzerine yapılan lisansüstü tezleri içermektedir. Konu ile ilgili diğer ülkelerde yapılan çalışmalar incelenebilir. Farklı ülkelerdeki bilgi işlemsel düşünme ve bilgisayarca düşünme eğilimleri ve uygulamaları karşılaştırılarak Türkiye'deki eğitim sistemine yönelik uyarlanabilir öneriler geliştirilebilir.
- Mevcut tezlerde daha çok ortaokul öğrencilerine odaklanıldığı görülmektedir. Gelecekteki araştırmalar ilkokul, lise ve üniversite seviyelerinde bilgi işlemsel düşünme ve bilgisayarca düşünme üzerine yapılan çalışmaları da inceleyerek, farklı yaş gruplarındaki eğilimleri ve ihtiyaçları belirlenebilir.
- Tezlerde ağırlıklı olarak nicel yöntemler kullanılmıştır. Gelecek çalışmalar için nitel araştırma yöntemlerini daha fazla kullanmak derinlemesine ve kapsamlı bilgi elde edebilir. Özellikle öğrenci ve öğretmen görüşlerine dayanan çalışmalar, alandaki mevcut durumun daha iyi anlaşılmasına katkı sağlayabilir.
- Öğrencilere yönelik çalışmaların yanı sıra öğretmenlerin bilgi işlemsel düşünme ve bilgisayarca düşünme konusundaki bilgi ve becerilerini artırmaya yönelik çalışmalar da yapılmalıdır. Bu, öğretmen eğitim programlarının geliştirilmesine katkı sağlayabilir.

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Röle Koordinasyonu ve Yük Akışı Analizi: Fotovoltaik Elektrik Dağıtım Şebekelerinde İnceleme

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Özet **–** Son yıllarda artan elektrik ihtiyaçlarına bağlı olarak, dağıtım şebekelerine birçok üretim birimi entegre edilmektedir. Bu kapsamda, üretim birimlerinin kurulumu öncesinde dağıtım şebekelerinde analizlerin yapılması, ileride yaşanabilecek entegrasyon problemlerinin önüne geçilmesi için gereklidir. Elektrik dağıtım sistemlerinin tasarım sürecinde, fotovoltaik (FV) sistemlerin dağıtım şebekesine entegrasyonundan kaynaklanabilecek potansiyel sorunlar ve operasyonel zorluklar dikkatle değerlendirilmelidir. Elektrik dağıtım şebekesinin güvenilir şekilde çalışmasını sağlamak için gerekli düzenlemeler oluşturulmalı ve kapsamlı planlar geliştirilmelidir. FV enerji sistemlerinin dağıtım şebekesine entegrasyonu, gerilim regülasyonu, harmonik sorunlar, bakım ve işletme topraklama yapısındaki değişiklikler, anlık kısa devre akım değerlerindeki artış, arıza sırasında veya arıza sonrasındaki davranışlar ve dağıtım şebekesinin gerilim ve frekans dalgalanmalarına verdiği tepkiler gibi konuları kapsamaktadır. Bunun yanında, jeneratörlerin karakteristiği, statik yükler ve tüketicilerin gereksinimleri de dağıtım şebekesinin karakteristiğini etkilemektedir. Bu kapsamda, bu çalışmada bir FV enerji santralinin dağıtım şebekesine entegrasyonu ile yük akış analizi ve röle koordinasyon kontrolü etkileri araştırılmış ve incelenmiştir. Yük akış analizinde, dağıtım şebekesinin verimliliği ve stabil çalışma durumu analiz edilerek tüketiciler ve şebeke için sağlıklı bir elektrik tedariği sağlanabilmektedir. Röle koordinasyon kontrolü ile arıza akımına en yakın yerden elektrik kesilerek, elektrik kesintisi birçok noktada hissedilmeden arıza bölgesi koruma altına alınmaktadır. Kısa devre arıza akımına karşı röle koordinasyon kontrolü ile aşırı akım önlenmekte ve arıza akımının devam etmesi durumunda ise kesici ile şebekenin enerjisi kesilmektedir. FV santralinin elektrik dağıtım şebekesine entegrasyonu, ETAP yazılım programı ortamında incelenmiş ve analiz edilmiştir.

Anahtar Kelimeler – Elektrik Dağıtım Sistemleri, ETAP, Fotovoltaik Enerji, Röle Koordinasyon, Yük Akış Analizi

I. GİRİŞ

Elektrik, insan hayatının kaliteli ve nitelikli gelişimi açısından vazgeçilmez bir gereksinimdir. Elektrik enerjisi talebi ve ihtiyacı incelendiğinde sürekli bir artış eğilimi gözlemlenmektedir. Bu çağda elektrik enerjisine duyulan talebin ve ihtiyacın sürekli artması, yenilenebilir enerji kaynaklarına (YEK) yönelimi artırmaktadır. Finansal unsurlar ve sanayinin gelişimine paralel olarak YEK' lerin önemi gün geçtikçe artmakta ve fotovoltaik (FV) enerji santrallerinin dağıtım şebekesindeki sayıları çoğalmaktadır. Elektriğe olan bağımlılığın dikkate alındığında, bu gelişim sürecinde dağıtım şebeke sisteminde sağlanan güvenilirlik ve devamlılık için ihtiyaçlar karşılanmalı ve entegrasyon problemleri giderilmelidir. Özellikle dağıtım şebeke sisteminde gerçekleşecek üretim entegrasyonları dikkat edilmesi gereken önemli bir kavramdır [1].

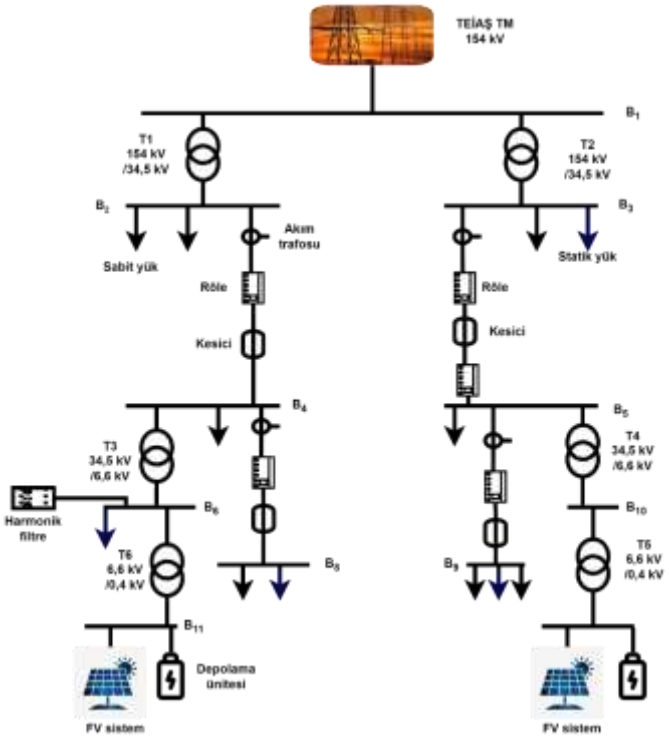
İki güç kaynağı arasındaki bağlantıda, gerilim, faz ve frekans gibi değişkenlerin eşit olması gerekmektedir. Kaynaklar arasındaki bağlantı, bu üç değişkenin her iki kaynakta da eşit olması durumunda gerçekleşmektedir. Bu entegrasyon sürecinde oluşabilecek problemlerin tasarım aşamasında belirlenmesi gerekmektedir. Bu doğrultuda, YEK' lerin standart yenilenebilir enerji sistemleri ile entegrasyonu,

depolama gereksinimini azaltacak ve uyum neticesinde kompleks sistem çözümleri elde edilecektir. Dağıtık üretim (DÜ) sistemleri için IEEE (Institute of Electrical and Electronics Engineers), DÜ'yü "Büyük ve merkezi üretimlere kıyasla, dağıtım ağının her bir noktasına bağlanabilecek kadar düşük güçlü üretimler" olarak tanımlamaktadır [2]. Uluslararası Enerji Ajansı ise DÜ'yü, "Müşteriye yerinde hizmet sunmak ve dağıtım ağına katkı sağlamak amacıyla dağıtım gerilim seviyelerinde şebekeye entegre edilen bir tür enerji üretim tesisi" olarak tanımlamaktadır [3]. DÜ kaynakları arasında rüzgar türbinleri, FV sistemleri, yakıt hücreleri, küçük hidroelektrik üretim tesisleri ve pistonlu motorlar gibi üretim kaynakları yer almaktadır. DÜ kapasitesi birkaç kilovattan onlarca megavata kadar değişmektedir [4]. Geleneksel merkezi üretimlerin aksine, DÜ elektrik enerjisinin son kullanıcıların yakınında küçük ölçeklerde üretilmesini ifade etmektedir. DÜ, günümüz yenilenebilir enerji oluşumunda bir değişim olarak görülmektedir [5]. Dağıtım sistemine dahil edilecek üretim birimleri hem dağıtım şebekesi hem de tüketici açısından yük ve gerilim profillerini önemli ölçüde etkilemektedir. Bu faktörler, dağıtım şebeke sistemi ve DÜ'nün işletme özelliklerine bağlı olarak olumlu ya da olumsuz olabilir [6]. Olumlu etkiler arasında dağıtım şebekesini destekleme, gerilim denge desteği, güç kalitesi verimliliğinde iyileşme, enerji kayıp-kaçağında azalma ve iletim şebekesi ve dağıtım şebeke kapasitesinin bağımlılığının kalkması yer almaktadır [7]. Dağıtım sistemine eklenecek üretim birimleri, gerilim dengesi, harmonik bozunum, topraklama uygunluğu, aşırı akım röle koruma koordinasyonu, kapasite sınırları ve şebeke güvenirliği açısından iyi değerlendirilmelidir [8]. DÜ, minimum güçlerde genel üretim sistemlerinin merkezi üretimine göre daha güvenilir bir enerji tedariki vaat etmektedir [9]. Dağıtılmış üretim, dağıtılmış üretim geliştiricileri ve sahipleri için önemli bir ekonomik faktör olmasının yanı sıra enerji kayıplarını azaltmakta, enerji arzının sürekliliğini artırmakta ve diğer teknik faydalar sağlamaktadır [10].

Arıza akımlarının artması sadece ekipman konumlandırmasını değil, aynı zamanda koruma uyumunu da etkilemektedir [11]. Dağıtım şebeke sistemine eklenen DÜ kaynakları olan YEK' lerin koruma koordinasyon çalışma sisteminde değişiklikler yapılması ve bazı önemli kısımların yeniden değerlendirilmesi gerekmektedir [12]. Dağıtım sistemine başka kaynakların eklenmesi, dağıtım sistemi üzerinde bazı etkilere neden olabilir. Üretilen enerjinin kalitesinin yanı sıra güç akışını değiştirebilir ve ayrıca gerilim değerleri ile kısa devre akımlarını da etkileyebilir. Bu tür enerji üretimini entegre etmek için koruma planlarındaki teknik zorlukların üstesinden gelmek gerekmektedir. DÜ, değişen kısa devre seviyeleri nedeniyle aşırı akım rölelerinin koruma koordinasyonu üzerinde olumsuz etkilere sahip olabilir. Aşırı akım röleleri, sistemin sağlıklı kısmının arızalanmamasını sağlamak ve gereksiz kesintileri önlemek için gereklidir [13].

II. MATERYAL VE YÖNTEM

Bu çalışmada, bir FV enerji santrali ve bu FV sistemin bağlı olduğu dağıtım şebekesi, ETAP yazılımı kullanılarak analiz edilmiştir. Analiz kapsamında FV sistemin entegrasyonuna etki eden durumlar ve çözüm yöntemleri incelenerek, verimlilik analizi yapılmıştır. Şekil 1' de, mevcut bir dağıtım şebekesinin 154 kV trafo merkezinden çıkan enerjinin farklı güçteki FV enerji santrallerine bağlantısı gösterilmektedir. ETAP yazılımı ve tasarım programı kullanılarak FV sistemin entegrasyonuna etki eden unsurların analizi ve çözüm yöntemleri geliştirilmiştir. Bu analizde yük akışı, röle koordinasyon uyumu, dağıtım merkezlerinin sayısı ve konumunun verimliliğe etkisi gibi unsurlar ele alınmıştır. Şekil 2' de belirtilen güç sisteminin algoritması, izlenecek adımlar ve başlıklar gösterilmektedir. Algoritmadan anlaşılacağı üzere, dağıtım sisteminde bulunan FV sistemlerde karşılaşılabilecek muhtemel entegrasyon problemleri belirtilmektedir. Bu problemler arasında FV sistemin tasarımı ve şebekeye entegrasyonu, harmonik etkileri, yük akış analizi, adalaşma riski, işletme topraklama yapısının değişimi, kısa devre akımının artması ve aşırı akım koruma rölesi koordinasyonunun bozulması gibi durumlar yer almaktadır. Bu çalışmada, ETAP yazılımı kullanılarak mevcut şebeke veya FV sistemin topoloji dizaynında yukarıda belirtilen entegrasyon problemlerine yönelik yapılan benzetim çalışmasından alınan sonuçlar değerlendirilmiş ve dağıtım şebekelerinde artan FV sistemlere yön verilmesi amaçlanmıştır.



Şekil 1. FV dağıtım şebeke topolojisi.

Şekil 2. Önerilen simülasyon algoritması.

A. Yük Akışı Analizi

Son yıllarda artan elektrik enerjisine olan talepler, dağıtım şebekelerinde elektrik üretim kaynaklarının artmasına neden olmuştur. Bu yaygınlaşan YEK sonucunda, dağıtım şebekesinin işletme ve topraklama noktalarında işleyiş karmaşık bir hale gelmiştir. Bu kapsamda, sorunların giderilmesi ve şebeke

büyümesinin kontrolünün sağlanması adına kapsamlı analizler yapılması gerekliliği ortaya çıkmıştır. Bu noktada, elektrik şebekelerinde yük akış analizi (YAA) kavramı önem kazanmıştır. Elektrik iletim ve dağıtım şebekelerinde sürekli hal durumuna ait karakteristik özelliklerin belirlenmesi için yapılan çalışma ve analizlere YAA denir. Bir şebekede YAA, belirli kısımlardaki bara koşulları için güç ve gerilimlerin hesabını içermektedir. Bu tip hesaplamalar, güç sistemlerinin dinamik davranışı kadar sürekli hal davranışının analizi için de gereklidir [14].

Dağıtım şebekesi topolojisinde ETAP yazılım programı üzerinde yapılan yük akış analizi, Newton-Raphson yöntemine dayanan AA yük akış analizi kullanılarak gerçekleştirilmiştir. Bu yöntem, AA yük akış analizini daha kısa iterasyonlarla ve sürede çözmektedir. YAA' da, şebeke sistemindeki bir baranın dışındaki tüm baraların net aktif ve reaktif güçleri belirlenmelidir. Net güç (aktif ve reaktif), sisteme giren (pozitif enjekte edilen) güç ile sistemden çıkan (negatif enjekte edilen) güç arasındaki farkı temsil eder. Yani, baraya bağlı üretim kaynağının verdiği güç ile yükün çektiği sabit veya statik güç arasındaki farktır. Sistemde gerilim kontrollü bir bara bulunuyorsa, bu baradaki sabit tutulacak gerilim genliği belirlenir ve çözüm sonucunda, baraya bağlı reaktif güç üreticisinin üretimi ile bara geriliminin açısı hesaplanır. YAA için giriş verileri; baralar, iletim hatları ve transformatör bilgilerini içerir. Her baranın gerilim genliği, faz açısı, net aktif güç ve reaktif güç değerleri bilinmelidir [15]. Baralar, salınım barası, yük barası ve gerilim kontrollü barası olmak üzere üç tipe sınıflandırılır. Salınım barası, her sistemde yalnızca bir tane bulunur ve genellikle bir numaralı baradır. Bu barada gerilimin genliği ve açısı ($V\angle\delta_i$) verilmekte olup, net aktif ve reaktif güç değerleri (P_k ve Q_k) yük akışından hesaplanmaktadır. Yük barası giriş bilgileri P_k ve Q_k şeklinde olup, V_k ve δ_k değerleri analiz yoluyla hesaplanır. P_k ve Q_k değerleri, Eşitlik 1'de verilen denklem üzerinden hesaplanabilmektedir [14].

$$P_k = P_{Gk} - P_{yk} \qquad (1)$$
$$Q_k = Q_{Gk} - Q_{yk}$$

Eşitlikte, P_{Gk} ve Q_{Gk} k. baraya bağlı jeneratörün sağladığı aktif ve reaktif gücü ifade ederken, P_{yk} ve Q_{yk} k. baraya bağlı yükün çektiği aktif ve reaktif gücü temsil etmektedir. Sistemdeki baraların çoğunluğu yük barası olarak sınıflandırılmaktadır. Gerilim kontrollü baranın giriş parametreleri P_k ve V_k olarak verilirken, Q_k ve gerilim açısı değerleri analiz sonucunda hesaplanmaktadır [14].. Yük akış analizi, Newton-Raphson hesaplama yöntemi kullanılarak gerçekleştirilmekte olup, Eşitlik 2'de verilen değerlerle tanımlanmaktadır.

$$X = \begin{pmatrix}\delta\\ V\end{pmatrix}, Y = \begin{pmatrix}P\\ Q\end{pmatrix}, f_{(x)} = \begin{pmatrix}P_x\\ Q_x\end{pmatrix} \qquad (2)$$

Newton-Rapson yöntemi kullanılarak yük akışı Eşitlik 3 ve Eşitlik 4 ile verilmiştir.

$$\Delta X(i) = \begin{pmatrix}\Delta\delta(i)\\ \Delta V(i)\end{pmatrix} = \begin{pmatrix}\delta(i+1) - \delta i\\ V(i+1) - Vi\end{pmatrix} \qquad (3)$$

$$\Delta y(i) = \begin{pmatrix}\Delta P(i)\\ \Delta Q(i)\end{pmatrix} = \begin{pmatrix}P - P_{x(i)}\\ Q - Q_{x(i)}\end{pmatrix} \qquad (4)$$

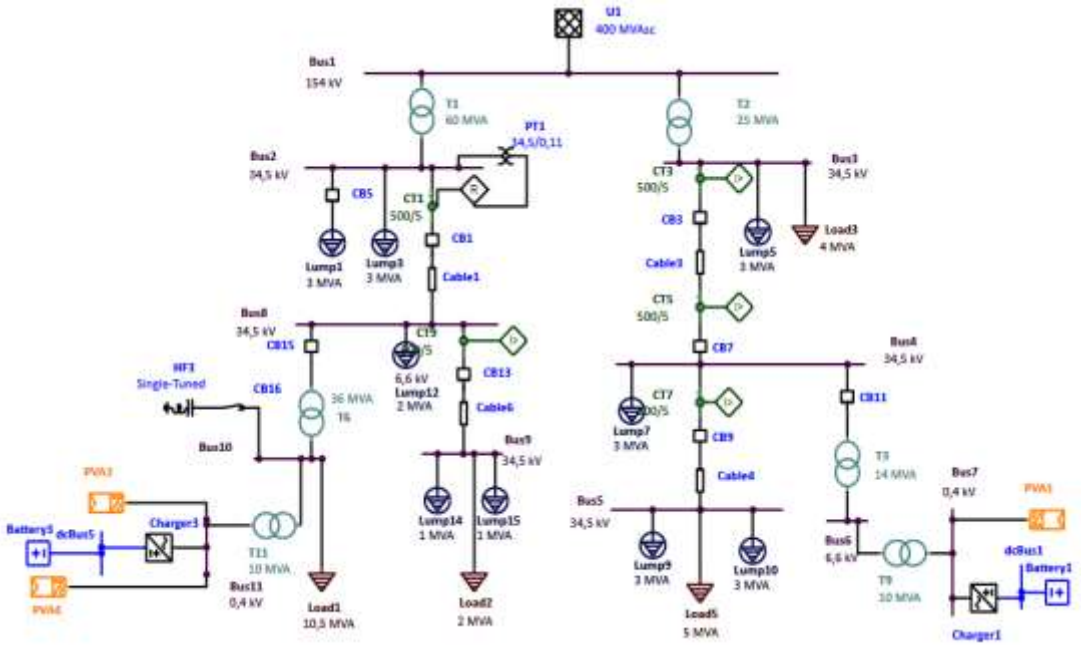
Eşitlij 3' te P ve Q vektörleri baralara enjekte edilen net aktif ve reaktif gücü içerir. Verilen denklemlere dayanan yinelemeler, dağıtım baraları üzerindeki yük akışının hesaplanmasını sağlar [15]. Bu çalışmada ETAP yazılım ortamında Bus 10' a entegre edilen PV enerji sisteminin aktif ve reaktif güç akışı analizinin yapıldığı dağıtım şebekesi üzerinde yük akış analizi yapılmıştır. Elde edilen sonuçlara göre dağıtım şebekesinden 1912 kW aktif güç ve 8,2 kVar reaktif güç akışı olurken, PV enerji sisteminden ise 1518 kW aktif güç ve 17 kVar reaktif güç gelmektedir.

B. Röle Koordinasyon Uyumu

Elektrik enerjisinin vazgeçilmez bir ihtiyaç haline geldiği bu dönemde, fosil yakıtların artan kullanımıyla elektrik tedariki bağımlılığı artmış, bu durumda tüketiciler ve endüstrinin YEK' lere yönelimi hızla artmıştır. Kırsal bölgelerde mevcut şebekenin radyal yapıda olması, enerji iletiminde uzun mesafeler ve dağıtım ağlarının oluşturulmasına yol açmıştır. Bu bağlamda, YEK' lerin kurulması ve bu kaynakların bölgesel olarak şebekeye entegre edilmesi gerekmektedir. YEK' ler, çevresel ve iklim koşullarından etkilendiğinden, şebeke üzerindeki yük akışını hızla etkileyebilmektedir. Bu süreçte, etkin bir şekilde kontrol altına alınarak şebeke koruması sağlanmalıdır. Elektrik güç sistemleri elemanlarının korunması için belirlenen sınır değerlerinin aşılması durumunda devreyi açıp kapayan röleler koruma sağlar. Röleler, elektrik şebekesinde bulunan akım trafoları ve kesiciler gibi devre elemanlarıyla koordineli olarak çalışarak ikincil koruma sağlarlar. Koruma röleleri, güç sistemlerinde kritik bir rol oynar [16]. Bu rölelerin koordinasyonu, hızlı, seçici ve güvenilir bir şekilde arızalı bölgelerin izole edilmesini sağlar. Akım trafoları, kesiciler ve diğer elemanlarla birlikte çalışarak sistemdeki anormal durumları tespit eder ve hatalı bölgeleri sistemden ayırır. Bu şekilde sistemin düzgün ve güvenilir bir şekilde çalışması sağlanır [19].

III. BULGULAR

Bu bölümde, ETAP benzetim programı kullanılarak FV sistemlerinin elektrik dağıtım şebekesine entegrasyonunun etkileri ve analizleri incelenmiştir. Şekil 3' de gösterilen güç sistemi topolojisi üzerinde yük akışı analizi ve röle koordinasyonu gibi çeşitli durum çalışmaları gerçekleştirilmiştir. Analizler, mevcut şebekeye FV sistemlerinin entegre edilip edilmediği durumları için yapılmıştır. Bu topoloji üzerinde, 11 dağıtım bara noktası, 6 adet indirici transformatör, farklı güçlerde (2 MW ve 4 MW) iki ayrı noktada yer alan FV sistemleri, 9 sabit tüketim noktası, 4 statik tüketim noktası (doğrusal olmayan yük), 1 basit harmonik filtre elemanı, FV sistemlere bağlı 2 batarya ünitesi ve kesicilere bağlı aşırı akım koruma röleleri bulunmaktadır. ETAP yazılım programı kullanılarak sistemin tasarım aşamasında transformatör parametreleri belirlenmiştir. Şebekede kullanılan 6 transformatörün, şebekeye uygun olarak belirlenen giriş ve çıkış gerilimleri sonrasında ETAP yazılım programı üzerinden transformatörlerin empedans ve direnç yüzdeleri hesaplanmıştır.

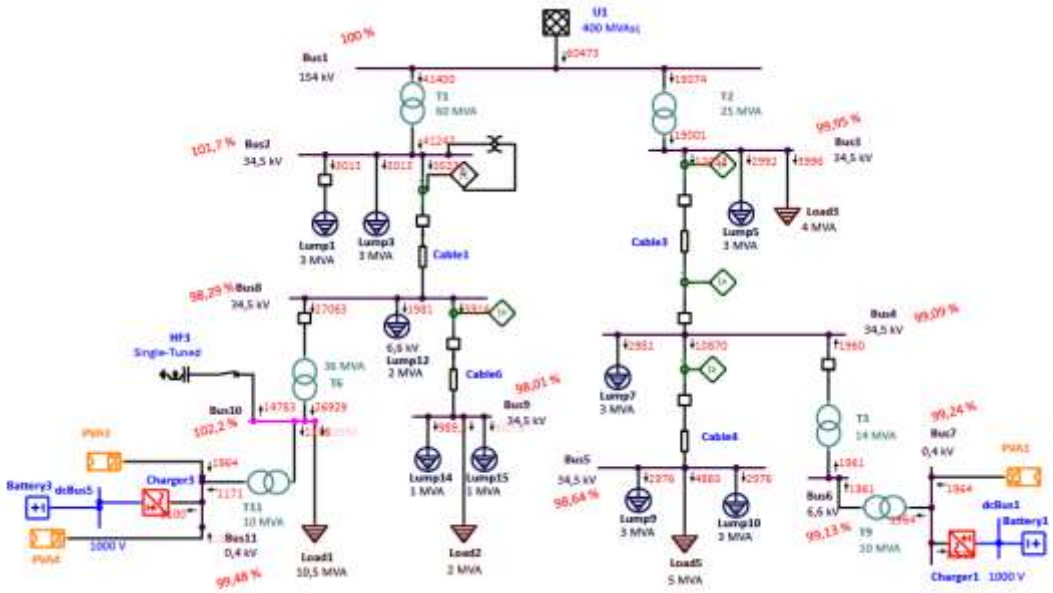


Şekil 3. FV dağıtım şebekesinin ETAP yazılım programı ile modellenmesi

C. Durum I: Yük Akışı Analizi

Yük akış analizi, güç sisteminin özelliklerini kararlı durum koşullarında belirlemek için kullanılan kritik bir analiz yöntemidir. Bu çalışmada, Şekil 4'teki tek hat şeması üzerinde 11 dağıtım bara ve 6 transformatör

içeren dağıtım trafo merkezi için yük akışı analizi yapılmıştır. ETAP benzetim programı kullanılarak FV sisteminin şebekeye entegre edilip edilmediği durumlar incelenmiştir. Elde edilen sonuçlar Tablo 1 ve Tablo 2'de sunulmuştur. FV sisteminin şebekeye entegrasyonu, bara gerilim profillerini etkileyen noktaları gözlemlememizi sağlamıştır. Yapılan analizler, FV sistemlerinin dağıtım şebekesine güvenli bir şekilde entegre edilebileceğini ve bu entegrasyonun şebeke güvenirliği ve stabilitesi üzerinde olumlu etkiler sağlayabileceğini göstermiştir.



Şekil 4. FV dağıtım şebekesinde yük akışı analizi

Tablo 1. Dağıtım şebekesine entegre edilen FV sistemi ile yük akışı analizi

Bara	Gerilim Değeri (kV)	Gerilim Değer Analizi %	Güç Durumu MW
Bus1	154.000	100	15.585
Bus2	34.5	100	6.044
Bus3	34.5	99.95	6.998
Bus4	34.5	99.09	2.981
Bus5	34.5	98.64	10.818
Bus6	6.6	99.12	1.961
Bus7	0.4	99.24	1.964
Bus8	34.5	100	2.004
Bus9	34.5	100	4.038
Bus10	**6.6**	**100**	**15.788**
Bus11	0.4	100	5.1

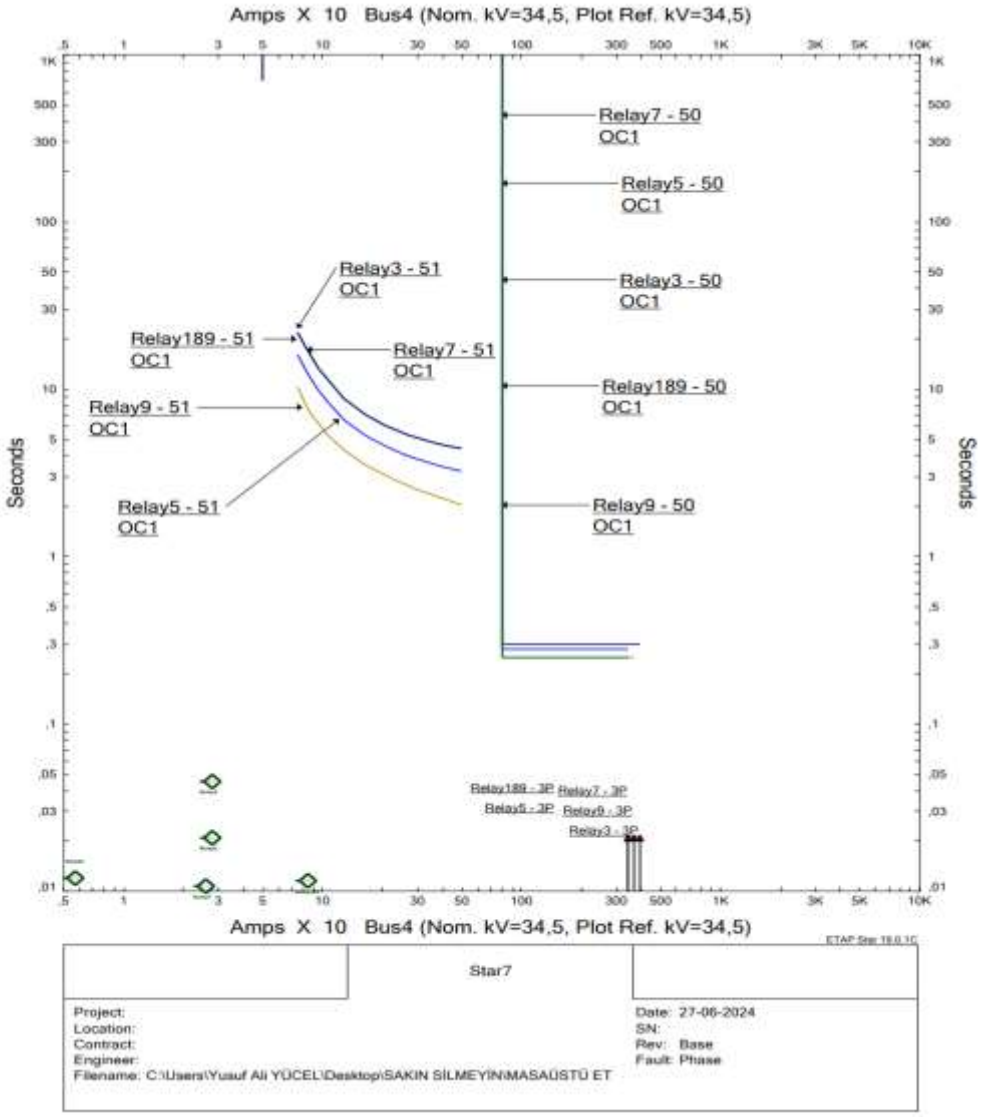
Tablo 2. FV sistemi olmadığı durumda dağıtım şebekesinde yük akışı analizi

Bara	Gerilim değeri (kV)	Gerilim değeri (%)	Güç değeri (MW)
Bus1	154.000	100.000	33.700
Bus2	34.500	100.000	12.02
Bus3	34.500	99.845	21.046
Bus4	34.500	98.823	20.950
Bus5	34.500	98.375	10.830
Bus8	34.500	99.446	12.010
Bus9	34.500	99.167	3.960
Bus10	**6.600**	**99.446**	**2.120**

D. Durum II: Röle Koordinasyon Kontrolü

Elektrik şebekesinde, doğru röle uyumunu sağlamak için genellikle zaman ve akım parametreleri tercih edilir. Aşırı akım koruma röleleri, şebeke üzerinde sadece arızalı bölümü devre dışı bırakmak için kullanılır [18]. Bu röleler, kısa devre gibi istenmeyen durumlarda devre enerjisini keserek şebeke

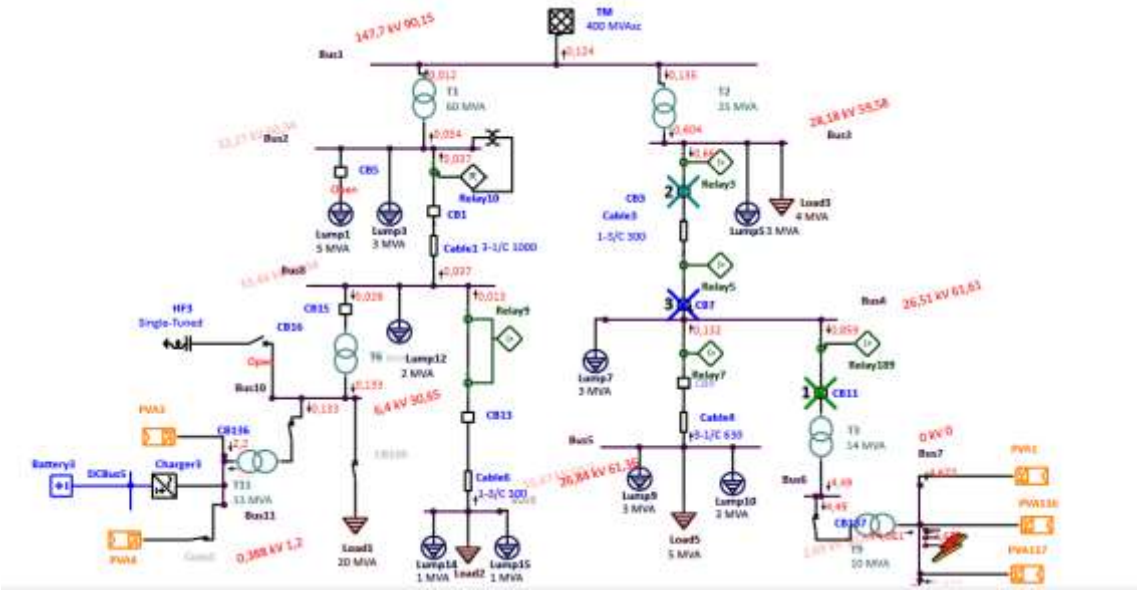
üzerindeki devrelere zarar vermeden ve insan güvenliğini sağlayarak arıza akımlarını engeller [19]. Dağıtım barası Bus9 üzerinde bir arıza akımı olduğunda, yüksek gerilim kesiciler CB13 ve CB1'in enerjiyi keserek arıza noktasının güvenliğini sağladığı ve büyük kayıpların önüne geçildiği görülmüştür. Bu durumda rölelerin doğru konumlandırılmasının önemi bir kez daha ortaya çıkmaktadır. YEK kaynaklarının şebekeye entegrasyonu, bu tür arızaları tetikleyebileceğinden, elektrik şebekesinde bu analizlerin büyük önemi bulunmaktadır. Şebeke analizinde kullanılan aşırı akım koruma rölelerinin zaman ayarı ve akım zaman eğrisi, Şekil 5' de gösterilmiştir. Bu analizde dikkate alınması gereken nokta, rölelerin akım zaman eğrisinde sıralı olarak doğru değerlere sahip olmalarıdır. Anlık akım bilgileri ve gecikme süreleri doğru ayarlandığında, arıza noktasına göre tüm rölelerin uygun bir şekilde çalıştığı görülebilir. Önemli olan, arıza noktasını en kısa sürede şebekeden ayırarak enerji kesintisinin etkisinin en az noktada hissedilmesini sağlamaktır. Şekil 6' da yapılan benzetim çalışmasında, arıza noktasında enerji kesimlerinin nasıl gerçekleştiği gösterilmektedir. Bu yöntemle enerji sürekliliği ve güvenilirliği sağlanabilir.



Şekil 5. Rölelerin akım- zaman eğrisi

Röle koordinasyon analizinde, FV sistemlerinden bağımsız baralar üzerinden yapılmıştır. FV sistemlerinin hava koşullarına bağlı olarak güç üretimlerinin değişebileceği bilinmektedir. Bu durum, dağıtım şebekesine hem harmonik hem de kısa devre akımı olarak katkı sağlayarak istenmeyen durumlar yaratabilir. FV sistemlerinin etkilerini göz önünde bulundurmayan röle koordinasyon analizlerinde röle koordinasyonunun bozulduğu ve şebeke sisteminde büyük kesintilere neden olabileceği gözlemlenmiştir.

Şekil 6’ da bu durum açıklanmaktadır. FV sisteminin bulunduğu bara kaynaklı arızada, röle koordinasyonunun bozulduğu ve 2. sırada çalışması gereken kesicinin devreye girmeden önce üst ana unsurdan şebekenin kesildiği gözlenmiştir.



Şekil 6. Röle koordinasyonunun bozulması

IV. SONUÇLAR

FV enerji sistemlerinin dağıtım şebekesine entegrasyonundan kaynaklanabilecek olası sorunlar belirtilmiştir. Yapılan analizler ve şebeke topolojisi üzerindeki diğer faktörler aynı zamanda şebekenin yük akış analizini de etkilemektedir. Yük akış analizinin sonuçları değerlendirilerek şebekenin verimliliği gözlemlenmiştir. Elektrik enerjisinin sürekliliği büyük önem taşıdığından elde edilen bulgular önemli bir öngörü sağlamaktadır. Ayrıca, şebekenin korunması da bu bağlamda ele alınmıştır. Bu noktada, sistemin kısa devre analizlerine dayalı olarak şebeke sisteminde bulunması gereken aşırı akım koruma rölelerinin konumlandırılması gerektiği vurgulanmıştır. Rölelerin özel olarak test edilmesiyle, arıza durumlarında şebekenin tepkisi ve koruma rölelerinin performansı incelenebilecektir. Bu çalışma, bir dağıtım şebekesine FV sisteminin veya YEK gibi üretim santrallerinin entegrasyonu öncesinde yapılan kapsamlı analizlerin önemini vurgulamaktadır. Elektrik enerjisinin sürekliliği, şebeke koruması, devre elemanlarının koruması ve tüketici mağduriyeti açısından önemli katkılar sunmaktadır. Bu çalışma, FV enerji sistemlerinin dağıtım şebekesine entegre edilmesiyle kısa devre koruması, röle koordinasyon kontrollü ve yük akışı analizleri ele alınarak güç şebekesinin kararlılığı, güvenilirliği ve sürekliliği açısından önemli bir kaynak teşkil etmektedir.

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The Mediating Role of Brand Attitude in the Effect of Brand Credibility on Brand Purchase Intention

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Abstract – The aim of this study is to examine whether brand attitude plays a significant mediating role in the effect of brand credibility on brand purchase intention. A survey was developed for the aim of the study. Data were collected from 180 people through face-to-face survey. SPSS and Process Macro were used to analyses the data obtained. The results of the statistical analyses show that brand attitude plays a significant mediating role in the effect of brand credibility on brand purchase intention. In other words, through the mediating role of brand attitude, brand credibility is found to have an indirect, significant and positive effect on brand purchase intention. In addition, the results show that brand credibility has a direct significant and positive effect on both brand attitude and brand purchase intention, while the direct positive effect of brand attitude on brand purchase intention is also significant. The study includes a discussion of the results.

Keywords – Brand Credibility, Brand Attitude, Brand Purchase Intention

INTRODUCTION

Brand credibility refers to the credibility of the product information contained in a brand, which requires that consumers' perceptions of the brand have the ability (expertise) and willingness (trustworthiness) to consistently deliver on its promises [1]. Brands that consumers perceive as having high credibility reduce the perceived risk and increase the perceived benefit. The positive perception of brand credibility, which is accepted as a characteristic of the brand, will have positive effects on the consumer's attitude towards the brand and purchase intention [2-3]. Current research is designed to answer the following research questions. First, does brand credibility have a positive impact on attitude towards brand? Second, does brand credibility have positive impact on brand purchase intention? Third, does attitude towards brand play a mediating role in the relationship between brand credibility and brand purchase intention.

LITERATURE REVIEW AND HYPOTHESES

Brand Credibility and Brand Attitude

Brand credibility is accepted as "consumers' ability and willingness to consistently fulfil what the brand promises" and is defined as the credibility of the product information contained in a brand [1]. In this context, brands with high credibility help customers to distinguish similar services or products offered by different brands [2] and contribute to brand choice by improving consumer perceptions about the quality level of the brand and increasing trust [4].

Attitude towards a brand is also defined as the consumer's general evaluation of a brand [5]. This attitude is a measurement of brand preference and consists of positive or negative evaluations and behaviours related to the brand [6-7].

In the literature, there is a lack of studies examining the relationship between brand credibility and attitude towards the brand. Many studies examine the effect of influencer or endorser credibility on attitude towards the brand [3-8-9-10-11]. In these studies, source credibility had a significant positive effect on attitude towards the brand. According to Brinol et al. (2004), there is a positive relationship between source credibility and consumers' attitudes towards the source [12]. Previous research also shows that high credibility has a direct impact on consumer attitudes and leads to favourable attitudes towards the brand [13]. Therefore, we propose the hypothesis:

H_1. Brand credibility has a significant and positive effect on brand attitude.

Brand Credibility and Brand Purchase Intention

Consumers are not worried about the brands they trust and can easily make the decision to buy the brand [14]. A reliable brand creates a desire to buy more and has positive effects on brands for consumers [15].

Studies in the literature include findings on the positive and significant effect of brand credibility on purchase intention. Erdem and Swait (2004) stated that brand credibility positively affects consumers' brand preferences and evaluations [1], while Wang and Yang (2010) considered brand credibility as three dimensions (trustworthiness, expertise and likeability) and concluded that it positively affects consumers' purchase intentions [16]. Sheeraz et al. (2016) and Haq et al. (2022) concluded that brand trustworthiness plays an important and positive role in predicting consumers' purchase intentions, suggesting that the more trustworthy a brand is, the higher the consumer's intention to purchase the brand [13-2]. Baek and King (2011) investigate the impact of service brand credibility and support the effect on purchase intentions in various types of services categories [4]. Leischnig et al. (2012) investigate the impact of brand credibility on consumers' repurchase intentions [17]. Based on this information, the following hypothesis has been formed:

H_2: Brand credibility has a positive effect on brand purchase intention.

Brand Attitude and Brand Purchase Intention

Purchase intention is defined as the expected behaviour of the consumer regarding the future purchase decision and the willingness of the consumer to purchase a product in the future [18-19]. Purchase Intention also indicates how likely an individual is to purchase a product [20]. Arachchi et al. (2023) states that attitude towards the brand significantly affects consumers' intentions [21]. According to Lee et al. (2023) brand attitude towards luxury fashion brands and consumer purchase intention depends on the authenticity of the brand [22]. In his study, he stated that internet celebrities are an important antecedent of consumer attitudes and purchase intentions towards their own brands. According to Fishbein's Theory of Reasoned Action, an individual's positive experience in the past will have a positive effect on the individual's behaviour [23]. Petty and Cacioppo (1986) state that consumers' brand purchase intention is a function of brand attitude [24]. Therefore, we consider that:

H_3: Brand attitude has a significant and positive effect on brand purchase intention.

Brand Attitude as a Mediator

In previous studies, a direct and indirect relationship between brand credibility and attitude towards the brand has been mentioned [2-13]. Biehal et al. (1992) state that brand attitudes affect brand purchase intentions and that attitude towards brand and attitude towards advertisements mediate purchase intention [25]. Anridho and Liao (2013) suggest that a brand with high credibility will support positive attitudes, which will positively affect purchase intentions [26]. Zheeraz et al. (2016) state that attitude towards the brand partially mediates the relationship between brand credibility and purchase intention [13]. Moreover, brand credibility has direct relationships with purchase intention [17] and attitude toward brand [10] and attitude toward brand has direct relationship purchase intention [22]. Therefore, attitude towards the brand can be used as a mediator between brand credibility and brand purchase intention. Based on the above literature, it is thought that brand attitude will play a mediating role between brand credibility and brand purchase intention.

H_4: Brand attitude has a mediating role in the effect of brand credibility on brand purchase intention.

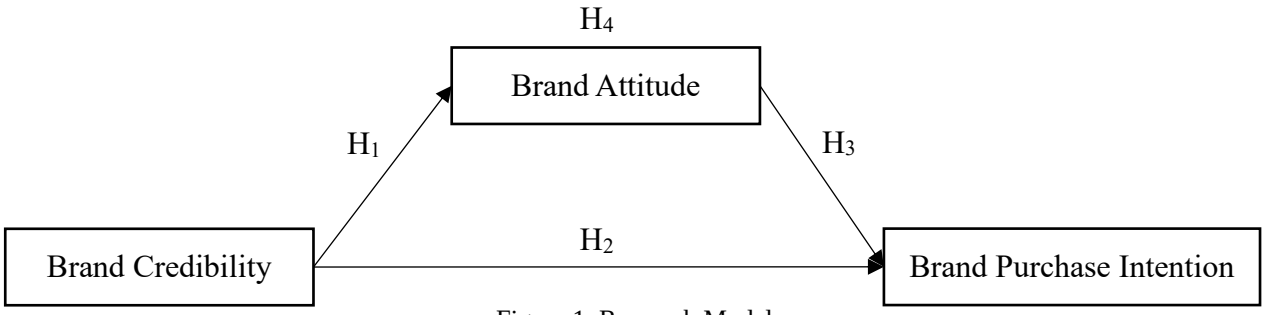

Figure 1. Research Model

MATERIALS AND METHOD

For this study, 6 items of the brand credibility scale [1], 3 items of the brand attitude scale and 2 items of the brand purchase intention scale [27] were adapted from previous studies. Data were collected from 180 people via face-to-face survey. The sample size of 180 people is more than 10 times the sum of the 11 scale items adapted for this study and should be considered a fair sample size [29]. Since Harman's single-factor test result is 42.724%, which is less than 50% [30] and the correlation coefficient between the two variables in Table 4 is less than 0.90 [31], the data set obtained does not have the problem of common method variance bias. SPSS and Process Macro were used to analyses the data obtained.

RESULTS

Table 1 shows that the number of males (n=115; 63.9%), those in the 36-43 age group (n=44; 24.4%), those with a high school degree (n=89; 49.4%) and those with an income of ≤ 20000 TL (n=103; 57.2%) is higher.

Table 1. Results of Frequency Analysis

Variable	Group	f	%
Gender	Female	65	36.1
	Male	115	63.9
	Total	**180**	**100.0**
Age	<27 years old	33	18.3
	28-35 years old	42	23.3
	36-43 years old	44	24.4
	44-51 years old	37	20.6
	>51 years old	24	13.3
	Total	**180**	**100.0**
Education Level (Graduated)	Primary/secondary school	16	8.9
	High school	89	49.4
	University	75	41.7
	Total	**180**	**100.0**
Income	≤20000 TL	103	57.2
	20001-30000 TL	59	32.8
	>30000 TL	18	10.0
	Total	**180**	**100.0**

Table 2 shows the results of the exploratory factor analysis (EFA) and the reliability analysis. As can be seen in Table 2, since Kaiser-Meyer-Olkin >.70, which is .793, and Sig. <.05, which is 0.000, the data set obtained has a fair and significant sample size to perform the factor analysis [32]. According to the EFA results, while the factor item loadings were above .50, the total variance explained, which was found to be 73.175%, was greater than 60% [29]. Finally, Cronbach's α is greater than 0.70 for all three factors [33]. These results support the construct validity and reliability of the factors.

Table 2. Results of Exploratory Factor Analysis and Reliability Analysis

Factor	Item	Loading	% of Variance	Cronbach's α
Brand Credibility	BC5	.829	47.657	.867
	BC6	.810		
	BC4	.753		
	BC2	.732		
	BC1	.654		
	BC3	.596		
Brand Attitude	BA3	.891	13.754	.911
	BA1	.856		
	BA2	.854		
Brand Purchase Intention	BPI1	.919	11.763	.867
	BPI2	.877		
% of Total Variance Explained			73.175	
Kaiser-Meyer-Olkin Measure of Sampling Adequacy			.793	
Bartlett's Test of Sphericity			Approx. Chi-Square= 1290.009	df= 55 Sig.=.000

As seen in Table 3, the skewness and kurtosis values of brand credibility, brand attitude and brand purchase intention are between ±2, indicating that the research data set has a normal distribution [34].

Table 3. Results of Normality Test

Descriptives	Brand Credibility	Brand Attitude	Brand Purchase Intention
Mean	4.3741	4.4833	3.9028
Variance	.376	.409	.693
Standard Deviation	.61323	.63936	.83247
Minimum	2.83	3.00	2.00
Maximum	5.00	5.00	5.00
Skewness	-.692	-.895	.115
Kurtosis	-.618	-.442	-1.449

According to the results in Table 4, there is a significant and positive correlation between brand credibility and brand attitude (Pearson correlation = .553; Sig. (2-tailed) = .000), between brand credibility and brand purchase intention (Pearson correlation = .342; Sig. (2-tailed) = .000), and between brand attitude and brand purchase intention (Pearson correlation = .362; Sig. (2-tailed) = .000).

Table 4. Results of Correlation Analysis

Correlations		Brand Credibility	Brand Attitude	Brand Purchase Intention
Brand Credibility	Pearson Correlation	1	.553**	.342**
	Sig. (2-tailed)		.000	.000
	N	180	180	180
Brand Attitude	Pearson Correlation	.553**	1	.362**
	Sig. (2-tailed)	.000		.000
	N	180	180	180
Brand Purchase Intention	Pearson Correlation	.342**	.362**	1
	Sig. (2-tailed)	.000	.000	
	N	180	180	180
Note: ** Correlation is significant at the 0.01 level (2-tailed).				

As this study's research model is similar to Hayes's Model 4, Hayes's Process Macro was run [35]. The results of the research model tested by running Process Macro are shown in Table 5. According to Table 5, brand credibility has a direct, significant and positive effect on both brand attitude (Std. Coeff=.553; p=.000) and brand purchase intention (Std. Coeff=.204; p=.015;). In addition, brand attitude has a direct, significant and positive effect on brand purchase intention (Std. Coeff=.249; p=.003) and brand attitude

plays a mediating role in the indirect effect of brand credibility on brand purchase intention (Std. Effect=.138; BootLLCI=.079; BootULCI=.302). As there is no zero (0) between BootLLCI and BootULCI, the paths are considered significant [35].

Table 5. Process Macro Results for Testing the Research Model

Paths	**R^2**	**F**	**Coeff**	**Std. Coeff**	**SE**	**t**	**p**	**LLCI**	**ULCI**
Total Effect: Brand Credibility→Brand Purchase Intention	.117	23.512	.464	.342	.096	4.849	.000	.275	.652
Direct Effect: Brand Credibility→Brand Attitude	.306	78,613	.577	.553	.065	8.866	.000	.449	.706
Direct Effect: Brand Credibility→Brand Purchase Intention	.160	16.811	.277	.204	.112	2.464	.015	.055	.498
Direct Effect: Brand Attitude→Brand Purchase Intention	.160	16.811	.324	.249	.108	3.008	.003	.111	.537

Indirect Effect: Brand Credibility→Brand Attitude→Brand Purchase Intention	**Effect**	**Std. Effect**	**Boot SE**	**Boot LLCI**	**Boot ULCI**
	.187	.138	.058	.079	.302

DISCUSSION AND CONCLUSION

One of the findings of this study, which examines the mediating role of brand attitude between brand credibility and brand purchase intention, reveals that brand credibility has a positive and significant effect on attitude towards the brand. These findings are consistent with previous studies [3-9-12]. Towards the brand.

Another finding confirms that brand credibility has a positive and significant effect on brand purchase intention. These results are consistent with previous studies on brand credibility [1-2-13]. Therefore, we can say that if the brand is perceived as credible, it will have a positive effect on consumers and increase their intention to purchase the product.

According to another finding, attitude towards the brand has a positive and significant effect on purchase intentions. The findings are consistent with the previous studies [21-24]. Therefore, positive attitude towards the brand has a positive effect on brand purchase intentions.

Finally, our results show that attitude mediates the relationship between brand credibility and brand purchase intention. This result shows that brand credibility changes consumers' brand attitude affects consumers' brand purchase intention, thus attitude plays a mediating role between brand credibility and brand purchase intention. These findings are consistent with previous research [13-25-26].

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Aprocitentan Behavioral Pattern in Molecular Docking Revealed with Molecular Dynamics

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Abstract – Aprocitentan is a novel antihypertensive agent recently approved by FDA. The substance is an ET-1 (endothelin-1) receptor antagonist that prevents the binding of ET-1 to both ET_A/ET_B receptors for the treatment of resistant pulmonary arterial hypertension, poorly controlled by other hypertensive drugs. TRYVIO® (Aprocitentan) is a member of a group of antihypertensive drug family named endothelial receptor antagonists (ERA). Aprocitentan is an active metabolite of macitentan (obtained by oxidative depropylation), an orphan drug used for the treatment of pulmonary arterial hypertension. The chemical name of aprocitentan is N-[5-(4-bromophenyl)-6- [2-[(5-bromo-2-pyrimidinyl)oxy]ethoxy]-4-pyrimidinyl]-sulfamide. It has a molecular formula of $C_{16}H_{14}Br_2N_6O_4S$ and a molecular weight of 546.2 g/mol. Pharmacodynamic and pharmacokinetic studies were appropriately performed and well documented. In this study, we aimed to study the molecular docking properties of aprocitentan and to collect more detailed data with further investigations of molecular dynamics. The molecular docking studies comprised the binding energy, bond and interaction types and the charge distribution through aprocitentan protein complex. For this purpose, aprocitentan molecule docked with endothelin B receptor (PDB ID: 8IY6) which is the target molecule of the agent for antihypertensive effect. Molecular docking studies' outputs composed of the docking poses of the emerging agent-protein complex. The bond and other interaction types were also shown. Further valuable information was obtained by molecular dynamic simulation studies which were proceeded during 25 ns.

Keywords – Hypertension, Aprocitentan, endothelin B receptor, molecular docking, molecular dynamics

I. INTRODUCTION

Cardiovascular diseases (CVDs) are the leading cause of death worldwide. Each year an estimated number of eighteen million people die from CVDs [1]. Among the numerous background pathologies of CVDs, hypertension is evaluated as a controllable risk factor for an estimated number of 1.5 billon people. Therapeutic intervention has been decreased hypertension gradually over last 50 years which includes medication besides the advice to change of other behavioral and environmental risk factors [2]. A local type of hypertension seen in the pulmonary arteries with a higher morbidity rate was related with the activity of endothelin-1 (ET-1); a vasoconstrictive factor released from the vascular endothelial cells. [3] After the discovery of ET-1 in 1998 three antihypertensive agents were approved. The last one, macitentan, had an active metabolite named aprocitentan formed by the oxidative depropylation. The discovery of vast antagonistic effect of this metabolite on the both receptors of endothelin-1 was made this active agent a point of interest which was resulted with the FDA approval recently [4].

In this study, we simulated the molecular docking of aprocitentan to endothelin B receptor. ET_B receptor, unlike the ET_A, is activated by endothelin-1 (probably after a threshold concentration) and shows vasodilator effect by the release of nitric oxide and prostaglandins [6]. This seems to be auto-control in the vascular system but needs further understanding due to the dual interaction of aprocitentan with both ET_A and ET_B. Therefore, hydrogen bonding and other interactions between aprocitentan and ET_B receptor by molecular docking simulations were shown. The docking behavioral pattern of the active molecule was posed and binding energy was recorded. Molecular dynamic studies gave further information of the ligand-protein complex in various conditions and in solution during a lapse of time.

II. Materials and Method

A. *Molecular Docking*

AutodockVina 1.1.2 program was used to perform the molecular docking study of aprocitentan [6]. The optimized geometry of the compound was optimized by molecular mechanics using the Gaussian 09 program [7]. The optimized molecular geometry of aprocitentan was visualized with the Gaussian 5.0.9 program [8]. The crystal structure of endothelin-B receptor protein (ET_B, PDB ID: 8IY6) was retrieved from the Protein Data Bank (https://www.rcsb.org/). Before starting molecular docking studies, non-standard parts were removed from the protein structure and then polar hydrogens and Kollman charges were added to the protein structure. The active site of the protein was determined using the DeepSite web server [9]. Images in molecular docking studies were captured using UCSF Chimera 1.17.2 and BIOVIA Discovery Studio Visualizer v21.1.0.20298 programs [10], [11].

B. *Molecular Dynamics*

Molecular dynamics simulation of the aprocitentan-8IY6 complex was performed using the YASARA program [12]. To increase the stability of the complex, the hydrogen bond network was optimized and the pH value of the protein residues was adjusted to 7.4 [13], [14]. Na^+ or Cl^- ions were added at a physiological concentration of 0.9% to neutralize the cell. Molecular dynamics simulation was performed for 25 ns using AMBER14 force field for protein, GAFF2 and AM1BCC for ligand, and TIP3P for water [15]-[17]. The equations of motion were implemented at a temperature of 298 K and a pressure of 1 atm (NPT ensemble) with a multiple time step of 2.5 fs for bound interactions and 5.0 fs for non-bonded interactions [18].

III. Results

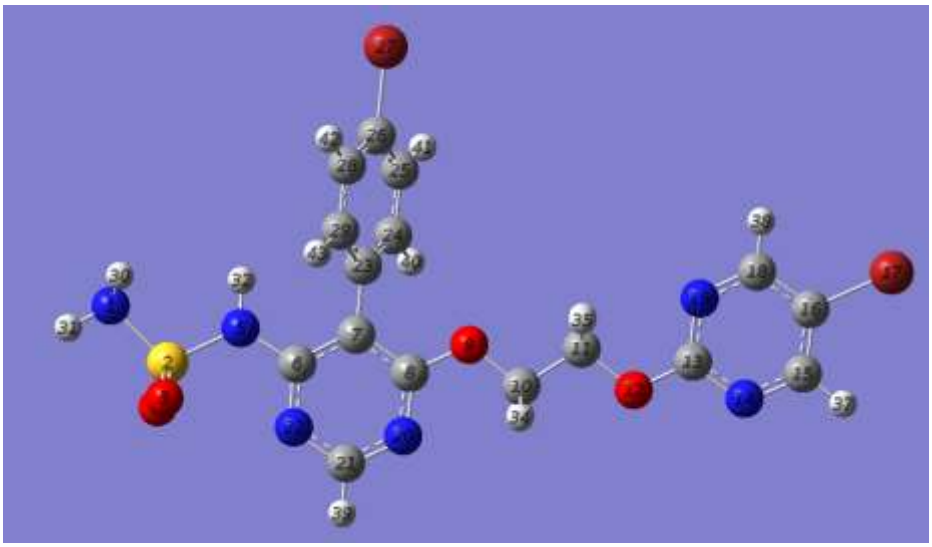

Fig. 1 Optimized structure of aprocitentan

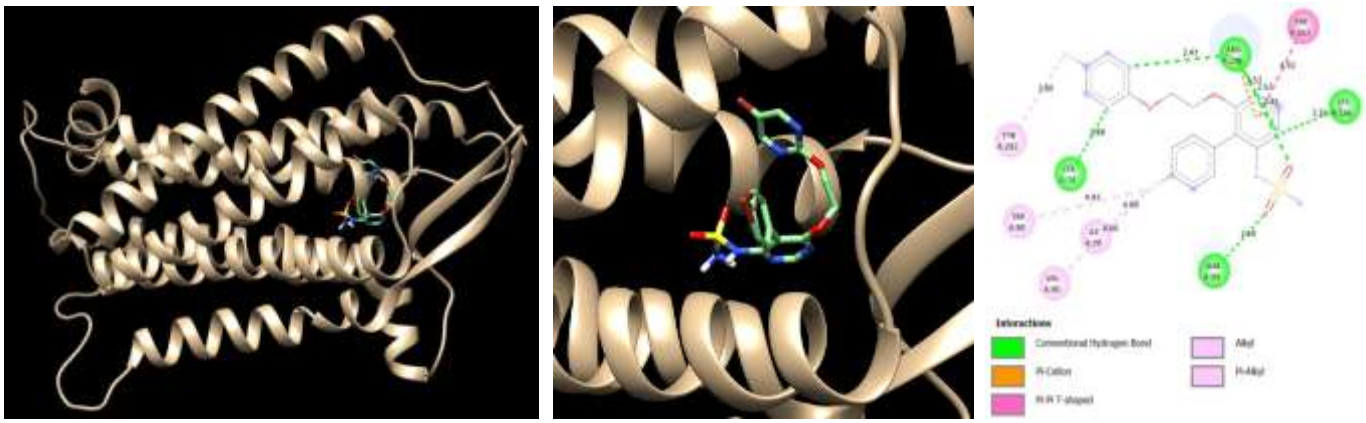

Fig. 2 Best poses of the aprocitentan-8IY6 complex 3D (left), 3D close-up (middle) and 2D (right)

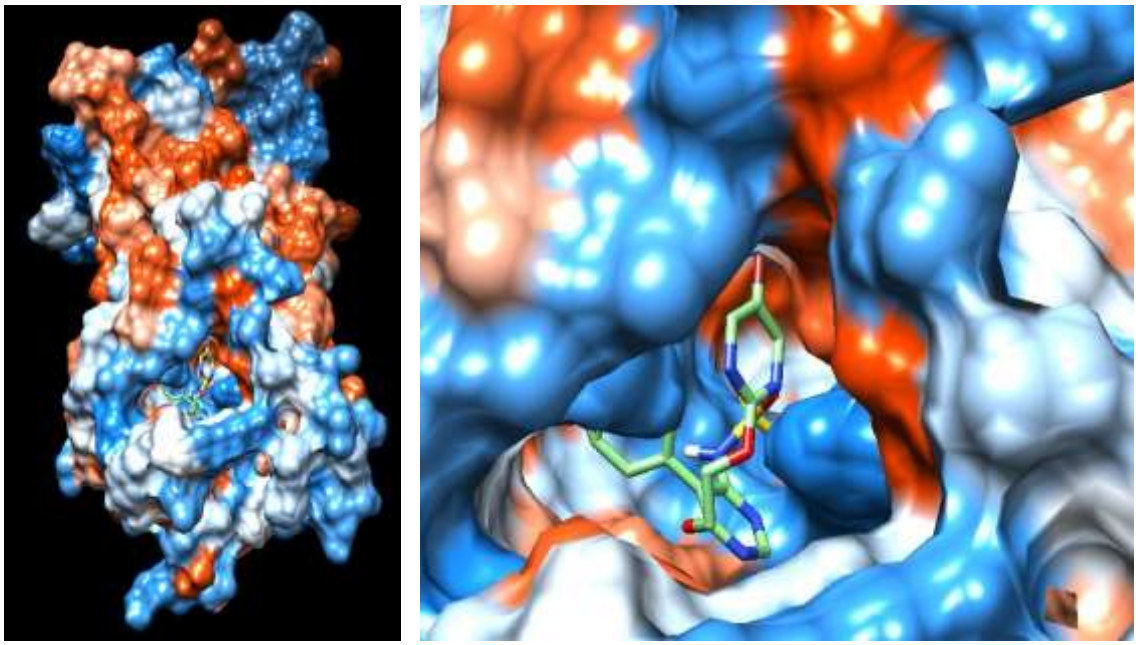

Fig. 3 Images of aprocitentan docking on the hydrophobic surface of the 8IY6 protein

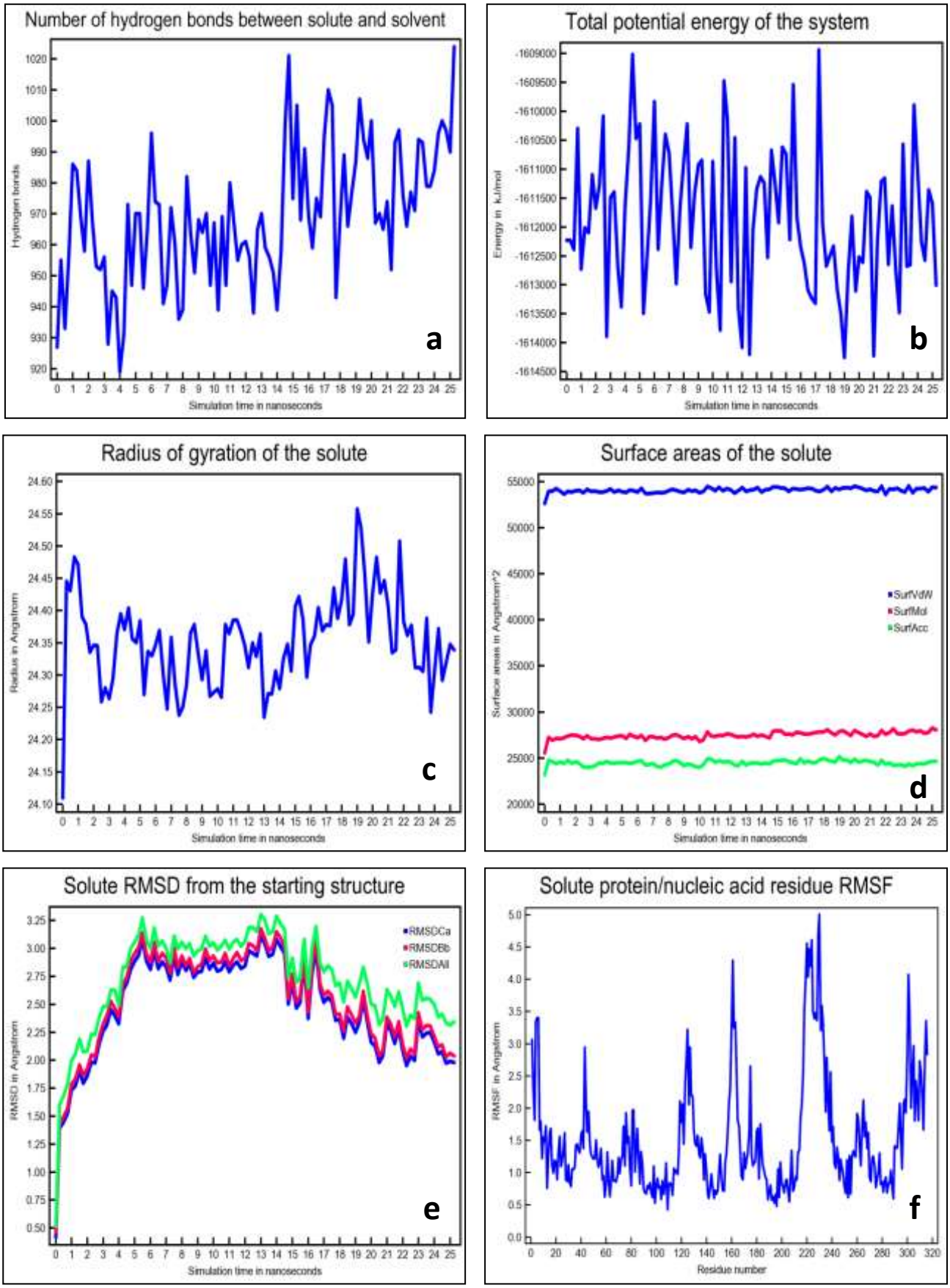

Fig. 4 MD simulation plots of the best binding pose of aprocitentan-8IY6 complex during 25 ns
a) Number of hydrogen bonds in a solvent system , b) Total potential energy,
c) Rg, d) SASA, e) RMSD, f) RMSF

III. DISCUSSION

Molecular docking behavioural pattern of aprocitentan compound to exhibit antagonistic properties was examined *in silico*. For this purpose, endothelin-B receptor protein (ET_B, PDB ID: 8IY6) was chosen. In molecular docking studies, the *xyz* coordinates of the binding sites of the selected protein were studied as x = 127.10, y = 108.90 and z = 79.40. The binding energy of the ligand-protein complex obtained as a result of the molecular docking simulation of aprocitentan with the ET_B protein was found to be -8.5 kcal/mol. This binding energy value revealed that the complex consisting of aprocitentan and 8IY6 formed spontaneously. Optimized structure of aprocitentan was shown in Figure 1. 3D and 2D images of the best pose of the aprocitentan-8IY6 complex are given in Figure 2, and the image of aprocitentan settling on the hydrophobic surface of 8IY6 is given in Figure 3. When the best binding pose of the aprocitentan-8IY6 complex was examined, hydrogen bonds and hydrophobic interactions between aprocitentan and 8IY6 can be seen. Aprocitentan molecule has made 6 hydrogen bonds with ET_B protein. The amino acid residues in the protein that make these bonds are ARG256 (3 bonds: 2.47 Å, 2.52 Å, 2.35 Å), LYS186 (2.35 Å), GLN94 (2.69 Å) and LYS74 (2.88 Å). It is thought that these 6 hydrogen bonds are effective in a strong interaction between aprocitentan and 8IY6. Hydrogen bonding amino acids are all basic and ARG256 itself was made half of the total hydrogen bonds which is not seen frequently.

The goal of molecular dynamics (MD) simulation of ligand-protein complex is to understand the dynamic behavior, interactions, and structural changes of complexes over time at the atomic level. MD simulations offer the opportunity to perform detailed analysis of various biochemical and biophysical processes.

In order to evaluate the stability of the best pose of the aprocitentan-8IY6 complex over time and to determine under which conditions it is more stable, a 25 ns MD simulation was performed under physiological conditions and the resulting graphs are given in Figure 4. It was observed that an average of 1025 hydrogen bonds were formed between aprocitentan-8IY6 and the solvent (Figure 4a). As seen in Figure 4b, the total potential energy of the system was found to be approximately -1612250 kJ/mol at the beginning and -161300 kJ/mol at the 25^{th} ns of the MD simulation. The average total potential energy of the system does not change dramatically for 25 ns which is an important indicator for the system maintains its stability. Solvent accessible surface area (SASA) is an important metric in MD simulations of ligand-protein complexes. SASA is used to monitor conformational changes of the protein or ligand which provide information about the stability and conformational state of the complex. As seen from the SASA graph of the aprocitentan-8IY6 complex (Figure 4d), the SASA value of the complex at the beginning of the MD simulation is 25000 $Å^2$. The SASA value did not change much at the 25^{th} ns, when the MD simulation was completed, revealed that the aprocitentan-8IY6 complex did not undergo much conformational change..

Radius of gyration (Rg) is a measure of the mean square distance of a molecule's distribution relative to its center of mass. In MD simulations, Rg can be used to determine how closely the protein and ligand are packed and how compact the complex is. A lower Rg value indicates more compactly packed protein and ligand and the complex is likely to be more stable. The Rg value of the aprocitentan-8IY6 complex was determined to be 14.60 Å on average at the beginning of the simulation, and approximately 14.60 Å at the end of the simulation (Figure 4c). As a result, aprocitentan-8IY6 complex maintained its Rg value and showed that the complex maintained its compactness significantly. The simulations of ligand-protein complexes, root mean square deviation (RMSD) is an important criterion for evaluating structural changes and stability. Low RMSD values indicate the structural stability throughout the simulation, while high RMSD values indicate significant structural changes. In MD simulations, keeping the RMSD values of the ligand-protein complex below 3 Å is considered sufficient to reveal the stability of the complex. As seen in Figure 4e, the RMSD values of the aprocitentan-8IY6 complex being less than 3 Å for 25 ns is an important indicator of the stability of the complex. Similarly, Root mean square fluctuation (RMSF) indicates the degree of mobility of the atoms or residues in certain regions of the protein and ligand. High

RMSF values indicate that the atoms or residues in that region are more movable and flexible, while low RMSF values are the sign of rigidity and stability. During the MD simulation process as seen in Figure 4f, the residues between 220 and 240 of the protein 8IY6 were most mobile.

IV. CONCLUSION

In this study, molecular docking and dynamic simulations performed to investigate the background of antagonistic property of aprocitentan compound *in silico*. As a result, aprocitentan exhibits a strong interaction with endothelin-B receptor. Molecular docking analysis revealed that the binding energy of the aprocitentan-8IY6 complex was -8.5 kcal/mol, reassuring the spontaneity of the reaction. During the binding of aprocitentan to 8IY6 protein 6 hydrogen bonds and numerous hydrophobic interactions were effective. MD simulations showed that the aprocitentan-8IY6 complex remained in a stable structure for 25 ns which was also confirmed by total potential energy and SASA analyses. Additionally, aprocitentan-8IY6 complex exhibited a compact and stable structure, maintaining low RMSD and Rg values. These findings support that aprocitentan exhibits antagonistic properties by establishing strong and stable interactions with the ET_B protein.

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Sınıf Öğretmenlerinin Empatik Beceri İle İlgili Görüşlerinin Belirlenmesi

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Özet – Bu araştırmanın amacı, Muş ilinde görev yapan sınıf öğretmenlerinin empatiye ilişkin görüşlerini, deneyimlerini ve eğitimde empati yapma konusunda karşılaştıkları zorlukları derinlemesine incelemektir. Bu amaca uygun olarak, gönüllülük esasına göre seçilen ve Muş ilinde görev yapan 11 sınıf öğretmeniyle mülakatlar yapılmıştır. Yapılan mülakatlar ses kaydına alınarak transkript edilmiş ve tematik analiz yöntemiyle analiz edilmiştir. Bu analiz sonucunda; Empatinin Tanımı (Duygusal Yer Değiştirme, Duygusal Anlayış), Sınıf Öğretmenlerine Göre Eğitimde Empati (Öğretmenlikte Empati, Eğitim Ortamlarında Empati), Empati Yapmanın Zorlukları (Yaşantı Eksikliği, Bilgi Eksikliği) olmak üzere üç ana tema ve bu temalara ait alt temalara ulaşılmıştır.

Araştırmanın bulguları, eğitimde empatinin önemine, özellikle de sınıf öğretmenliği açısından kritik bir beceri olduğuna, öğretmenlerin empatik becerilerini geliştirmeleri ve bu becerileri sınıf içi uygulamalarda etkili bir şekilde kullanabilmeleri için gerekli olan destek ve eğitim ihtiyaçlarını belirlemeye yönelik önemli bilgiler sunmaktadır. Öğretmenlerin empati yaparken karşılaştıkları zorluklar ve bu zorluklarla başa çıkma stratejileri, öğretmenlerin profesyonel gelişimlerine katkıda bulunacak şekilde ele alınmıştır. Elde edilen bulgulardan yola çıkarak öğretmenlere ve eğitim yöneticilerine, empati yapmaya yardımcı olacak ve empati yapmayı zorlaştıran durumlarda karşılaşılabilecek sorunları önleyebilecek çeşitli öneriler sunulmuştur.

Bu çalışma, Muş ilinde görev yapan öğretmenlerin özgün deneyimlerini ve empati konusundaki görüşlerini derinlemesine inceleyerek, literatürdeki mevcut boşlukları doldurmayı hedeflemektedir.

Anahtar Kelimeler – Empati, sınıf öğretmenleri, eğitimde empati, öğretmen-öğrenci ilişkisi, empatiyi zorlaştıran durumlar

I. GİRİŞ

Empati, bir bireyin başkasının duygularını ve bakış açılarını anlama yeteneği olarak tanımlanmakta ve öğretmenlerin öğrencilerle olan ilişkilerinde önemli bir rol oynamaktadır [8]. Eğitim bağlamında empati, öğretmenlerin öğrencilerinin duygusal ve sosyal ihtiyaçlarını anlamalarına, onlarla etkili iletişim kurmalarına ve olumlu bir öğrenme ortamı yaratmalarına yardımcı olmaktadır [20]. Öğretmenlerin empatik becerileri, öğrencilerin akademik başarılarını ve genel refahlarını artırarak, onların duygusal ve sosyal gelişimlerine katkıda bulunabilmektedir [2].

Empati, öğretmen-öğrenci iletişiminde kritik bir unsurdur. Etkili iletişim, öğrencilerin kendilerini değerli hissetmelerini sağlamakta ve onların öğrenmeye daha istekli olmalarına yardımcı olmaktadır [19]. Empatik bir yaklaşım, öğretmenlerin öğrencilerinin bireysel ihtiyaçlarını daha iyi anlamalarına ve onlara uygun destek sağlamalarına olanak tanımaktadır [17]. Bu durum, öğretmenlerin sınıf yönetimi becerilerini de olumlu yönde etkileyerek, daha verimli bir öğrenme ortamı oluşturmaktadır [3].

Öğrencilerin akademik ve sosyal yaşamlarında önemli bir rol oynayan öğretmenlerin empatik becerileri, öğrencilerin kendilerini ifade etmelerini ve duygusal olarak desteklenmiş hissetmelerini sağlamaktadır [4]. Empatik öğretmenler, öğrencilerin motivasyonunu artırarak, onların akademik ve sosyal başarılarını desteklemektedir [7]. Ancak, öğretmenlerin empati yaparken karşılaştıkları zorluklar, bu becerinin sınıf içi uygulamalarda her zaman etkili bir şekilde kullanılmasını engelleyebilmektedir. Örneğin, zaman ve kaynak yetersizliği, duygusal tükenmişlik ve profesyonel sınırları koruma gibi zorluklar, empatiyi uygulamaya koyarken karşılaşılan başlıca sorunlardandır [10].

Literatürde, empati eğitiminin ve öğretmenlerin empatik becerilerinin geliştirilmesinin önemi sıkça vurgulanmaktadır [20]. Ancak, mevcut çalışmalar genellikle genel öğretmen gruplarını ele almakta olup, belirli bir bölgedeki öğretmenlerin özgün deneyimlerine ve karşılaştıkları zorluklara yeterince odaklanmamaktadır [1].

Bu çalışmada, Muş ilinde görev yapan sınıf öğretmenlerinin empatiyle ilgili görüşlerini ve empati yapmada karşılaştıkları zorluklarla ilgili deneyimlerini detaylı bir şekilde inceleyerek, bu alandaki bilgi boşluğunu doldurmak amaçlanmıştır. Araştırmanın alt amaçları ise şunlardır:

1. Sınıf öğretmenlerinin empati kavramını nasıl tanımladıklarını ve empatiyi nasıl kullandıklarını belirlemek.

2. Sınıf öğretmenlerinin empati yaparken karşılaştıkları zorlukları ve bu zorluklarla başa çıkma stratejilerini incelemek.

3. Öğretmenlerin empatik becerilerini geliştirmeleri ve sınıf içi uygulamalarda etkili bir şekilde kullanabilmeleri için gerekli olan destek ve eğitim ihtiyaçlarını belirlemek.

Araştırmanın bulguları, öğretmenlerin empatik becerilerini geliştirmeleri ve bu becerileri sınıf içi uygulamalarda etkili bir şekilde kullanabilmeleri için gerekli olan destek ve eğitimlerin belirlenmesine katkı sağlayacaktır.

II. MATERYAL VE YÖNTEM

A. Araştırmanın Modeli

Bu araştırmada, Muş ilinde görev yapan sınıf öğretmenlerinin eğitimde empati kavramına bakış açılarını derinlemesine incelemek amaçlandığından nitel araştırma yaklaşımlarından olgubilim deseni kullanılmıştır. Nitel araştırma, katılımcıların deneyimlerini ve bakış açılarını derinlemesine incelemeyi

amaçlayan bir araştırma yöntemidir, [18]. Olgubilim deseni ise, katılımcıların doğrudan deneyimlerine dayanarak anlam inşa etmeyi ve tematik analizler yapmayı amaçlayan bir nitel araştırma desenidir [13].

B. *Çalışma Grubu*

Bu çalışmanın amacına uygun olarak amaçlı örnekleme tekniklerinden uygun örnekleme tercih edilmiştir. Amaca uygun örneklemede doyuma ulaşıldığında çalışma grubu sayısının yeterli olduğu kabul edilmektedir [12]. Bu bilgiye dayanarak, çalışma grubu ile yapılan görüşmelerde yeni bilgi gelmediğinden dolayı çalışma grubunu Muş ilinde görev yapan ve çeşitli yaş, cinsiyet ve mesleki deneyime sahip 11 sınıf öğretmeni oluşturmaktadır.

C. *Verilerin Toplanması ve Analizi*

Veriler, empati kavramı, eğitimde empati kullanımı, empati konusundaki deneyimler gibi konuları kapsayan yarı yapılandırılmış mülakat formu kullanılarak toplanmıştır. Yarı yapılandırılmış mülakat formu, araştırmacının belirli bir dizi soruyu takip ederken, katılımcının deneyimlerini ve görüşlerini derinlemesine açıklamasına olanak tanımaktadır [6].

Mülakatlar ses kaydına alınmış ve daha sonra transkript edilmiştir. Transkript edilen veriler, tematik analiz yöntemi ile analiz edilmiştir. Bu çalışmada, veriler öncelikle kodlanmış, daha sonra benzer kodlar bir araya getirilerek temalar oluşturulmuştur.

D. *Geçerlik ve Güvenirlik*

Araştırmanın geçerliği ve güvenirliği için çeşitli önlemler alınmıştır. İlk olarak, mülakat soruları geliştirilirken bir ön uygulama yapılmış ve soruların anlaşılırlığı, uygunluğu ve kapsamı değerlendirilmiştir. Bu ön uygulama sonuçlarına göre, sorularda gerekli düzenlemeler yapılmıştır. Verilerin geçerliliğini artırmak amacıyla, elde edilen bulgular katılımcılarla paylaşılmış ve onların geri bildirimleri doğrultusunda doğrulanmıştır. Güvenirliği sağlamak için, transkript edilen veriler bağımsız bir araştırmacı tarafından tekrar gözden geçirilmiş ve kodlamalar arasındaki tutarlılık kontrol edilmiştir. Ayrıca, araştırma sürecinde elde edilen ses kayıtları ve transkriptler gizlilik esasına uygun olarak sadece araştırmacı tarafından erişilebilir durumda tutulmuş ve üçüncü kişilerle paylaşılmamıştır.

III. BULGULAR

Araştırmaya katılan sınıf öğretmenlerinin eğitimde empatiye ilişkin görüşlerini belirlemek amacıyla yapılan görüşmelerden elde edilen verilerin içerik analizi sonuçları 3 ana temaya ulaşılmış ve bu temalar aşağıdaki şekilde sunulmuştur.

Şekil 1. Sınıf Öğretmenlerinin Empati Hakkındaki Görüşleri

Empatinin Tanımı

Araştırmaya katılan öğretmenlerin empatiyle ilgili tanımları, Duygusal Yer Değiştirme ve Duygusal Anlayış olmak üzere 2 alt temaya ayrılmıştır.

1) Duygusal yer değiştirme

Öğretmenler empatiyi, kişinin kendisini başkasının yerine koyma olarak tanımlamıştır. Örneğin katılımcılardan K1, K2, K3 ve K10'un empati tanımları şu şekildedir:

- K1: "*Empati, bir kişinin yerine kendini koyabilme sanatıdır*."
- K2: "*Karşımızdaki kişinin yerine kendimizi koyup onun duygu ve düşüncelerini hissedebilmek ve anlayabilmektir*."
- K3: "*Empati, kişinin bir olay karşısında karşıdakinin gözünden bakabilmesidir*."
- K10: "*Empati, karşıdaki insanın yerine kendini koyma ve o şekilde düşünmedir.*"

Bu tanımlamalar, öğretmenlerin empatiyi bireysel deneyimlerine ve günlük yaşantılarındaki gözlemlerine dayanarak çeşitli şekillerde tanımladıklarını göstermektedir. Bu çeşitlilik, öğretmenlerin empatiyi nasıl deneyimlediklerine ve uyguladıklarına dair zengin bir perspektif sunmaktadır.

2) Duygusal anlayış

Bazı katılımcılara göre empati, karşımızdaki kişinin duygu ve düşüncelerini anlama çabası olarak ifade edilmiştir. Örneğin katılımcılardan K4, empatiyi "*…bireyin yaşamış olduğu olay yerine kendini koyarak anlama çabası…*" K6 ise, "*Bir kişinin kendisini başka bir kişinin yerine koyup onun duygu ve düşüncelerini anlayarak yaşantısında bunu belli etmesi…*" olarak tanımlamıştır.

Öğretmenlerin tanımlamaları, empatiyi hem duygusal hem de bilişsel bir süreç olarak ele aldıklarını göstermektedir

Araştırmaya katılan sınıf öğretmenlerinden elde edilen bulgular, öğretmenlerin empatiyi genellikle başkalarının duygularını anlama ve bu anlayışla onlara yaklaşma becerisi olarak gördüklerini ortaya koymaktadır. Bu tanımlar, literatürde yer alan empati tanımlarıyla uyum göstermektedir ve öğretmenlerin empati hakkında yeterli bilgiye sahip olduklarını ortaya koymaktadır.

Sınıf Öğretmenlerine Göre Eğitimde Empati

Sınıf Öğretmenlerine Göre Eğitimde Empati teması; Öğretmenlikte Empati ve Eğitim Ortamlarında Empati olmak üzere 2 alt temaya ayrılmakta olup şu şekildedir:

3) Öğretmenlikte empati

Araştırmaya katılan öğretmenler; sınıf öğretmenlerin, çocuğun hayatında önemli bir yer kapladığını vurgulamakta, K7'nin bu konuda kullanmış olduğu "*Bana bir harf öğretenin 40 yıl kölesi olurum*" atasözü bu önemi açıkça ortaya koymaktadır. K8 ile yapılan görüşmeden ulaşılan, öğrencilerinin K8 için söyledikleri "*Öğretmenim okul ikinci yuvamız. Siz de bizim ikinci annemizsiniz*." sözleri, sınıf öğretmenlerinin öğrencilerin gözündeki önemini göstermektedir. Katılımcılar, bu denli önemli ve kutsal olarak nitelendirilen öğretmenlerin, empatik becerilerinin de önemli olduğunu öne sürmekte, bu önemi çeşitli nedenlere dayandırarak örneklemektedir. Bu görüş ve örnekler; Yaş Grubu ve Uzun Süreli Birliktelik, Öğrenciyle İletişim, Veliyle İletişim, Empatinin Öğrenmeye Etkisi alt temaları altında sunulmuştur.

Küçük yaş grubu ve uzun süreli birliktelik

Katılımcılara göre, haftanın beş günü ve neredeyse her gün altı ders saati boyunca küçük yaş gruplarındaki öğrencilerle birlikte olan sınıf öğretmenleri, bu öğrencilerle uzun süreli ve derinlemesine bir etkileşim içindedir. Bu durum, öğretmenlerin öğrencilerle güçlü bir bağ kurmalarını ve onların duygusal, sosyal ve akademik ihtiyaçlarını daha iyi anlamalarını sağlamaktadır. Empati becerisi bu bağlamda önemli bir rol oynamaktadır.

K1, öğretmen ve öğrenci arasında kurulan duygusal bağın empati ile güçlendirildiğini ve empati kurmanın küçük yaş grubu öğrencilerle etkili iletişimin temel taşı olduğunu belirtmektedir. Benzer şekilde, K7 de sınıf öğretmenliğinin kutsal bir meslek olduğunu ve empati kurmanın bu mesleğin vazgeçilmez bir parçası olduğunu vurgulamaktadır. K7, *"Bir sınıf öğretmeninin hamuru da küçük çocuk"* diyerek, öğretmenlerin öğrenciler için ilk model olduklarını ve bu modelin öğrenci üzerindeki etkisinin büyük olduğunu ifade etmektedir.

K11, sınıf öğretmenlerinin empati kurmak zorunda olduklarını, çünkü karşılarındaki öğrencilerin çocuk olduğunu ve onların dünyasını anlamanın öğretmenlerin görevlerinden biri olduğunu belirtmektedir. K11, *"Eğitim sisteminde dördüncü sınıfa kadar bizdeler. Öğrenciler bizim herhangi bir kötü özelliğimizi de iyi özelliğimizi de alıyorlar"* diyerek, öğretmenlerin davranışlarının öğrenciler üzerindeki etkisine dikkat çekmektedir.

K4, küçük yaş grubundaki öğrencilerin hassasiyetlerine dikkat çekmekte ve empati ile onların dünyalarını anlamanın önemini vurgulamaktadır. *"Küçük yaş grubundaki bir öğrencinin bizim, yani yetişkinler gibi aynı şekilde düşünmesini, aynı şekilde görmesini bekleyemeyiz"* diyen K4, bu yaş grubuna yönelik empatik yaklaşımın önemini ifade etmektedir. K5 ise sınıf öğretmenlerinin dört yıllık bir süre zarfında öğrencilerle yoğun bir ilişki içinde olduklarını ve bu süreçte empati kurmanın ne kadar önemli olduğunu belirtmektedir. *"Dördüncü sınıf öğrencisiyle birinci sınıf öğrencisinin becerileri, algısı, sosyal ve psikolojik ihtiyacı hepsi birbirinden farklıdır"* diyen K5, sınıf öğretmenlerinin bu farklılıkları anlamasının önemine işaret etmektedir.

K9 da sınıf öğretmenlerinin çocuklarla uzun süre vakit geçirdiklerini ve bu nedenle hem örnek olma hem de empati kurma sorumluluklarının bulunduğunu belirtmektedir. *"Ortaokulda hiçbir öğretmenimiz onlarla bizim geçirdiğimiz kadar vakit geçirmeyecek"* diyen K9, sınıf öğretmenlerinin öğrencilerle olan ilişkilerinin derinliğine dikkat çekmektedir. K10 ise, küçük yaş grubuyla dört yıl boyunca sürekli bir arada olmanın, öğretmenlerin öğrencileri daha iyi gözlemlemelerine ve anlamalarına olanak sağladığını ifade etmektedir. K10, *"Biriktirdiğimiz her şey, deneyimler, onlara karşı yaklaşımlarımız, onların tepkileri, derslere karşı verdikleri özgüven, ilgi, her şeyi çok daha iyi fark edebiliyoruz"* diyerek, empati olmadan bu sürecin etkili bir şekilde yönetilemeyeceğini belirtmektedir.

K3, küçük yaş grubu öğrencilerinin oyun oynama ihtiyacını empati ile anlamanın önemini vurgulamaktadır. *"Öğrenciler oyun oynamayı çok seviyor. Ama öğrenci açısından düşündüğümüzde, öğrencilerin en büyük ihtiyaçlarından biri oyun oynamak ve hareketli aktivitelerde bulunmaktır"* diyen K3, empatik olmayan yaklaşımların öğrenciler üzerindeki olumsuz etkilerine dikkat çekmektedir. K8, sınıf öğretmenlerinin öğrencilerin hayatında oynadığı rolün önemini vurgulamakta ve empatik becerilerin bu süreçte ne kadar kritik olduğunu belirtmektedir. K8*, "Çocukların gözü bizde açılıyor ve bu nedenle her şeyi bizimle birlikte görmeye başlıyorlar"* diyerek, öğretmenlerin öğrenciler üzerindeki etkisini ve bu etkileşimin uzun vadeli önemini açıklamaktadır.

K6, küçük yaş grubundaki öğrencilerin empati ile yetiştirilmesinin önemine dikkat çekmekte ve *"Bu yaş grubunda bu becerileri kazandırmak daha kolay"* diyerek, küçük yaş grubundaki öğrencilere beceri kazandırmanın daha kolay olduğunu savunmaktadır. Ancak bu görüş, küçük çocuklara bazı şeyleri vermenin daha zor olduğunu belirten K2'nin görüşüyle zıtlık oluşturmaktadır. K7'nin *"Ağaç yaşken eğilir"* atasözü ise K6'nın görüşünü desteklemektedir.

Sonuç olarak, sınıf öğretmenleri küçük yaş gruplarındaki öğrencilerin gelişimsel, bilişsel ve duygusal özelliklerin daha üst kademelerdeki öğrencilere göre daha farklı olduğunu, onları anlamak için o yaş seviyesine inmek gerektiğini, bu yaş grubuyla olan uzun süreli birlikteliklerinde onların duygusal, sosyal ve akademik ihtiyaçlarını anlamak için empati yapmanın gerekliliğini vurgulamıştır. Bu süreç,

öğretmenlerin öğrenciler üzerinde olumlu etkiler yaratmasını sağlayarak, eğitimde empatinin önemini ortaya koymaktadır.

Öğrenciyle iletişim

Sınıf öğretmenlerinin öğrencilerle iletişiminde empati yapmanın önemi, çeşitli öğretmen görüşleri üzerinden açıkça ortaya koyulmaktadır. Öğretmenler, çocukların duygusal ve akademik gelişimlerini desteklemenin yanı sıra, sınıf içi iletişim ortamını daha sağlıklı hale getirmenin empati ile mümkün olduğunu vurgulamaktadırlar.

K7, 14 yıllık tecrübesinden yola çıkarak, çocukların bakış açılarının yetişkinlerinkinden farklı olduğunu ve bu nedenle öğretmenlerin empati yaparak onların duygusal dünyalarını anlamalarının gerekliliğini ifade etmektedir. Benzer şekilde, K1 ve K3, özellikle küçük yaş gruplarındaki öğrencilerin duygusal ihtiyaçlarını ve sosyal ilişkilerini anlamanın empati ile mümkün olduğunu belirtirken, K5 ise bireysel ihtiyaçlara özel olarak dikkat göstermenin önemine vurgu yapmaktadır.

K8 ise kendi öğrencilik döneminden örnek vererek, kendisini en çok anlayan öğretmenin empati yapabilen ve onun yerine koyabilen öğretmen olduğunu belirtmektedir. 35 yaşını aşmış olan K8'in, ilkokul dönemindeki çocuklara kıyasla çok fazla öğretmen değiştirmesine rağmen hala kendisini anlayan o öğretmeni hatırlaması, empati yapmanın öğrenciyle güçlü bir bağ kurmada ne kadar etkili olduğunu göstermektedir.

K9, sınıf içinde yaşanan bir olayı örneklendirerek, empati yapmanın öğrencilerin sorunlarına daha duyarlı bir şekilde yaklaşılmasını sağladığını ve bu sayede çözüm süreçlerinin daha etkili olduğunu açıklamaktadır.

Son olarak, K11 ise hassas konularda empati yapmanın önemini vurgulayarak, çocukların duygusal olarak incinmesini önlemenin ve iletişimde sağlıklı bir ortamın oluşturulmasının empatiyle mümkün olduğunu ifade etmektedir.

Bu görüşler, sınıf öğretmenlerinin empati yapmanın öğrencilerle iletişimdeki merkezi rolünü ve bu becerinin eğitim süreçlerindeki olumlu katkılarını açıkça ortaya koymaktadır.

Veliyle iletişim

Sınıf öğretmenleri, empatinin velilerle iletişimde önemli bir rol oynadığını vurgulamaktadır. K11, veli-öğretmen etkileşiminin duygusal yönlerini önemseyerek, bazen velilerle yaşanan anlaşmazlıkların empatiyle çözülebileceğini ve bu durumun sınıf içi atmosferi nasıl etkilediğini *"…bazen veli geliyor, anlatıyor, anlatıyor, anlatıyor. Hani düşündüğünde veliye hak verebiliyorsun empati özelliğini kullandığında. Hani bunu böyle yapmasaydım veya öğrenciyi hani kırmışım veya örnek veriyorum mutlu etmişim. Yani üzüntü de oluyor, sevinç de olabiliyor yani bazen*." sözleriyle açıklamaktadır. K5 ise sadece öğrencilerle değil, aynı zamanda ailelerle de empatik bir iletişim kurmanın gerekliliğine dikkat çekerek, bu durumun eğitim sürecindeki önemine vurgu yapmaktadır. K4 ise sınıf öğretmenlerinin öğrenci ve

ailelerle yoğun bir iletişim içinde olduklarını ve bu iletişimin empatiyle desteklenerek daha verimli hale getirilebileceğini ifade etmektedir.

Bu görüşler, sınıf öğretmenlerinin veliyle iletişimde empati kullanmanın önemini ve bu becerinin sınıf içi dinamikleri iyileştirdiğini açıkça ortaya koymaktadır.

Öğrenmeye etkisi

Katılımcılar, öğretmenlerin empati yeteneğinin öğrencilerin öğrenme süreçlerini olumlu etkilediğini belirterek, öğretmenlerin öğrencilerin duygusal ve gelişimsel özelliklerini anlayarak hareket etmelerinin, öğrenme sürecini daha verimli ve keyifli hale getirdiği vurgulamıştır.

Çalışmaya katılan sınıf öğretmenleri, öğrencilerin bakış açısını anlamanın ve onların duygusal ihtiyaçlarını karşılamanın öğrenmeyi nasıl etkilediğine dair çeşitli görüşler sunmuştur. Örneğin, K9 *"Öğretmen hani karşıdaki kişi gibi hissedebilirse yeni bir konu nasıl öğreniyor ya da arkadaşı gibi düşünebilirse, hissedebilirse eğitim daha da kolaylaşır, daha eğlenceli hale gelir, daha da verimli hale gelir."* sözleriyle öğretmenin empati kurarak öğrencilerin nasıl öğrendiğini anlamasının eğitimi kolaylaştıracağını belirtmiştir K5 ise öğretmenlerin, farklı yaş gruplarındaki çocukların duygusal ve gelişimsel ihtiyaçlarını dikkate alarak hareket etmeleri gerektiğini vurgulayarak *"Belirli gelişim dönemlerinden geçen çocuklara hitap ediyorsunuz ve onlar gibi düşünebilmelisiniz ki onlara verimli olabilesiniz. Yani bir lise çocuğuna hitap ettiğiniz gibi ana okul çocuğuna edemezsiniz. O nedenle hangi gruptaysanız, hangi grupla çalışıyorsanız onu anlayacak beceriye sahip olmamız gerekiyor."* sözleriyle, çocuklar gibi düşünebilmenin eğitimde verimi artırdığını ortaya koymaktadır.

Benzer şekilde K3,

> *"Örneğin, o gün ders anlatılacağı zaman, mesela bir konu anlatılıyor, bunu öğrencilere nasıl indirgeyebileceğimizi öğretmenin empati yoluyla kavrayabileceğini düşünüyorum. Mesela bir konu anlatacağız, en basitinden branş öğretmenlerini düşünelim. Mesela matematik branşçılarını düşünelim ya da fende, aslında sınıf öğretmenlerinden çok çok daha fazla bir bilgiye sahipler. Ama öğrencilerin öğrenci açısından bakamadıkları için olaylara, bence öğrencilere de gerekli bilgileri aktaramıyorlar. Yani gerekli olan eğitim veremiyorlar, gerekli kazanımları kazandıramıyorlar. Burada da bence empatik beceriler devreye giriyordur. Yani öğrencinin bakış açısıyla bakabilmek."*

sözleriyle öğretmenlerin empatik becerilerinin öğrencilerin bakış açısını anlamalarına yardımcı olduğunu ve bunun eğitimdeki başarıyı artırdığını belirtmektedir. K2 de her öğrencinin bilgiyi alma şeklinin farklı olduğunu ve bu yüzden öğrenciyi tanımanın önemli olduğunu vurgulayarak K3 ile örtüşmektedir.

K1, *"empati kurma becerisi arttıkça zaten öğrenciyle bağınız artıyor. Öğrenciyle kurduğunuz bağın artması zaten sizin akademik olarak da öğrenciye verdiğinizle daha iyi, verimli hale geliyorsunuz."* sözleriyle empati kurmanın öğrenciyle olan bağı güçlendirdiğini ve bunun akademik başarıyı artırdığını ifade etmiştir.

Katılımcılar ayrıca, öğrencilerin oyun oynama ve fiziksel aktivitelerle enerjilerini atmalarının akademik başarıyı olumlu etkilediğini belirtmiştir. K1 ve K3, oyun oynamanın önemini vurgulamış ve çocukların enerjilerini atmaları gerektiğini ifade etmiştir. K1, çocukların yeterince oyun oynamadıklarında akademik başarılarının düştüğünü gözlemlediğini söyleyerek şu ifadeleri kullanmıştır:

> *"Çocuklar gün içerisinde eğer yeteri kadar oyun oynuyorlarsa bu akademik başarılarını da olumlu yönde etkiliyor."*

K3 ise öğretmenlerin kazanımları yetiştirmek adına beden eğitimi, müzik ve görsel sanatlar gibi dersleri azaltmamaları gerektiğini belirterek *"Öğrencilerin gözünden bakmamız gerekiyor olaya o yaş seviyesindeki, ilkokul yaşındaki çocukların, o yaş seviyesindeki çocukların en büyük ihtiyaçlarından biri oyun oynamak. Eğlenmek. Hareketli aktivitelerde bulunmak."* sözleriyle bunun çocuklar için ne kadar önemli olduğuna değinmiştir.

Sonuç olarak, sınıf öğretmenliği bağlamında empatik yaklaşımın benimsenmesi, öğrenci merkezli bir öğretim anlayışını desteklemekte ve öğrenmeye olumlu katkılar sağlamaktadır. Öğretmenlerin öğrencilerin bakış açısını anlayarak ders materyalini kişiselleştirmesi, her öğrencinin ihtiyaçlarına uygun destek sağlanmasını mümkün kılmaktadır. Bu yaklaşım, olumlu bir sınıf ikliminin oluşturulmasına, öğrencilerin duygusal gelişiminin desteklenmesine ve sosyal becerilerinin güçlendirilmesine katkı sağlamaktadır. Öğrenciler, kendilerini anlaşıldıklarında ve desteklendiklerinde daha motive olmakta ve öğrenme sürecine daha istekli katılmaktadır. K3, bu durumu şöyle ifade etmiştir:

> *"Öğrenci o an kendisini çok yetersiz hissedip direkt kendisini kapatabilir. Bu da sağlıklı bir öğrenmeyi gerçekleştiremez. Öğrenci o an kendisini kapattığında, öğretmen hangi kazanımı vermeye çalışırsa çalışsın, neler öğretmeye çalışırsa çalışsın, öğrenci o an hiçbir şey öğrenemeyecek. Bu da yine empatik becerinin eğitime olan ilişkisiyle alakalı."*

Bu ifadeler, empatik bir öğretim yaklaşımının benimsenmesinin, sınıf öğretmenliği bağlamında öğrenmeye olumlu yönde katkı sağladığını ortaya koymaktadır.

4) Eğitim ortamlarında empati

Katılımcılar, öğretmenlerin empatik becerilerinin eğitim ortamlarındaki önemini şekilde vurgulamaktadır. Örneğin K6, öğretmenlerin sınıf içi ve okul genelinde empati becerisine sahip olmalarının gerekliliğini belirterek, öğretmenlerin rol model olarak topluma ve öğrencilere örnek olmaları gerektiğini ifade etmektedir. K9, empatinin sadece öğrencilerle değil, meslektaşlarla olan ilişkilerde de kritik bir rol oynadığını vurgulayarak, iş birliği içinde empatik davranışların sorunların çözümünde önemli olduğunu

> "*Mesela diyelim ki dışarıda dersi, beden eğitimi dersi var, pencereleri kapatmalıyım. Ya da ben beden eğitimine çıkıyorsam çocuklarımı uyarmalıyım ki diğer öğretmen arkadaşlarım içeride sıkıntı yaşamasınlar. Hani bu konuda hem diğer öğretmen arkadaşlarıma hem de çocuklarıma örnek olmalıyım. Empati açısından.*"

sözleriyle örneklendirmektedir. K7 ise iş arkadaşları ve idarecilerle olan deneyimlerinden hareketle, empati becerisinin iş ortamında insan ilişkilerini olgunlaştırdığını ve sorunların anlayışla çözümünde etkili olduğunu belirtmektedir.

Bu görüşler, öğretmenlerin empatik becerilerinin eğitim kurumlarında genel bir pozitif atmosfer oluşturduğunu ve iş birliği ile iletişimi güçlendirdiğini ortaya koymaktadır.

Empati Yapmanın Zorlukları

Araştırmaya katılan sınıf öğretmenleri bazı durumların empati yapmayı zorlaştırdığını veya engellediğini belirtmişlerdir. Bu zorluklar kendi içinde "Yaşantı Eksikliği" ve "Bilgi Eksikliği" olmak üzere 2 alt temaya ayrılmıştır.

5) Yaşantı eksikliği

Katılımcılara göre, empati kurma becerisi, bireylerin yaşadıkları deneyimlerle geliştiğinden, yaşantı eksikliği bu becerinin gelişimini olumsuz etkileyebilmektedir. Katılımcılar, empati kurmanın zorluklarını ve yaşantı eksikliğinin bu süreç üzerindeki etkilerini çeşitli örneklerle dile getirmektedir.

K11, empati kurmanın her zaman mümkün olmadığını söylemekte,

> "*Her durumda empati yapma şansımız zaten yok. Hani bazı durumlarda önceden yaşadığımız bir olay olduğunda hani ne yapabiliyoruz? Empati yapabiliyoruz. Ama her olaydan empati maalesef olmuyor.*" sözleriyle ortaya koyarak, "*Mesela, çocuk, bir tane cenazesi var. Mesela hani istediğimiz kadar hani empati yapmaya çalışan eğer o bizim yakınımız hayattaysa çocukla ne yapabiliyoruz hani o belli bir duyguyu empati yapabiliyoruz ama onun dışında istesek de zaten bazı duygular ne yapıyor empati kazanıyor yani insanın şeyinde, düşüncesinde.*"

örneğiyle de bu görüşü desteklemektedir. Benzer şekilde K8 de empati kurmanın herkesin yetiştiği farklı aile ve kültürel ortamlar nedeniyle her zaman tam anlamıyla mümkün olmadığını belirterek, "*Ben de kendimi onların yerine koymaya çalışıyorum. Aslında şey de değil, hani mesela illaki aynı ortamda büyümüş olmak da değil. Sadece biraz daha tam olarak koyamayız bence. Ama biraz daha anlamaya çalışabiliriz açıkçası. Çünkü tam olarak olmaz. Aynı ailede yetişmedik değil mi, aynı kültürde yetişmedik belki. Yetişsek bile bence her şey tam anlamıyla olmaz. Elimizden geldiği kadar. Bence zaten elimizden geleni yapsak yeter.*" İfadelerini kullanmaktadır.

K10, empati kurma yeteneğinin zamanla ve deneyimle geliştiğini, "*Eğitimdeki en önemli faktörlerden bir tanesi çocuk ve çocuğun eğitimde en başta onun yerine kendimizi koyabilme, zaten bunun üzerine eğitimler görüyoruz elbette ama bunu biraz da tabii ki sahada daha fazla geliştiriyoruz. Yani eğitimler bunun üzerine olsa da ne olursa olsun teorikte oluyor. Bu uygulamada çok farklı bir şekilde yönlendiriyor ve yıllar size bunu çok daha güzel kazandırabiliyor."* şeklinde ifade etmekte ve empati kurmanın kişisel yaşam deneyimleriyle nasıl değiştiğini

> " *Ben öğretmenlik mesleğimi böyle bayağı ayırıyorum hani evlendikten sonra farklı bir yöne gitti, çocuk doğduktan sonra bir annelik rolü geldi, farklı bir şey geldi üstümüze. Ama çocuğum okula başladıktan sonra çok başka bir tarafa gitti. Yani aslında empatiyi ben direkt yaşayarak*

biraz daha fazla geliştirmeye başladım. Şu anda çocuklara bakışım onların öğrenmesindeki yaşadıkları zorluklar o kadar daha iyi anlıyorum ki. Aslında empati yaşamaya başladım. Ondan sonra çok daha farklı bir yöne girdi diyebilirim."

şeklinde dile getirerek deneyimlerin empati kurmaya olan pozitif etkisini ortaya sermektedir.

K1, öğretmenlik mesleğinin ilk yıllarında empati kurmanın zorluklarını "*Çocukların mesela sıkıldığını o zaman anlamıyordum. Çocukların işte aralarında bir sorun sıkıntıları var mı yok muydu anlamıyordum. Öğrencilerin bireysel olarak sıkıntısı var mı yok muydu anlamıyordum. Böyle bir şeyin varlığını bile çok düşünmüyordum.*" şeklinde açıklayarak, tecrübe kazandıkça empati kurmanın önemini anladığını ve bu becerinin geliştiğini "*Bunu tecrübe edindikçe altında farklı nedenler yatabileceğini anlamaya başladım.*" şeklinde ifade etmektedir.

Öğretmenlerin yıllar geçtikçe empatik becerilerinin arttığını "*mesleğe atılan kişi önce çıraktır, sonra kalfadır, sonra ustadır. Mesleğe başladıktan bir sene sonra usta olmuyor netice itibariyle. Öğretmenlik de bence çıraklık, kalfalık ve ustalık dönemi olarak yıllar geçtikçe ustalaşılabilen bir meslek alanıdır.*" sözleriyle destekleyen K1, öğretmenlik mesleğinin kendi içinde dönemlere ayrıldığını da ortaya koymaktadır.

Katılımcıların sözleri, tecrübesizliğin ve aynı durumu tam anlamıyla yaşamamış olmanın empati kurmayı güçleştirdiğini ortaya koymakta, K7'nin kullanmış olduğu "*Ateş düştüğü yeri yakar*" atasözü bu durumu çok daha net bir şekilde açıklamaktadır.

6) Bilgi eksikliği

Katılımcılar, çocuk hakkında yetersiz bilgiye sahip olmanın empatiyi zorlaştırdığını, hatta engellediğini ortaya koymakta, K6 bu durumu "*Karşıdaki bir insana mesela bir olay yaşadınız, bu olayın neticesinde işte farklı yaklaşıyorsunuz fakat olay daha doğrusu bir empatik düşünce sayesinde olayın içeriğini öğrendikten sonra bu defa o davranışlarının yanlış olduğunu düşünüp başka olaylarda da artık daha farklı davranmaya çalışıyorsunuz.*" şeklinde özetlemektedir. Bu bilgi eksikliklikleri;

- Çocuğun sağlık durumu
- Ebeveyn eksikliği (ölüm veya boşanma)
- Çocuğun yaşadığı ortam ve ekonomik durumu

başlıkları altında toplanmıştır.

Sağlık durumu

Katılımcıların görüşleri, öğretmenlerin öğrencilerin sağlık durumları hakkında yeterli bilgiye sahip olmamasının empati kurma süreçlerinde karşılaştıkları zorlukları vurgulamaktadır. Bu eksiklik, öğrencilerin yaşadığı sağlık sorunlarını fark edememeye ve bu nedenle öğrencilerin davranışlarını yanlış yorumlamaya neden olmaktadır.

K5, bir öğrencisinin ders esnasında sürekli yer değiştirdiğini ve çöpe gidip kalem açtığını belirterek başlangıçta bu davranışları dikkatsizlik veya sıkılma olarak yorumladığını ve öğrenciye yönelik uyarılarda bulunduğunu ancak daha sonra rehberlik servisi tarafından yapılan göz taraması sonucu öğrencinin ciddi bir görme problemi olduğunun ortaya çıktığını söylemektedir. Bu durumu fark ettikten sonra K5, "*Şimdi kendimi onların yerine biraz daha koyuyorum. Yaptıkları her davranışın altında bir sebep arıyorum. Daha çok boyutlu düşünmeye başladım mesela o olaydan sonra çocuklara karşı*" diyerek, bu deneyimin empati kurma becerisini geliştirdiğini ifade etmektedir. Bu örnek, öğretmenlerin sağlık bilgisi eksikliği nedeniyle öğrencilerin davranışlarını doğru analiz edemeyebileceklerini ve bu tür bilgilerin empati kurma sürecini nasıl etkilediğini göstermektedir.

K3 ise otistik bir öğrencisinin durumunu fark edemediği bir olayı paylaşmaktadır. Öğrencinin fiziksel yetersizlikleri nedeniyle öğrenme güçlüğünü bu fiziksel sorunlara bağlamış ve otizm ihtimalini göz ardı etmiştir. K3

> *"...öğrencinin zaten bedensel olarak da bazı yetersizlikleri vardı. Öğrencim birazcık dezavantajlı bir öğrenciydi o yönden. 6 yaşına kadar hiç yürüyememiş, yemek çiğneyememiş. Kas problemi olan bir öğrenciydi. Biz o yüzden yazı yazamamasının ya da geç öğrenmesini buna bağlamıştık. Aile buna bağlamıştı ve bana da o şekilde söyleyince ben de otistik olabileceğini düşünememiştim hani o kas rahatsızlığından dolayı olacağını düşünmüştüm.*"

diyerek durumu açıklamaktadır. Öğrencinin yazıları ters okuması ve yazması gibi belirtiler fark edildikten sonra, öğrenci RAM'a yönlendirilmiş ve otizm teşhisi konulmuştur. Bu deneyim, öğretmenlerin öğrencilerin sağlık durumları hakkında yeterli bilgiye sahip olmamaları durumunda empati kurma sürecinin nasıl zora girebileceğini ortaya koymaktadır.

Bu bulgular, öğretmenlerin öğrencilerin sağlık durumları hakkında yeterli bilgiye sahip olmalarının empati kurma becerilerini doğrudan etkilediğini göstermektedir. Öğretmenlerin, öğrencilerin davranışlarının altında yatan sağlık sorunlarını doğru bir şekilde analiz edebilmeleri için gerekli bilgi ve donanıma sahip olmaları gerekmektedir. Aksi takdirde, yanlış yorumlamalar ve yargılarda bulunarak öğrencilerin eğitim sürecine olumsuz etkilerde bulunabilmektedir.

Ebeveyn eksikliği

Katılımcılar, ebeveyn eksikliğinin öğrencilerin okul hayatındaki davranışlarını ve akademik başarılarını nasıl etkilediğine dair önemli gözlemler paylaşmışlardır. Öğretmenlerin bu durumlarda empati kurma becerilerinin, öğrencilerin yaşadığı zorlukları anlamada ve destek olmada kritik bir rol oynadığı belirtilmiştir.

K8, annesi olmayan bir öğrencinin yaşadığı zorlukları anlatırken öğretmen olarak kendi duygusal refleksini şu şekilde ifade etmiştir: *"Sabahları aç gelen bir öğrenci düşününce, derslere konsantre olamadığını ve bu durumun onun okul performansını etkilediğini fark ediyorum. Bu nedenle ona karşı daha anlayışlı olmaya çalışıyorum."* K8'in bu yaklaşımı, öğrencilerin temel ihtiyaçlarının karşılanamamasının akademik başarılarını nasıl etkilediğini göstermektedir.

K7, ailesi boşanmış ve annesiyle babası ayrı yaşayan bir öğrencinin duygusal durumunu anlatırken, öğrencisinin annesiyle ilgili yaşadığı duygusal zorlukları ve ona destek olduğunu paylaşmıştır. Bu durum, öğretmenin öğrencinin duygusal ihtiyaçlarını anlama ve ona rehberlik etme çabasını göstermektedir.

K2, özel günlerde (örneğin anneler günü, babalar günü gibi) öğrencilerin duygusal durumlarını göz önünde bulundurarak empati kurmanın önemine değinmiştir. K2, bu özel günlerde ebeveyni olmayan veya ayrı olan öğrencilerin duygusal olarak incinmemesi için özen gösterdiklerini ifade etmiştir. Bu yaklaşım, öğrencilerin duygusal refahlarının sınıf içi etkileşimlerde ve özel günlerde nasıl önem taşıdığını vurgulamaktadır.

Bu bulgular, öğretmenlerin ebeveyn eksikliği gibi zorlu durumlarla başa çıkarken empati kurmanın önemini ortaya koymaktadır. Ebeveyn eksikliğinin öğrencilerin akademik performansı ve genel iyi halleri üzerinde nasıl etkiler yarattığı göz önüne alındığında, öğretmenlerin bu öğrencilere daha duyarlı yaklaşarak destek olmaları gerektiği açıktır. Bu destek, öğrencilerin okul başarısı ve duygusal refahlarını olumlu yönde etkileyebilir.

Yaşanılan ortam ve ekonomik durum

Katılımcılar, öğrencilerin yaşadıkları ortam ve ekonomik durumların, okul hayatlarına nasıl etki ettiğine dair gözlemlerini paylaşmışlardır. Öğretmenlerin, öğrencilerin yaşam koşullarını anlamak için yapılan ev ziyaretlerinin önemini vurgulamışlardır.

K10, ev ziyaretlerinin önemine dikkat çekerek veli ziyaretlerinin, öğrencinin ev ortamını anlamak için çok önemli olduğunu, öğrencinin yaşadığı fiziksel şartların, evdeki diğer bireylerin durumu gibi detayların, öğrencinin davranışları ve akademik performansı üzerinde büyük etki yarattığını belirtmiştir. Ayrıca K10, bir öğrencisinin yaşadığı ekonomik zorluklara dikkat çekerek, bu durumu öğrencinin daha iyi anlaşılması ve desteklenmesi için kritik bulmuştur.

K6 ise, ev ziyaretlerinin ardından yaşadığı farkındalığı şu sözlerle aktarmıştır: *"Bir öğrencimin ev ziyaretinde gördüm ki, öğrenci çok küçük bir evde yaşıyor ve kişisel eşyaları yok. Bu durumu öğrenciyle olan iletişimimi ve ona karşı olan yaklaşımımı olumlu yönde değiştirmeme yardımcı oldu."*. K6'nın bu deneyimi, öğrencilerin maddi zorluklarının anlaşılmasının, öğretmenlerin onlara daha etkili şekilde destek olabilmesini sağladığını göstermektedir.

İkiz olan iki öğrencisinin annesinin intihar etmesi ve sonrasında yaşadıkları zorlukları, "*Bu iki kız öğrencinin annesi, maalesef farklı bir durum söz konusu, intihar etmiş... Ve bu yaşananlardan dolayı ötürü de eğitimlerine bir dönem maalesef şey olmamışlar, gitmemişler okula... Ben bunları öğrendikten sonra daha böyle bir dikkat etme, daha hassas davranma gibi bu durumlar oluştu bende.*" şeklinde ifade eden K4, öğrencilerin yaşadığı travmatik olayların onların eğitim hayatını nasıl olumsuz etkilediğini vurgulayarak, bu tür durumların öğretmenler tarafından dikkatle ele alınması gerektiğini belirtmektedir.

K4'ün deneyimi, öğrencilerin kişisel trajedilerinin öğretmenler tarafından nasıl ele alınması gerektiğini ve bu durumların eğitimlerini nasıl etkileyebileceğini vurgulamaktadır.

K3 ise dezavantajlı bölgelerden gelen öğrencilerin yaşadığı zorlukları, "*Sınıf öğretmenliği açısından az önce bahsettiğim gibi mesela sınıflarımızda her şeyiyle iyi böyle öğrenciler yok, çok dezavantajlı bölgelerden gelenler var. Aile içerisinde çok farklı davranışlarda bulunanlar var. Mesela ailesi tarafından belki şiddet gören öğrencilerimiz olacak.*" sözleriyle belirtmiştir. K3'ün gözlemi, öğrencilerin sosyal ve ekonomik çevrelerinin, onların okul başarısını ve genel gelişimini etkilediğini göstermektedir.

K2, özel günlerde ekonomik durumu zayıf olan öğrencilerin incinmemesi için gösterilen çabaları şu şekilde anlatmıştır: "*23 Nisan'da kutlamalar yapılırken hani kıyafetler falan alıyoruz. İşte hani çocukların yine incinmemesi için durumu iyi olmayan çocuklara çok fazla bunu yansıtmamaya çalışırken, kıyafet alımı konusunda özellikle elimizden gelen yardımı yapıyoruz.*" Bu yaklaşım, ekonomik açıdan dezavantajlı öğrencilerin toplumsal etkinliklere eşit katılımını sağlamanın önemini vurgulamaktadır.

Bu bulgular, öğrencilerin yaşadıkları ortam ve ekonomik durumlarının, onların eğitim hayatında karşılaştıkları zorlukları anlamada öğretmenlerin empati yapmasının ne kadar önemli olduğunu vurgulamaktadır. Öğretmenlerin, öğrencilere daha etkili bir şekilde destek olabilmeleri için, öğrencilerin ev ortamlarını ve ekonomik durumlarını anlamaları gerekmektedir. Bu sayede, öğrencilerin yaşadıkları zorluklar göz önünde bulundurularak, daha uygun ve etkili çözümler üretilebilmektedir.

IV. TARTIŞMA VE SONUÇLAR

Sınıf öğretmenlerinin empati hakkındaki görüşlerinin incelendiği bu araştırmadan elde edilen bulgular, empati kavramının öğretmen-öğrenci ve öğretmen-veli ilişkilerinde önemli bir rol oynadığını ve bu ilişkilerin güçlendirilmesinde empatik yaklaşımların vazgeçilmez olduğunu göstermektedir.

Sınıf öğretmenlerinin empati becerileri, öğrencilerin duygusal ve akademik gelişimlerini desteklemektedir. Öğretmenlerin, öğrencilerin duygusal ihtiyaçlarını anlamaları ve bu ihtiyaçlara duyarlı bir şekilde yanıt vermeleri, sınıf içi iletişim ortamını daha sağlıklı hale getirmektedir [2]. Empati kurma, öğrencilerin bakış açılarını anlamayı kolaylaştırır ve onların öğrenme süreçlerini daha verimli hale getirir [3].

Katılımcı öğretmenlerin ifadeleri, empatik yaklaşımın öğrenciler üzerindeki olumlu etkilerini açıkça ortaya koymaktadır. Örneğin, bir öğretmenin belirttiği gibi, öğrencilerin en büyük ihtiyaçlarından biri oyun oynamak ve hareketli aktivitelerde bulunmaktır ve bu ihtiyaçların empatiyle anlaşılması, eğitim sürecini daha etkili kılmaktadır.

Empati, veli-öğretmen etkileşimlerinde de önemli bir rol oynamaktadır. Veli ile empatik bir iletişim kurmak, öğretmenlerin sınıf içi atmosferi iyileştirmesine ve öğrenci başarısını artırmasına yardımcı olur [11]. Öğretmenlerin empatik yaklaşımları, velilerle yaşanan anlaşmazlıkların çözümünde de etkili

olmaktadır. Bu durum, öğretmenlerin sadece öğrencilerle değil, aynı zamanda ailelerle de güçlü ve anlamlı ilişkiler kurmasını sağlar [19]. Katılımcıların görüşleri de veli ile iletişimde empatinin olumlu etki yarattığını göstermekte ve bu durumun öğrenciyi daha iyi anlamayı sağlayarak sınıf içi dinamikleri de güçlendirdiğini ortaya koymaktadır.

Empati, öğretmenlerin öğrencilerin öğrenme süreçlerini olumlu yönde etkileyen bir faktördür. Öğretmenlerin, öğrencilerin duygusal ve gelişimsel özelliklerini anlayarak hareket etmeleri, öğrenme sürecini daha verimli ve keyifli hale getirir [16]. Elde ediler bulgular, öğrencileri anlayarak öğretme sürecini yürütmenin, öğrenmeye olumlu etkisi olduğunu açıkça ortaya koymaktadır.

Sınıf öğretmenlerinden elde edilen bulgular, empatinin öğretmen – öğretmen ve öğretmen – idareci arasındaki ilişkiyi güçlendirerek olumlu bir okul iklimi oluşturduğunu göstermektedir. Özellikle idarecilerin empatik bir tutum sergilemesi okul iklimini olumlu etkilemekle kalmayıp öğretmenlerin daha istekli ve verimli olmasını sağlar. Ekici (2020) tarafından yapılan *"İlkokulu Yöneticileri ile Öğretmenler Arasındaki İletişim Durumlarının İncelenmesi"* adlı çalışma bu durumu açıkça ortaya koymakta ve elde edilen bulguları desteklemektedir.

Sonuç olarak, empati, sınıf öğretmenlerinin mesleki rollerini etkin bir şekilde yerine getirmelerinde ve öğrenciyi anlayarak yaşanabilecek olumsuz durumların önüne geçmede kritik bir öneme sahiptir. Öğrencilerle ve velilerle kurulan empatik ilişkiler, eğitim sürecinin kalitesini artırır ve öğretmenlerin eğitimde rol model olmalarını sağlar [14]. Empatik yaklaşımlar, öğretmenlerin öğrencilere daha duyarlı ve anlayışlı bir şekilde yaklaşmalarını sağlayarak, onların duygusal ve sosyal gelişimlerini destekler [9].

Bu bulgular, empati becerisinin öğretmen eğitim programlarında daha fazla vurgulanması gerektiğini ortaya koymaktadır. Milli Eğitim Bakanlığı tarafından 2024 yılında yayınlanan Türkiye Yüzyılı Maarif Modelinde de bu konuya özel bir vurgu yapılmıştır. Bu modele göre empati, bireylerin birbirini anlaması ve sosyal ilişkilerde daha sağlıklı bir etkileşim kurması açısından hayati bir öneme sahiptir [15]. Eğitim süreçlerinde empati geliştirilmesi, öğrencilerin akademik başarılarının yanı sıra, toplumsal barış ve uyumu da artırmaktadır. Bu nedenle, Türkiye Yüzyılı Maarif Modeli, empatinin eğitimin her aşamasında ve her düzeyinde aktif olarak öğretilmesini ve uygulanmasını önermektedir.

V. ÖNERİLER

- Öğretmenler, öğrencilerle ve velilerle daha etkili iletişim kurabilmek için empati temelli iletişim becerilerini geliştirmelidirler.
- Okuldaki öğretmenler arasında daha sıkı iş birlikleri ve dayanışma sağlanmalıdır. Bu, öğrencilere ve diğer öğretmenlere karşı daha empatik bir ortam yaratmaktadır.
- Okul yöneticileri, öğretmenlerin duygusal ihtiyaçlarını ve pedagojik gereksinimlerini anlayarak daha destekleyici bir liderlik sergilemelidirler.

- Öğretmenler, özel hayatının gizliliği ilkesini ihlal etmeyecek şekilde, birbirleriyle tecrübe paylaşımı yapabilirler. Bu tecrübe paylaşımları, öğretmenlerin benzer durumla karşılaştıklarında oluşabilecek olumsuzlukların önüne geçerek, öğretmenleri olayın ardında benzer sebepler olabileceği düşüncesine yöneltebilir ve böylece öğretmen – öğrenci iletişimini güçlendirerek olumlu bir sınıf iklimi oluşturabilir.
- Öğretmenler veli ev ziyaretlerine daha fazla önem vermelidirler. Veli ev ziyaretleri öğretmenlere, çocuğun aile yapısını ve yaşadığı ortam hakkında bilgi verecek ve öğretmenlerin çocuğu daha iyi anlamasına olanak sağlayacaktır.
- Öğretmenler; eğitim öğretim döneminin başında veli toplantıları yapabilir, bu toplantılarda çocuğun fiziksel ve ruhsal sağlığı, özel gereksinimleri, akademik ve duygusal gelişimine olumlu veya olumsuz etkide bulunabilecek her türlü durum hakkında velilerden bilgi isteyebilir. Bu bilgilerin diğer velilerce duyulmamasına dikkat edilerek, çocuğun bilgilerinin gizli kalması sağlanabilir.
- Öğretmenlerin gözlem, ev ziyaretleri, veli toplantıları ve velilerle yapılan ayrı görüşmelerden elde ettikleri ve çocuğu anlayıp ona göre davranmak için gerekli olan bilgileri girebilecekleri bir dijital ortam sağlanabilir. E-okulda çocuk ve aileyle ilgili bilgilerin yer aldığı formlar mevcuttur ancak bu formlar detaylandırılmamaktır. Öğrenciler hakkında önemli bilgilerin yazılabileceği bir bölümün olması, özellikle kalabalık sınıflarda öğretmenin öğrenci hakkındaki bilgilere istediği zaman ulaşabilmesini sağlayacak hem de öğretmen değişikliği gibi durumlarda yeni gelen öğretmenin bu bilgilere kısa sürede erişimini sağlayacaktır.

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An Automation Application For Users To Manage Their Medication Inventory And Patient Information

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Abstract – Medication management and monitoring of their numbers are of great importance for both pharmacists and patients to ensure healthy medication use. In this study, it was developed to enable patients to manage their medication needs effectively and reliably through pharmacy automation. The application was developed in PHP language. The main purpose of the application is to enable users to perform their daily pharmacy transactions more efficiently and error-free. For this purpose, an automation system has been created so that users can easily manage their medication inventory and patient information. This system allows users to track medication inventory, update medications in stock, and securely store patients' prescription information.

Keywords –Medicine tracking, Automation, Pharmacy

I. INTRODUCTION

Nowadays, the importance of technological innovations in the healthcare sector is increasing. In this context, pharmacy owners are turning to automation systems to effectively manage drug treatments and provide better service to patients. In recent years, a rapid change is noticeable in the health services and organizational structures provided in health institutions. The number of healthcare institutions increasing day by day competes with each other with the quality and cost of the service provided. For this reason, healthcare institution managers are renewing themselves towards the principles of organizational science [1]. Today, e-health appears as a common name for all technological fields [2]. Health informatics, which comes to mind when e-health is mentioned, develops methods and tools that will contribute to high-quality, efficient care of individuals and societies [3]. Improving health mediated by e-health and digital technologies is important in reaching the desired level in terms of the use of tools in health [4]. Health services are aimed at preventing, diagnosing and treating diseases, and large amounts of medical drugs are used for this purpose [5]. It is extremely important that the drugs are at the right place and time, from the production of the drugs until they reach the patient [6]. In recent years, the issue of fraud and misuse of drugs in the pharmaceutical supply chain has become increasingly common [7]. On the one hand, while people are looking for ways to be healthier, drugs with new names and labels are being introduced to the market every day for treatment purposes. However, counterfeit drugs produced outside of standards not only have serious negative effects on human health, but also cause serious economic losses in the healthcare sector [8]. Therefore, it is necessary to both prevent counterfeit medicine problems and overcome other supply chain problems. Safe and transparent drug delivery process and stock tracking are important. There are many expert opinions suggesting the need to improve and constantly monitor the control and management of the pharmacy pharmaceutical market [9]. In the literature, there were studies on different web-based control systems in different fields [10-11].

The drug supply and tracking system is a system that must be followed through various processes until it reaches the end user. In this study, a web-based application was developed to keep track of medications.

II. Materials and Method

In this study, web-based medication tracking automation was developed using PHP language. The database relationships of the developed pharmacy automation system are shown in Figure 1.

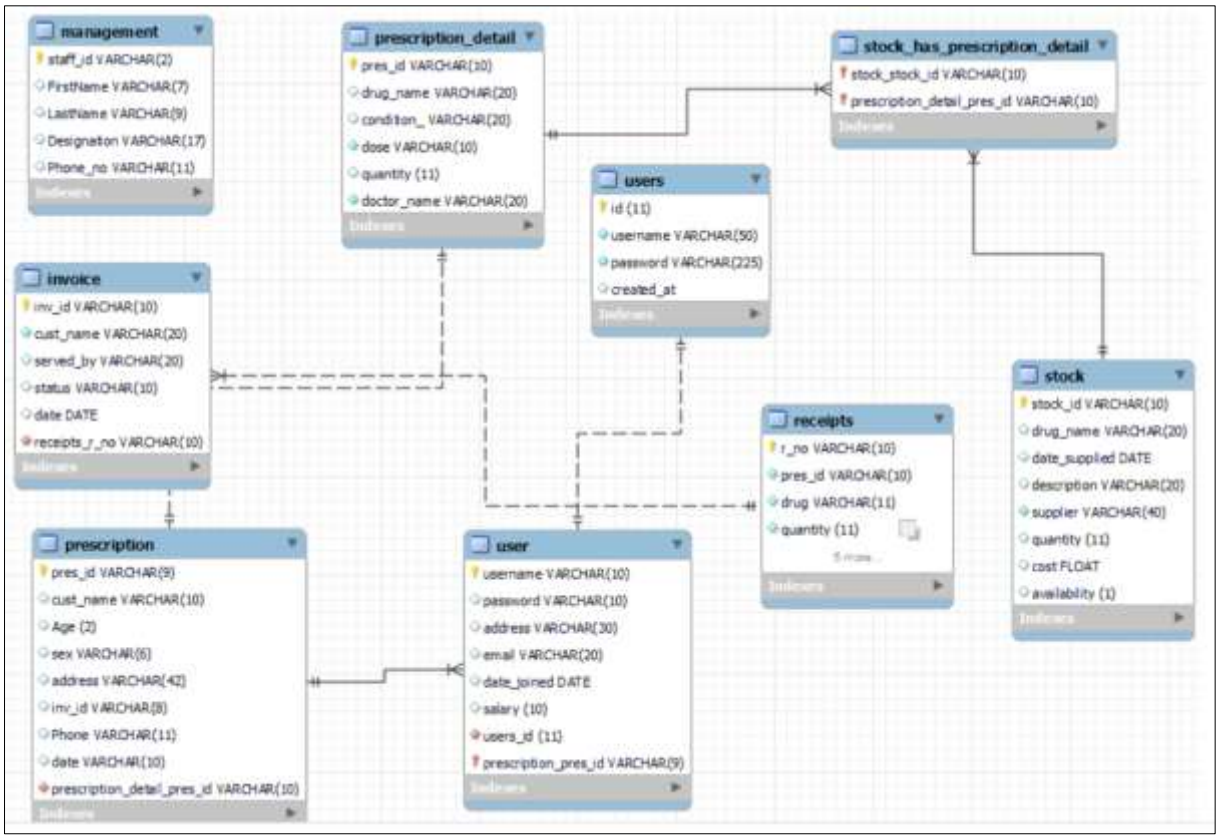

Fig. 1 Relationships between tables in the database

These tables and relationships form the basic database structure of the pharmacy automation system.

- Relationship between *user* and *users* table, a user can have one or more users records.
- Relationship between *user* and *prescription* table, a user can have one or more prescription records.
- Relationship between *prescription* and *prescription_detail* table, a prescription can have one or more prescription_detail records.
- Relationship between *prescription* and *invoice* table, a *prescription* can have one or more *invoice* records.
- Relationship between *invoice* and *receipts* table, an *invoice* can have one or more *receipts* records.
- Relationship between the *stock* and *prescription_detail* table, the *stock_has_ prescription_detail* intermediate table is used to model this relationship.

With the developed web-based application, a secure authentication mechanism was first created for users to log in to the system. This authentication system ensures system security by allowing users to have different access levels according to their special authorizations. Figure 2 shows the system login screen.

Fig. 2 System login screen

After the officials log in, they are directed to the screen where they can choose the actions to take. The screen interface with this guidance is shown in Figure 3.

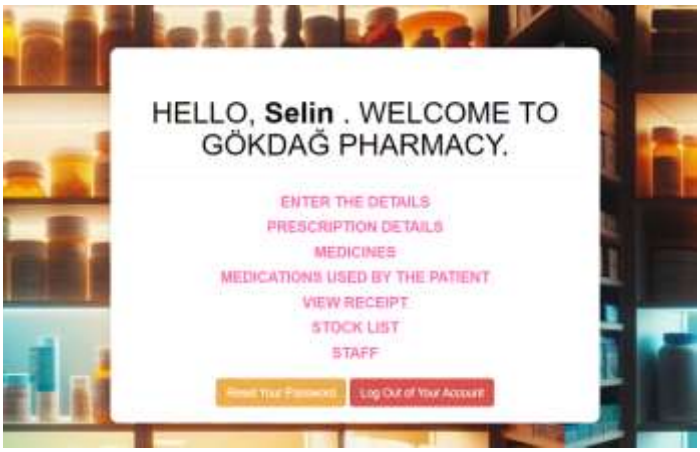

Fig. 3 Control interface screen

Then, thanks to an advanced interface that welcomes users, a comprehensive platform is provided where the patient can record detailed information and prescription information. This developed user interface allows all important information about patients to be recorded completely and accurately. It also enables the prescriptions written by doctors to be questioned in detail. Thus, all details of the current medication treatment and the medications recommended by the doctor are meticulously recorded and easily accessible when necessary. This feature helps both pharmacists and healthcare professionals provide the best service to patients and enables safer and more effective management of drug therapy processes. The patient detail page is shown in Figure 4.

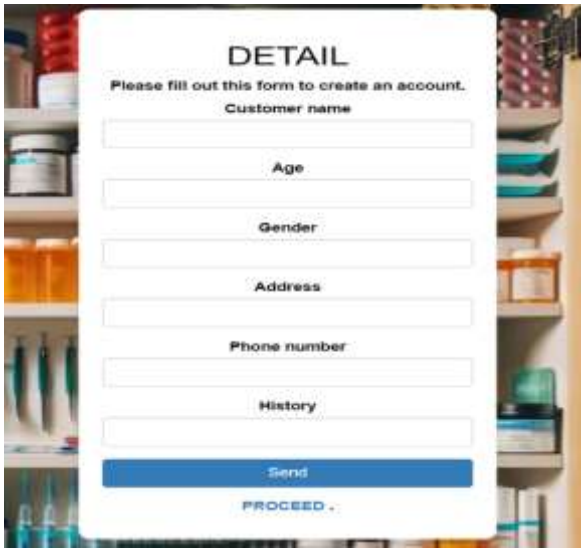

Fig. 4 Detail page

Figure 5 shows the interface page where the necessary information for inventory management is obtained.

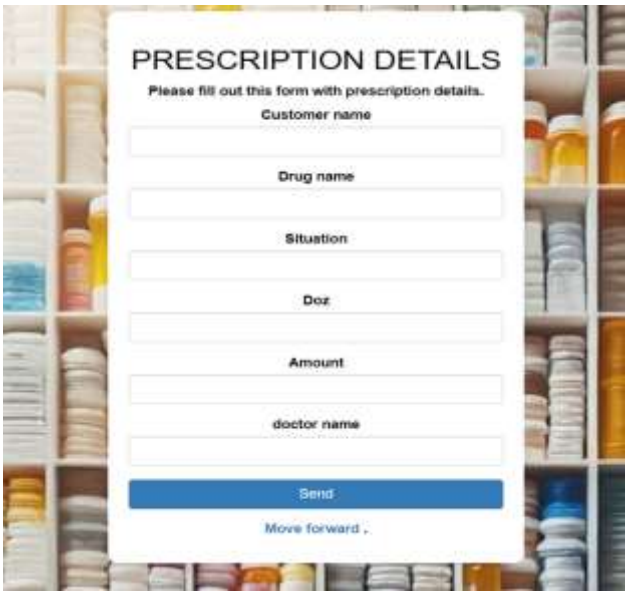

Fig. 5 Inventory Detail page

The required code to check whether there is a drug in the database is shown in Code block-1.

Code block-1: Checking whether there is drug or not

```
……..
……
$query ← "SELECT availability FROM stock WHERE drug_name = ?";
if ($stmt ← …_prepare($link, $query)) Then {
   …_stmt_bind_param($stmt, "s", $drug_name);
   if (…_stmt_execute($stmt)) Then { …_stmt_store_result($stmt);
      $num_rows ← …_stmt_num_rows($stmt);
      if ($num_rows > 0) Then { …_stmt_bind_result($stmt, $availability);
         …._stmt_fetch($stmt);
         if ($availability == 1) Then { echo 'This medicine is available';
```

```
        } else { echo  'This medicine is not available, Sorry';
        } } else { echo  'This medicine is not available, Sorry';  }
……..
……
```

An inventory module was developed to manage the pharmaceutical inventory, as shown in Figure 6. Users can view the medications patients are taking in this module.

Fig. 6 Medicine inventory list

The code required to add drugs to the database was also shown in code block-2.

Code block-2: Adding drugs to the database

```
if (empty($cust_name_err) && empty($drug_name_err) && empty($condition__err) &&
empty($dose_err) && empty($quantity_err) && empty($doctor_name_err)) Then {
      $check_stmt ← …_stmt_init($link);
if (.._stmt_prepare($check_stmt, "SELECT availability FROM stock WHERE drug_name ← ?"))  Then {
…_stmt_bind_param($check_stmt, "s", $drug_name);
        if (…_stmt_execute($check_stmt)) Then {       …….
          if (…_stmt_fetch($check_stmt)) Then {       …….
            if ($availability == 1) Then {                  …….
              if (…_stmt_prepare($stmt, "INSERT INTO ..?)")) Then { .._stmt_bind_param($stmt, …);
                  $param_cust_name ←$cust_name;
                  if (…_stmt_execute($stmt)) Then {  echo "Successfully entered";
                  } else { echo "Something went wrong. Please try again later.";  } ……  }      }
            else {   echo "Drug is not Available!";  }      }       }       }    }…..
```

Figure 7 shows the interface that allows pharmacists to easily view, add, update and delete medications in stock. Additionally, a patient knowledge base was created to store and manage patient information. This knowledge base was designed to store patients' prescription information securely and access it when desired.

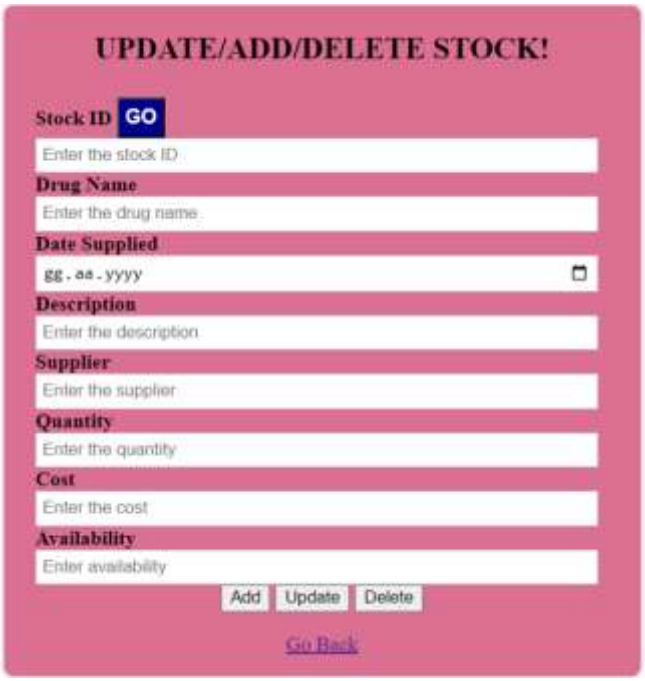

Fig. 7 Medication control and follow-up screen

Then, an interface was developed where personnel authorizations can be updated, added and deleted. Details of the personnel authorization control interface are shown in Figure 8.

Fig. 8 Personnel authorization control interface

In the developed application, the receipt of the medications used and taken by the patient can be viewed. Figure 9 shows the reporting page and the interface containing the details of the transactions made to the users.

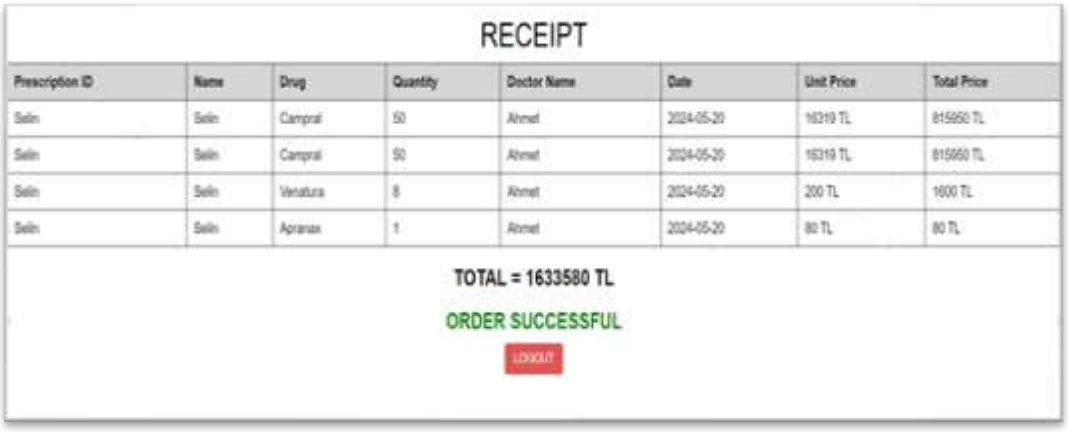

Fig. 9 Report control interface

III. CONCLUSION

With the developed application, a pharmacy automation system was created where users can safely and effectively manage their drug inventory and quickly meet patients' drug demands. This system increases the work efficiency of users and ensures that patients receive better service. In addition, thanks to the user-friendly interface and reliable structural design of the system, users can easily interact with the system and quickly access the information they want. Pharmacy automation is an important tool for reliably meeting patients' medication needs while allowing users to effectively manage their medication inventory. Thanks to this web-based application, pharmacies can work more efficiently and provide better service to patients. The application will contribute to establishing a healthier and more reliable relationship between pharmacists and patients.

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A Web-Based Application For Security And Crime Reporting System

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Abstract – Crime reporting systems can sometimes be vital for people. The security and crime reporting system developed in this study is a web-based application that allows users to make various security and crime reports. This system allows users to quickly report criminal incidents and emergencies to authorities. After registering, users can report crimes, view the list of missing and wanted persons, and send emergency notifications. The system also has a special admin panel for administrators. The admin panel allows administrators to manage crime and emergency notifications, edit missing and wanted person information, and add new records. The database of the developed application contains tables to store user information, crime notifications, missing and wanted persons information. With Google Maps API integration, users' location information is obtained and emergency notifications are delivered more effectively and accurately. This system was developed to increase public safety and enable users to get help quickly in emergency situations.

Keywords – Crime Reporting, Crime Prevention, Crime and Security

I. INTRODUCTION

The purpose of suspicious transaction reporting is to warn the competent authorities about possible transactions aimed at exonerating crimes. It covers different fields, including various social sciences such as crime psychology and ethics. As a result of studies that examine the concept of crime together with psychology, more effective applications and scientific approaches can be developed [1]. In addition, individuals' basic security needs are very important from a psychological perspective. Maslow placed the need for security at the second level in the hierarchy of psychological needs in humans [2-3]. It is also important to define the crime and focus on its causes [4]. There are also different personality factors that cause crime. It has been observed that people who are extroverted are more open to environmental stimuli and less likely to be affected by the negative consequences of their behavior. Psychoticism, neuroticism and extraversion scores in personality tests may differ [5-6]. In the international declaration published by the United Nations, it is stated that everyone has the right to life, liberty and security of person. [7]. How can crime be prevented and prevented? Some specific information allows us to reach some findings about the crime. Gender, age, income level, marital status, region, living environment, criminal-victim relationship, and data about the crime tool may be among this specific information [8]. According to 2010 data in the USA, the crime of theft increased by 2% compared to 2001, and the total loss of theft victims was stated to be 4.6 billion dollars. Statistics also show that approximately 15 million serious crimes were committed in America in 2010. In addition, it has been stated that there are crimes that are not reported to official channels and whose damages cannot be clearly determined [9].

In this study, a criminal notification application for web-based security was developed to reduce the crime rate.

II. Materials and Method

The relationships between the tables of the application developed in PHP for security and crime reporting are shown in Figure 1.

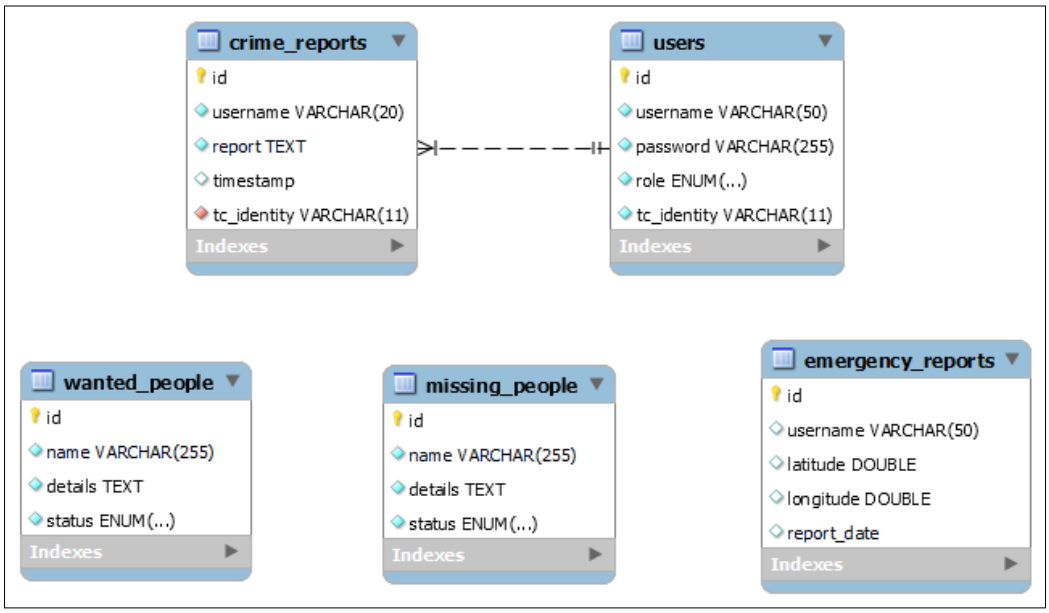

Fig. 1 Tables and their relationships

***crime_reports* Table: This table stores crime reports.**

- **id:** Primary key, a unique ID for each report.
- **username:** The name of the user who made the report (Username from session).
- **report:** Details of the crime report.
- **timestamp:** The time the report was made.
- **tc_identity:** ID number of the user making the report.

***users* Table: This table stores users.**

- **id:** Primary key, a unique ID for each user.
- **username:** The user's name.
- **password:** The user's password.
- **role:** The user's role (user or admin).
- **tc_identity:** User's TR ID number.

Relationship between *crime_reports* and *users* table, a user can report more than one crime.

***wanted_people* Table: This table stores wanted people.**

- **id:** Primary key, a unique ID for each called person.
- **name:** Name of the person called (Name from the form).
- **details:** Details of the person being called (Details from the form).
- **status:** The person's status (active or inactive).

***missing_people* Table: This table stores missing people.**

- **id:** Primary key, a unique ID for each missing person.
- **name:** The name of the missing person (Name from the form).
- **details:** Details of the missing person (Details from the form).

● **status:** The person's status (active or inactive).

***emergency_reports* Table: This table stores emergency reports.**
● **id:** Primary key, a unique ID for each report.
● **username:** The name of the user who made the report (Username from session).
● **latitude:** The latitude of the reported location.
● **longitude:** Longitude of the reported location.
● **report_date:** The time the report was made.

In Function 1, the function of sending the emergency location was demonstrated. There are different functions in this algorithm, they are briefly shown here.

	Function-1: Emergency location sending function
1.	**function sendEmergency**() {
2.	**if** (navigator.geolocation) { **Then**
3.	navigator.geolocation.getCurrentPosition(function(position) {
4.	**var** lat ← position.coords.latitude;
5.	**var** lon ←position.coords.longitude;
6.	**var** xhr ←new XMLHttpRequest();
7.	xhr.open("POST", "send_emergency.php", true); // Send emergency notification
8.	xhr.setRequestHeader("...");
9.	xhr.onreadystatechange ← function() {
10.	**if** (xhr.readyState .. && xhr.status ...) { **Then**
11.	**alert**("Emergency alert has been sent."); // if notification successful
12.	} };
13.	xhr.**send**("latitude←" + lat + "&longitude←" + lon);
14.	});
15.	} **else** {
16.	**alert**("Geolocation API not supported.");
17.	} }
18.	**end function**

The login screen of the developed application is shown in Figure 2. On the homepage, users will see two buttons: “Log In” and “Register”. Through these buttons, users are directed to the login or registration pages.

Fig. 2 User registration and login screen

After registration, the user's panel is shown as shown in Figure 3. The user panel is a page where users logged in to the system can perform various operations and access information. On this page, users can view the list of wanted persons and missing persons registered in the system. Details can be accessed by clicking on the person's names. Users can also report crimes and emergency reports from this page. The emergency button determines the user's current location and makes the notification. Users are notified with success messages after making crime and emergency notifications.

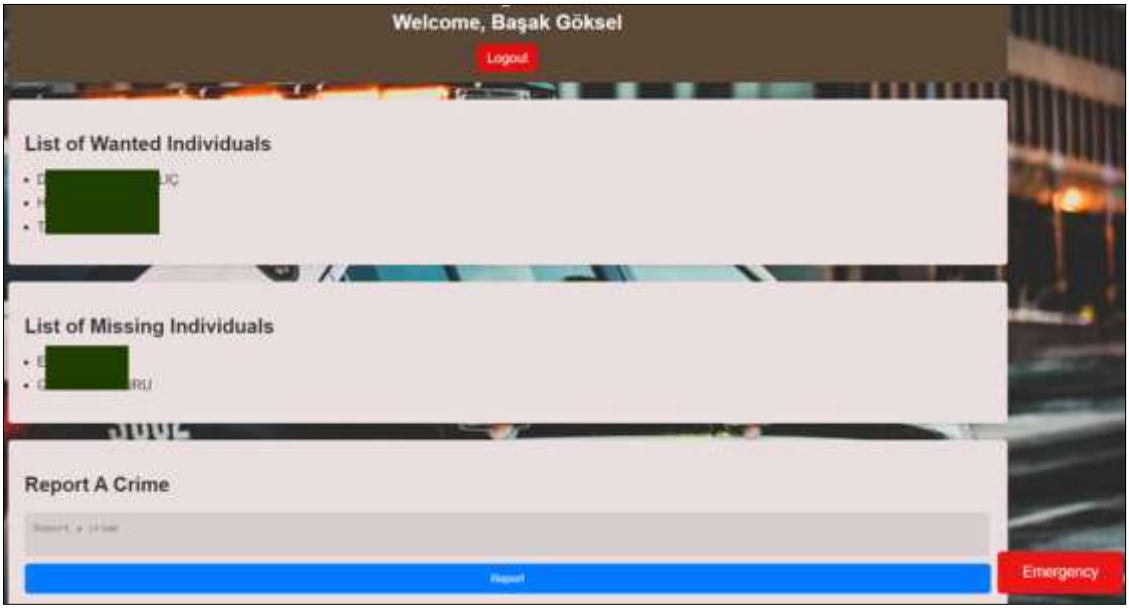

Fig. 3 User panel

Report listing is shown in Figure 4.

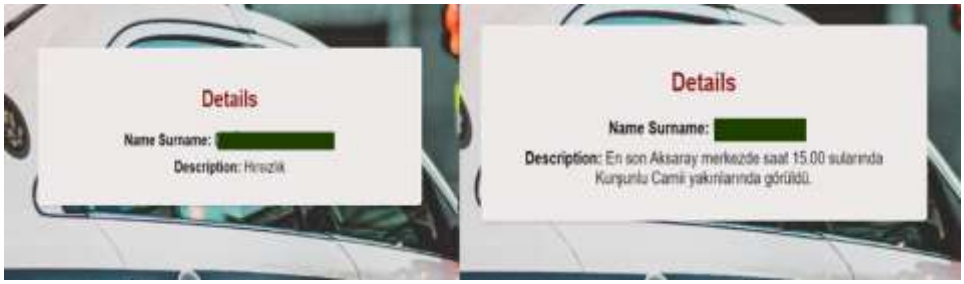

Fig. 4 Detail panel

The admin panel is a page where admin users logged into the system can perform various management operations. In this panel, administrators can view, edit and delete crime reports, wanted persons and missing persons registered in the system. Administrators can also add new wanted persons and missing persons. Crime and emergency notifications are listed and details for each notification can be reviewed. The admin panel provides overall management of the system and effective tracking of notifications made by users. Administrators can take necessary actions by auditing the notifications made by users and can quickly respond to users' security needs. Figure 5 shows the admin management panel.

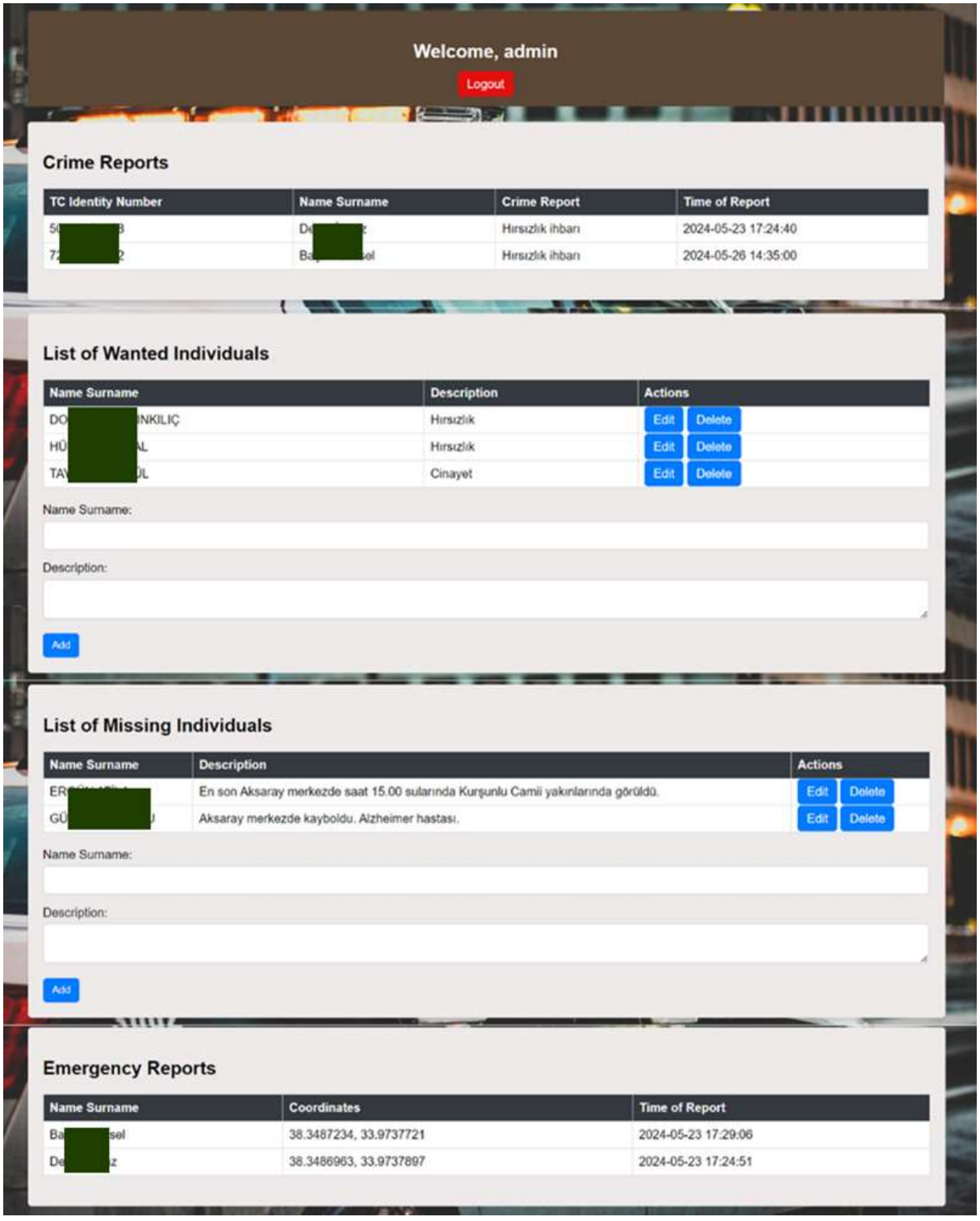

Fig. 5 Admin management panel

Figure 6 shows the interface of the page where notifications can be edited.

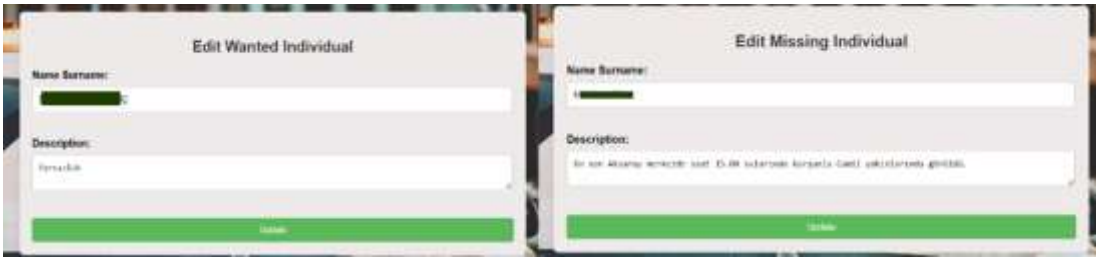

Fig. 6 Notification editing page

III. CONCLUSION

Within the scope of this study, a security and crime reporting system has been developed that allows users to make crime and emergency notifications, as well as view wanted and missing people. The project has a user-friendly interface through which users and admins can easily perform various functions. The system has been designed and implemented to meet the needs of users and admins. Management of crime notifications and emergency notifications can be done effectively via the admin panel. This security and crime reporting system can contribute to reducing crimes and increasing the sense of security in society. Users can report crimes more quickly and effectively, which can speed up the process of solving crimes. Additionally, seeing lists of missing and wanted people can help the community feel safer. Because it encourages awareness and cooperation. As a result, this system can have a positive impact on the safety and well-being of society and be a more effective tool in fighting crime.

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Monitoring Cutting Tools During Machining of 316L Stainless Steel Using Dimensional Analysis of Chips

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Abstract **–** This study aims to introduce an innovative method for monitoring tool wear during the machining of 316L stainless steel. This monitoring is crucial for anticipating tool failures, reducing replacement costs, and improving production efficiency. In this research, a new approach is proposed, based on the dimensional analysis of chips.

Initially, we measured the tool wear rate after each pass, as well as the dimensions of the chips in terms of width and thickness. Then, we analyzed the dimensional variations of the chips to establish a correlation between these variations and the tool wear rate.

We found an inverse correlation between them, indicating that changes in chip dimensions are directly related to changes in tool wear rate. Finally, we derived a predictive equation from a simple linear regression between the chip dimensions and the wear rate. The predicted data showed a very satisfactory agreement with the experimental values, confirming the accuracy of the proposed tool wear monitoring model.

Keywords – Correlation analysis, Chips, Cutting tools, 316L stainless steel, Wear

I. INTRODUCTION

In the field of production engineering, creating parts with impeccable precision and tolerance is of paramount importance. Tolerances define the acceptable margins for manufactured parts' dimensions and geometric characteristics [1]. Perfect tolerance ensures that parts are made with absolute precision according to the required specifications [2]. Any deviation from these tolerances can compromise the performance, quality, and even safety of the final products [3].

Ensuring the precision of machined parts requires meticulous monitoring of the cutting tools used in the process. Cutting tools must maintain optimal performance levels to ensure the precision and quality of the parts [4], [5]. Tool wear or failure can lead to undesirable dimensional variations and surface defects, compromising compliance with the required tolerances [6].

This is where production engineering comes into play, developing, designing, and implementing efficient and reliable manufacturing processes [7]. The goal of production engineering is to optimize manufacturing operations while ensuring quality and meeting specifications [8]. This requires the implementation of sophisticated monitoring systems for cutting tools to quickly detect problems and intervene promptly to maintain the precision and quality of machined parts [9], [10].

Our work on a new methodology for tracking cutting tool wear during the machining of parts is of great importance. By proposing an innovative approach to monitor tool wear, our study could help companies manage preventive maintenance and quality in their manufacturing processes. A more precise and efficient methodology for assessing tool wear would have a direct impact on the quality of produced parts

while reducing unexpected production interruptions and associated maintenance costs. Thus, our research offers a valuable opportunity to improve operational efficiency and competitiveness for companies in various industrial sectors.

Several studies have utilized chips to monitor cutting tool wear based on different data such as chip shape or color [11], [12], [13], [14]. This study aims to propose a mathematical model to predict cutting tool wear during the machining of stainless steels, based on the dimensional analysis of chips.

The study begins with the collection of data from experimental tests conducted on a conventional lathe, using a stainless-steel workpiece and a carbide insert under fixed cutting conditions. We measured the tool wear rate as well as the width and thickness of the chips after each machining pass. Then, we sought to establish a correlation between the values from the dimensional analysis of the chips and those of the wear.

II. Materials and Method

A. Experimental Approach

The experiments were carried out on a 316L stainless steel specimen. The specimen was machined on a conventional lathe, with a carbide insert. The length machined during each pass and the cutting conditions were kept constant throughout the machining operation. The experimental approach is represented in Fig. 1.

At the end of each pass, we measured the wear rate using a video measurement machine until the wear reached the average value VB = 300 µm. The wear values are presented in Table 1 and Fig. 2. The dimensions of the chips, width, and thickness, were also measured by the same video measurement machine and are represented in Table 2 and Table 3 and Fig. 3 and Fig. 4.

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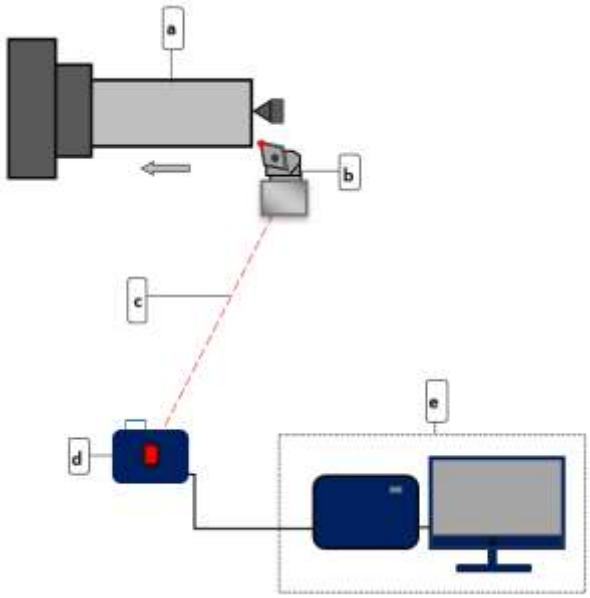


Fig. 1 Experimental Procedure, a. Specimen, b. Cutting Tool, c. Laser Beams, d. Vibrometer, e. Acquisition System

Table 1. Wear values obtained

Teste N°	VB (µm)
1	77
2	85
3	108
4	132
5	146
6	155

7	185
8	200
9	216
10	231
11	246
12	262
13	293
14	308
15	323

Table 2. Obtained thickness values

Teste N°	e (µm)
1	51
2	54
3	50
4	49
5	46
6	44
7	40
8	37
9	30
10	29
11	26
12	16
13	14
14	12
15	09

Table 3. Obtained width values

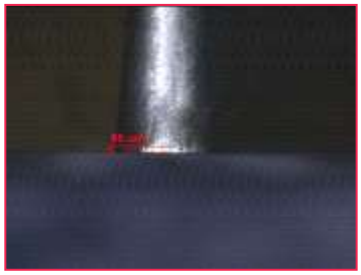
Teste N°	L (µm)
1	532.75
2	515.66
3	473
4	467.33
5	475.33
6	437
7	361.33
8	299.33
9	271.66
10	283.66
11	274
12	251
13	226
14	210
15	209

B. Data Processing

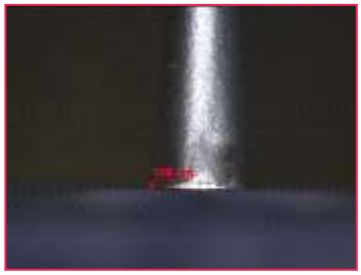
The approach followed in this study and the data processing were conducted as follows:

- First, we measured the wear rate of the cutting tool for each pass.
- Next, we also measured the dimensions, thickness (e), and width (L) of the chips.
- The next step is to analyze the dimensional variations of the chips between passes and try to find the relationship between these variations and the wear rate VB. We have already observed an inverse relationship between the two.
- Then, we extracted the tool wear prediction model from the simple linear regression equation between e, L, and VB.

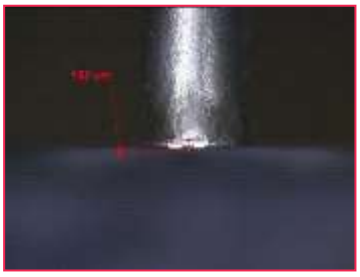
$v_B = 77$ µm



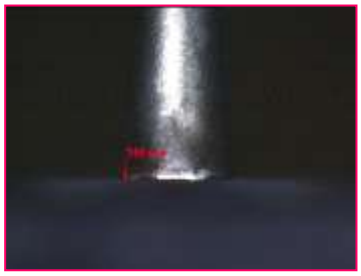
$v_B = 85$ µm



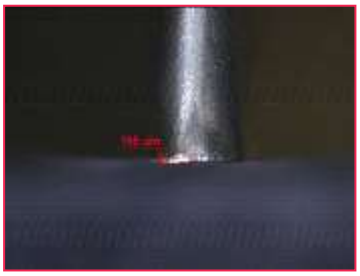
$v_B = 108$ µm



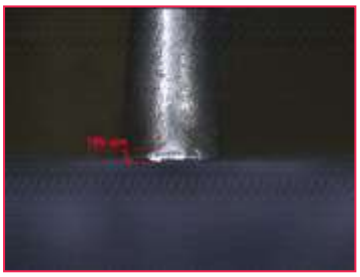
$v_B = 132$ µm



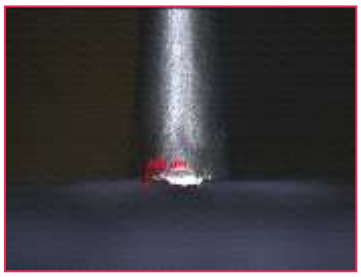
$v_B = 146$ µm



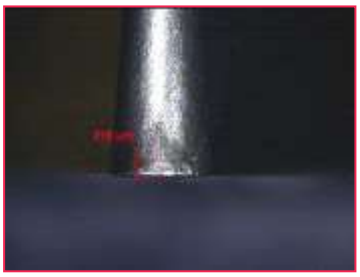
$v_B = 155$ µm



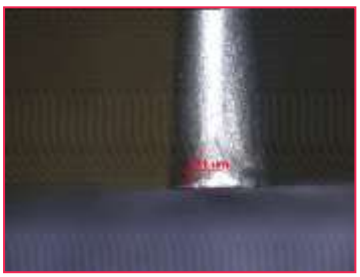
$v_B = 185$ µm



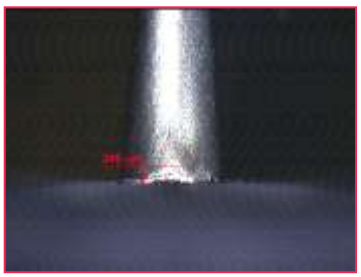
$v_B = 200$ µm



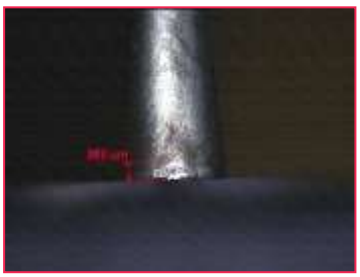
$v_B = 216$ µm



$v_B = 231$ µm

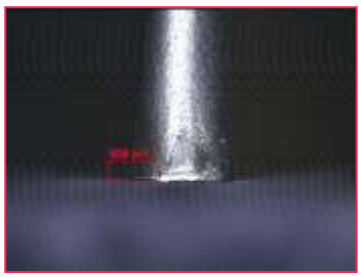


$v_B = 246$ µm

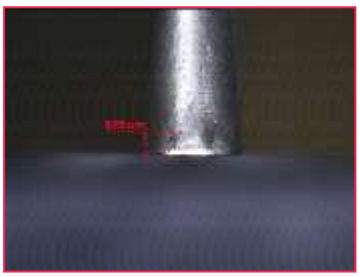


$v_B = 263$ µm

$v_B = 293$ µm



$v_B = 308$ µm



$v_B = 323$ µm

Fig. 2 The wear of the cutting tool during the 15 passes

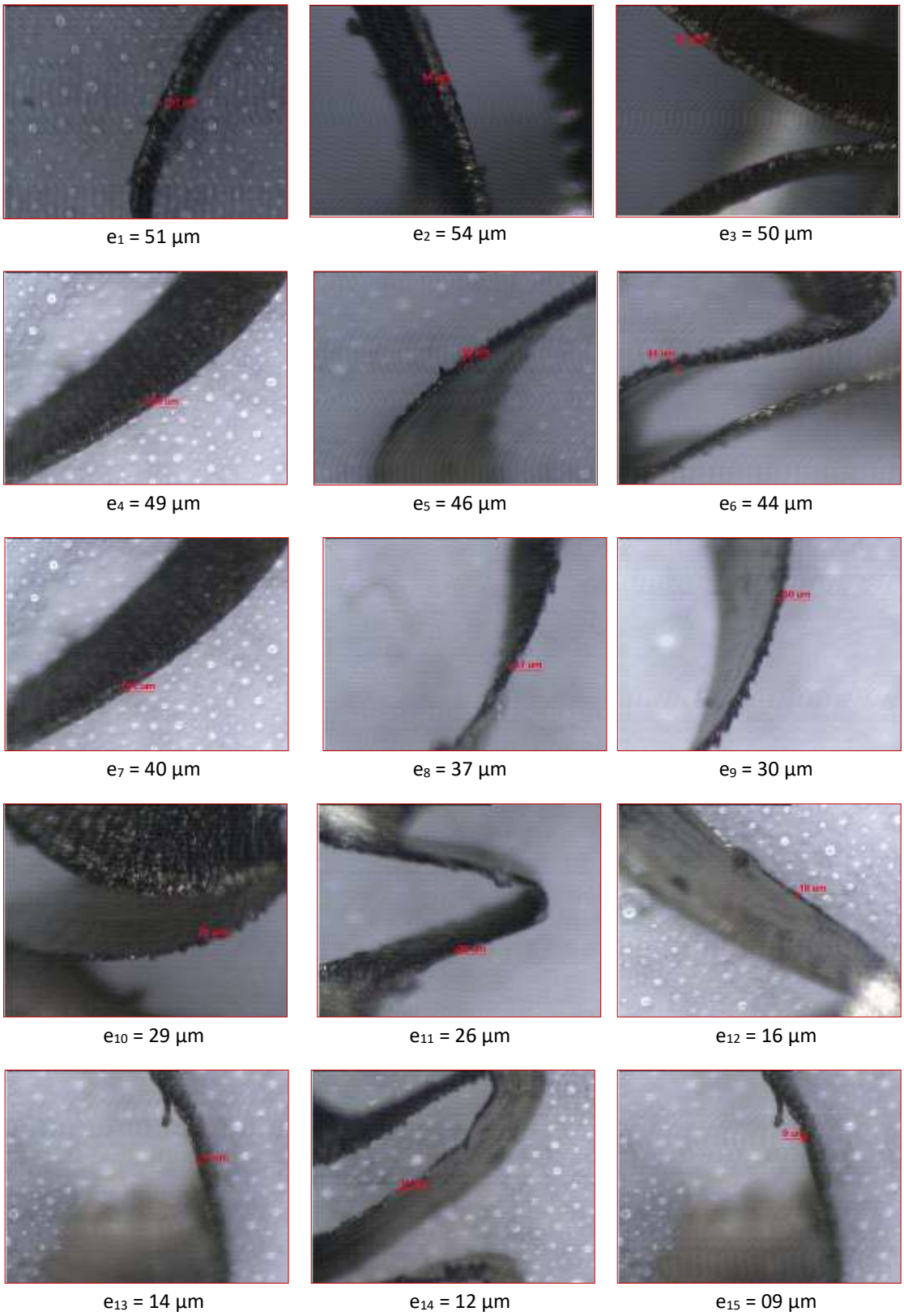


Fig. 3 The thickness values for the 15 passes

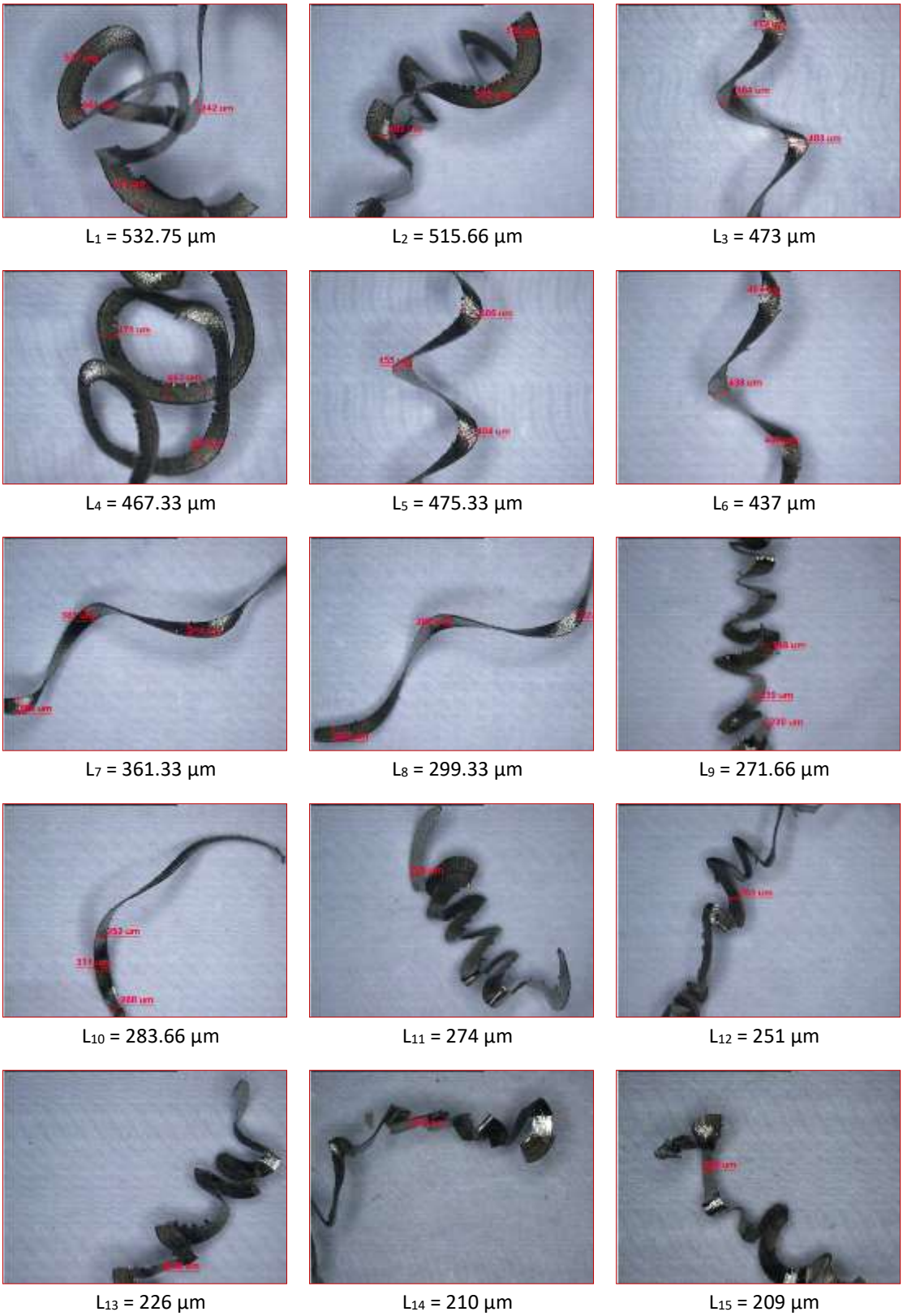


Fig. 4 The width values for the 15 passes

III. RESULTS

After capturing the state of the cutting tool's edge and the wear values for each pass, as illustrated in Fig. 2, as well as the chips and their thickness and width measurements, respectively illustrated in Fig. 3 and Fig. 4, we undertook the analysis of the dimensional evolution of these chips and compared them to the tool wear. We observed that the increase in tool wear rate results in a decrease in the width and thickness of the chips after each pass, as illustrated in Fig. 5, Fig. 6, and Fig. 7.

During the initial passes, we noticed that each chip had variable dimensions, indicating they were not very homogeneous. This required taking four width measurements on the same chip to calculate their average for more accurate measurements. In contrast, the chips produced during the final passes were more homogeneous in both dimensions and shape.

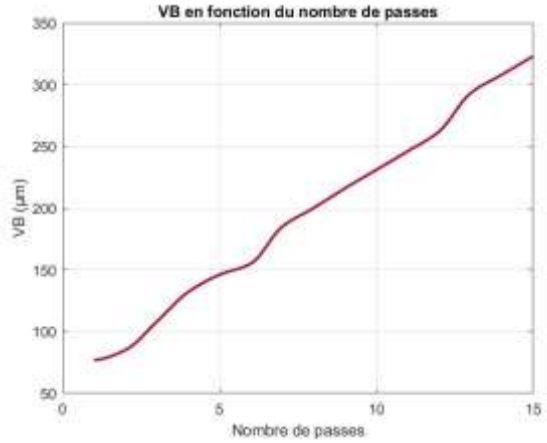


Fig. 5 The experimental evolution of tool wear

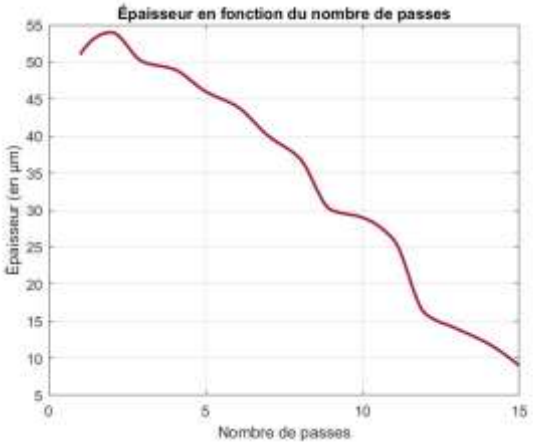


Fig. 6 The experimental evaluation of chip thickness

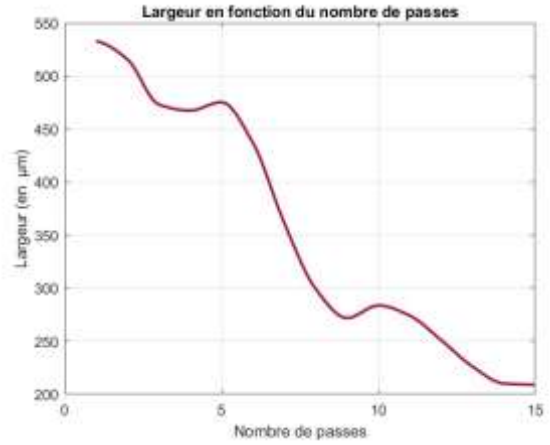


Fig. 7 the experimental evaluation of chip width

IV. DISCUSSION

After that, we analyzed the correlation between the thickness and width of the chips and the tool wear values, observing an inverse relationship between these dimensions and the tool wear rate, as illustrated in Fig. 8 and Fig. 9 respectively, according to the correlation coefficient tending towards -1.

We particularly noticed that the correlation between chip thickness and tool wear is the most significant. This led us to extract predictive values from a simple linear regression equation between these two variables. The predicted wear values were found to be very close to the actual values, as illustrated in Fig. 10, demonstrating that the mathematical model based on chip thickness can accurately predict tool wear in real time.

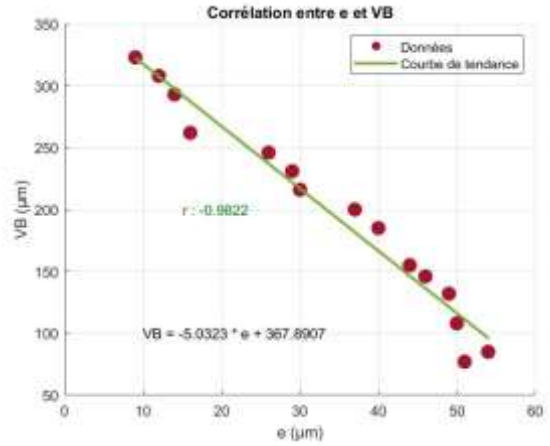


Fig. 8 The correlation between tool wear and chip thickness

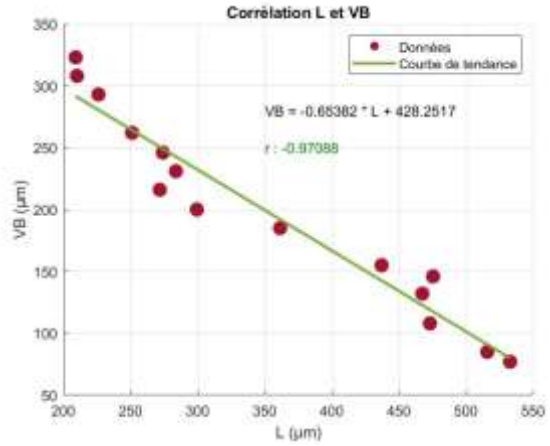


Fig. 9 The correlation between tool wear and chip width

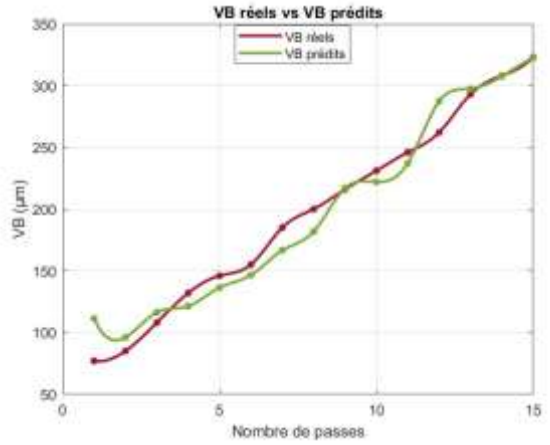


Fig. 10 Predicted wear values vs actual wear values

V. CONCLUSION

This study examined in detail the wear of the cutting tool through the analysis of chips generated during the machining process. Our results demonstrated a significant correlation between the thickness and width of the chips and the tool wear rate. Specifically, a decrease in chip thickness and width was observed as tool wear increased. This inverse relationship was supported by statistical analysis, with a correlation coefficient close to -1. Additionally, we observed an evolution in the homogeneity of the chips over the passes, from significant variation to more uniform chips, indicating a stabilized tool wear process.

The use of simple linear regression allowed us to develop an accurate mathematical model to predict tool wear in real time based on chip thickness. The predicted values were closely aligned with the actual tool wear values, confirming the effectiveness of the proposed model.

In conclusion, this research provides valuable insights into the relationship between chip characteristics and cutting tool wear. These results can be used to improve tool wear monitoring strategies and contribute to more efficient and preventive machining management. Furthermore, this approach can be extended to other machining processes and materials, paving the way for new applications in the field of manufacturing.

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Data on Facial Skin Tumors, Tirana - Albania

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Abstract – The most common epithelial tumor of the facial skin is basal cell carcinoma (BCC), which is distinguished by local infiltrative growth rather than a very infrequent metastasis. Rarely, this neoplastic process exhibits aggressive behavior, deep invasion, and a high risk of recurrence following surgery. It is unclear exactly what causes the pathogenesis and what influences the rapid growth.

Although the tumor can develop on any skin exposed to the sun, it most commonly occurs in the middle region of the face and scalp. This study's objective is to review the body of knowledge regarding BBCs. In the Department of Plastic and Reconstructive Surgery in Tirana, 42 patients with BCC received treatment for a year, from March 2022 to March 2023. 34 cases (81%) with tumors matched type T1 (81%), 5 cases (12%) had T2 tumors, and 3 cases (7%), T3 tumors. This is according to the AJCC classification. Every patient underwent prompt reconstruction following surgical removal of the neoformation. A clinical margin of 3-5 mm is necessary for surgical excisions of small BCCs (1-2 cm), and the tumor's recurrence risk ranges from 4% to 14%.

According to the literature review, data gathered from our own experiences show that the only way to have a good prognosis for the disease is to receive the right treatment in conjunction with an early diagnosis. Environmental factors such as sun exposure, trauma, and smoking are significant contributors to the development of facial skin tumors.

Keywords – Facial Skin Tumors, Basal Cell Carcinoma - BCC, Surgical, AJCC, Tirana.

I. INTRODUCTION

In non-melanoma skin tumors, basal cell carcinoma (BCC) is the most common type. There has been an uneven distribution of the incidence increase; with the United States and Australia that have the highest rates (30%) [1-2].

In 1988, the American Joint Committee on Cancer released the morphologic features required to classify a BCC as giant. Merely 1% of all BCC meet these requirements. A spontaneous mutation of the PTCH gene, located on chromosome 9q22.3, is associated with facial skin tumors.

Doing a one- or two-step surgery is the gold standard. With one-step surgery, the reconstructive process is final, and the surgical defect is addressed directly. A five-year tumor-free rate of over 99% for primary BCC and over 95% for recurrent BCC is achieved with one-step surgery using Mohs Micrographic surgery, which yields superior clinical outcomes compared to other interventions that have a rate of 93% and 80%, respectively.

According to Burns et al. [3], patients who have already had a BCC have a 44% three-year risk of getting another one. Neoplasm is typically diagnosed in older (40–80 years old), fair-skinned individuals, though many cases that start in younger or other racial groups have been reported in the literature.

According to Efron et al. [4], a spontaneous mutation of the PTCH gene, which is in chromosome region 9q22.3, is linked to the etiopathogenesis of BCC. Many genetic disorders (such as Xeroderma pigmentosum and Gorlin Syndrome) are linked to basal cell carcinoma in the literature [5-6].

Environmental factors such as smoking, trauma, and sun exposure are important in the development of tumors [7-9].

Though it can form on any skin exposed to the sun, the tumor most commonly appears in the middle of the face and scalp.

Small basaloid cells with an oval, monomorphism nucleus that are arranged in a cluster and invade normal tissue are the defining characteristics of BCC. These cells typically grow slowly and exhibit relatively benign, less aggressive behavior. On the other hand, giant BCC is an uncommon skin cancer that is marked by a poor prognosis, recurrent metastases, deep tissue invasion with infiltration of the dermis or extra dermal structures (muscle, bone, etc.), and aggressive biological behaviors.

The American Joint Committee on Cancer defines a giant basal cell carcinoma as a tumor with a maximum dimension of 5 cm or more (T3). However, other definitions of "giant" include carcinomas larger than 10 cm.

Reviewing the body of research on BBCs and describing the Author's personal series are the goals of this study.

II. Materials and Method

II.1. Literature evaluation

A literature search was conducted using Pub Med, The Cochrane Collaboration, Embase, Scopus, and the National Library of Medicine to find articles related to skin basal cell carcinoma. The search terms "Metastatic BCC," "Aggressive Basal Cell Carcinoma," "BCC," and "Basal Cell Carcinoma" were utilized.

II.2. Risk element

Certain clinical characteristics have historically been closely associated with an aggressive BCC phenotype. Big size, the location of the face, neglect, or a long-standing tumor are said to be significant factors in the development of GBCC [10].

The prognosis is influenced by large size at first examination: In general, it is proposed that the size of 1 cm represents the threshold at which malignant behaviors change [1, 11].

Large size is typically the consequence of long-standing tumors, or a rapid growth caused by a specific histotype [9, 11].

The relationship to the middle face area is not entirely clear; numerous publications have noted that tumors developing on the medial cantus or nasolabial fold tend to progress more aggressively [12].

Because scar tissue can obstruct monitoring and delay the clinical detection of recurrence, incomplete excision is regarded as a risk factor [1]. However, Schroeder et al. [2] state that there is no proof that insufficient treatment alters the behaviors of the tumor.

Some authors have recently directed their attention towards histologic variants and specific characteristics like perivascular and per neural invasion [8, 12].

The neoplasms that tend to be less aggressive are nodular and superficial BCC [25, 26 art. 1], while morphea form and infiltrating neoplasms are linked to an increased risk of developing giant basal cell carcinoma. The final characteristic that highlights aggressive behaviors is the invasion of the nervous and circulatory systems, as was previously reported. These histologic findings are incredibly uncommon to find; literature reports that perivascular diffusion may increase neoplastic tissue trophism, which in turn may contribute to tumor extension. Rather, the 10% of aggressive Bcc cases that have neuronal involvement are thought to be at risk for rapid diffusion because of the small resistance cutting plane along a nerve fiber [5, 11].

Additional histologic features that could be deemed as minor criteria include increased mitotic rate, fibrosis, palisadism, and inflammatory infiltration [1-2]. It would seem sense that a high number of mitotic figures would be associated with a rapid turnover of cells, but the significance of inflammatory infiltration needs to be defined.

III. RESULTS

Forty-two BCC patients received treatment at Tirana, Albania's Department of Plastic and Reconstructive Surgery between March 2022 and March 2023.

Thirty-four tumors were classified as T1 (81%), five as T2 (12%), and three as T3 (7%), by the AJCC.

Tumor size and the interval between its onset and diagnosis were correlated. Between five and ten years, the presence of lesions was linked to BCC. Every patient underwent prompt reconstruction following surgical removal of the neoformation [13].

We carried out the regional lymphadenectomy in four cases. There were no detected lymph node metastases. Two patients in five non-surgical cases (all BCCs were on the face) were referred to the dermatology department for a PDT because they were in poor health and didn't follow up.

Four patients declined treatment for cosmetic reasons, and one patient with superficial BCC refused surgical excision and was treated with laser CO_2.

Despite repeated attempts to get the patient back for treatment, the patient was never found. For reconstruction, local flaps and skin grafts were employed.

IV. DISCUSSION

The most prevalent type of skin cancer, basal cell carcinoma, is primarily found on sun-exposed and sun-damaged skin. BCC often exhibits a benign course, exhibiting modest growth and little local invasion.

On rare occasions, it exhibits an aggressive phenotype that involves local invasion, destroying surrounding structures and causing a loss of function. The lifetime risk of developing BCC is more than 30% due to the disease's rapid incidence increase.

The epidermis' pluripotent epithelial cells give rise to basal cell carcinomas, which typically grow 1 mm in diameter annually. Aggressive BCCs, on the other hand, can grow larger more quickly.

A rare variety known as giant BCC penetrates extra dermal structures like cartilage, muscle, and bone. Giant BCC is defined by the American Joint Committee on Cancer as a tumor larger than 5 cm; fortunately, only 1% of patients have a tumor this size, however in our series, 2.27% of patients had a tumor this size.

We believe that a high rate such as our report is associated with our patient's advanced age on average, their occupation (farmer, bricklayer, etc.), their geographic location, and their lower educational profile.

The largest tumor had developed four to seven years prior to the diagnosis, as shown by our series and the literature review. In the tiny village, the skin issues are misdiagnosed and treated insufficiently, with a 12% recurrence rate. As a result, the delay grew longer [3].

The literature reports that spontaneous regression of small BCCs that have not been fully excised is a common occurrence. The case of giant basal cell carcinoma, which has a high recurrence rate, is different.

In five of our series' non-complete resection cases, we see BCC recurrences within two months of surgery. In one instance, the skin graft was refused in the area where the neoplasm was still present, enabling us to achieve radicality with a second surgical procedure.

Beadles reported the first case of metastasis in 1894, and cases are extremely uncommon [14].

Sahl, Snow and Levine verified that although the incidence of metastases is 0.03% overall, it increases to 1.9% in carcinomas larger than 3 cm in diameter. In 45% of lesions bigger than 10 cm and 100% of tumors bigger than 25 cm, metastases take place [12].

Several writers put forth a set of standards in the latter part of the year 900 to classify a BCC as metastatic:

1. The primary lesion is in the skin rather than the mucosa.
2. Metastases do not originate from the primary lesion but rather happen at a different location.
3. The primary lesion's and the metastatic lesion's histology should be comparable.
4. There must be no squamous cell characteristics in the lesion [3, 6].

There are no cases of diffuse pathology in our patients, and no neoplastic infiltration was discovered during front limphectomy procedures.

We noted two deaths, not from metastases but from intracranial structures involved because of the patient refusing surgical treatment. More patients are refusing surgery due to this unresolved issue in oncologic surgery because they don't know what's wrong or they don't want the scar.

Patients have reported that in their early stages, these lesions are painless and cause no discomfort, especially when they are in the trunk. When a tumor has grown to a large size, interferes with the function of the affected structure, or negatively impacts the patient's social life, the patient is referred to a surgeon in cases involving the face.

Walling, et al., explains a common situation where a patient with an oncologic disease refused surgery for cosmetic reasons [1]. This circumstance frequently leads to an intolerable delay in treatment, necessitating the use of a more drastic and damaging curative procedure.

It is acknowledged that informed consent is essential to the doctor-patient dynamic. Any time a patient is interviewed, the doctor must go over the advantages and disadvantages of the suggested procedure, the repercussions of not accepting treatment, and the probable outcome. Surgeons become frustrated when patients refuse to receive treatment.

It's important for doctors to keep in mind that patients have the right to refuse surgery if they can make an informed decision and act in the best interests of themselves. A competent patient is entitled to reject any treatment, even if it shortens their life, and to select suboptimal care if they believe it will result in the highest quality of life. People with severe or chronic illnesses frequently refuse treatment, even if doing so will cause them to pass away.

It is widely acknowledged that the most effective way to treat basal cell carcinoma is through surgery [1, 11]. The surgical excision of a small BCC (1-2 cm) requires a clinical margin of 3-5 mm, and the tumor's recurrence risk is 4%–14%. Surgery for BCC requires a wider safety margin (10 mm), and there is a 68% chance of tumor remnants [15].

Doing surgery in one or two steps is the gold standard [7].

With one-step surgery, the reconstructive process is final, and the surgical defect is addressed directly. [vb14,15 art.3]. Health margin control is the issue with this surgery. A five-year tumor-free rate of over 99% for primary BCC and over 95% for recurrent BCC is achieved with one-step surgery using Mohs Micrographic surgery, which yields superior clinical outcomes compared to other interventions that have a rate of 93% and 80%, respectively [3].

However, some authors favor a delayed reconstruction, and they wait to close the defect completely until they have received a conclusive histopathological diagnosis [15].

Long-term surgery that removes vital tissue, such as bone, dura mater, or nervous structure, can leave a complex defect that has the potential to be fatal. Reconstruction has evolved into a multidisciplinary process involving anesthesiologists, plastic surgeons, neurosurgeons, and vascular surgeons, among others [3,5,11].

Reconstructive techniques range from free flap transfer to split skin graft. The decision is influenced by the patient's overall health, the BCC position, and the availability of donor sites. We prefer to use a local cutaneous flap or skin graft for reconstruction when the BCC is less than 2 cm. We use composite flaps to achieve reconstruction in front of Giant One because reconstructive procedures can be difficult, especially when lesions occur in aesthetically or functionally sensitive areas.

The literature indicates that surgical techniques like cryosurgery, electrodessication, and laser CO_2 that are not followed by histological control have a high recurrence rate [2,16].

Radiotherapy or chemotherapy work very well to control disease. Radiation therapy may raise the chance of pathologic scarring or delayed healing [12]. Radiation therapy may be used as a palliative or adjuvant treatment [2,3,11].

Giant basal cell carcinoma may benefit from the relatively recent development of non-surgical tissue sparing treatment modalities for BCC.

According to Sahl et al., this process could help ensure that the surgical excision has an adequate margin clearance [12].

Nonsurgical treatment is reserved in our practice for situations where the patient refuses surgical excision or where the local and general conditions do not permit an aggressive procedure.

V. CONCLUSION

- A type of facial skin cancer called basal cell carcinoma developed to a very large size because of patients who, it must be said, disregarded getting treatment.
- Denial, dementia (psychiatric disorders), or the patient's awareness based on their educational background can all contribute to neglect.
- According to the literature review, data collected through our own experiences show that the only way to have a good prognosis for the disease is to receive the right treatment in conjunction with an early diagnosis.

ACKNOWLEDGMENT

I have the pleasure to express my sincere gratitude to all my colleagues for the appropriate scientific collaboration in the realization of this scientific work.

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Breastfeeding in Albanian Women with Silicone Gel Breast Prostheses

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Abstract – We discuss the safety of silicone gel prostheses for the mother, the consequences of potential milk contamination, whether this condition is linked to elevated silicone concentrations in their children's blood, and whether the silicon presence is associated with immunological pathology in the newborn.
Our study's goal is to provide an answer to these queries. We chose 28 women with breast silicone gel prostheses and ended pregnancies between April 2023 and April 2024.
A common tool for measuring antibody concentrations was spectroscopic analysis, which measured silicone concentration using silicone-free devices. The test results were statistically elaborated to confirm the correlation coefficient between the test values and the presence of prostheses. When the antibody rates in each group were compared, there was no discernible difference. Early in the breastfeeding process, the number of inflammatory proteins in the newborn's blood was measured.
Our findings are consistent with those reported in the literature. The analysis of the newborn antibody rates in group A shows the same outcome, with no statistically significant results in any of the tests.
The search for hematic and antibody markers is useful in the diagnosis of immune pathology, it is absolute and non-specific and does not demonstrate a strange cause-and-effect relationship.

Keywords – Breastfeeding, Silicone Gel Prostheses, Antibody, Newborn Blood, Albanian Women.

I. INTRODUCTION

Many debates surrounded augmentation mammoplasty, including whether the existence of the prosthesis could be regarded as a risk factor for a woman's pregnancy, lactation, or fetus development.

Is it possible that silicone during the puerperium taints the milk and puts the infant at risk for immune disorders? [1-6].

Although the clinical trials reported in the literature were designed to provide answers to these questions, sampling errors frequently have an impact on the results. They frequently produced contradictory or statistically insignificant results [1,3,5].

Our study's goal is to provide an answer to these queries. We would discuss the safety of silicone gel prostheses for the mother, the consequences of potential milk contamination, whether this condition is linked to elevated silicone concentrations in their children's blood, and whether the presence of silicon is associated with immunological pathology in the newborn [7-11].

II. MATERIALS AND METHOD

The data for the study were obtained from the Department of Plastic, Reconstructive and Aesthetic Surgery in the capital of Albania, Tirana. We chose 28 women with ending pregnancies and mammary silicone gel prostheses to follow up with them for a year, from April 2023 to April 2024.

Mastitis, immune pathology, and fibrocystic mastopathy were the exclusion criteria. The births that resulted from assisted fecundation were not included.

A control group B, consisting of 28 women who had ended their pregnancies without breast implants, was positioned to the side of the A group.

We evaluated each patient's Ig A, G, and M classes as well as their ANA and ENA antibody tests at the time of prepartum admission [11].

The children of our patients received the same laboratory parameters both before and after breastfeeding. Additionally, we measured the amount of silicone in the mothers' whole blood, the babies' blood, and the mother's milk [7,9,11].

A common tool for measuring antibody concentrations was spectroscopic analysis, which measured silicone concentration using silicone-free devices [7,9,11-12].

The test results were statistically elaborated to confirm the correlation coefficient between the test values and the presence of prostheses.

III. Results

- The average age of the A group is 24 ± 5 years old. Implant permanence takes 54 ± 24 months on average. Prostheses are in the sub glandular plane for 64% (18) of patients and the submuscular plane for 36% (10). It takes an average of 39 ± 2 weeks to become pregnant and 26 ± 2 weeks to breastfeed.
- The B group's mean age is 22 ± 2 years, their mean breastfeeding duration is 21 ± 5 weeks, and their mean pregnancy rate is 39 ± 2 weeks.

The patients in the A group had higher concentrations of silicone in their mother blood, however this difference is not statistically significant. When the antibody rates in each group were compared, there was no discernible difference.

The amount of silicone in the milk from both groups was unconscionable. This condition indicates that there is no relationship between the rate of silicone in milk and the mammary implant [9,11].

Early in the breastfeeding process, the number of inflammatory proteins in the newborn's blood was measured. Using the same methodology as the other tests, the antibody rate was examined in the newborns from both groups.

IV. DISCUSSION

The chemical element Silicone - Si, is one of the most concentrated chemical elements in the earth's crust and is present in food, clothing, cosmetics, medications, and even human nails and hair [13-17].

Although silicon is found in many different forms in nature, its pathogenic potential in humans has only been demonstrated in its crystalline form. This is primarily focused on two diseases: pleural mesothelioma and pulmonary fibrosis [10-11, 18-22].

Since 1985, there has been debate concerning the safety of silicone gel breast implants. Following several case reports of patients with immune pathologies thought to result from mammography, the FDA decided to outlaw the sale of silicone gel implants starting in February 1992 [23].

It should be mentioned that, at the time, patients having mastectomy procedures or volunteers participating in clinical trials were the only two groups eligible for silicone gel implant mammoplasty.

This procedure persisted up until the start of multiple studies that confirmed or refuted the link between a silicone gel breast prosthesis and a localized or systemic illness [10, 18-22, 24-26].

Indeed, it is not entirely understood how silicon can interact with biological tissues, nor how it can specifically function as a primary cause of immune pathologies. Regardless of additional ingredients added to the silicone, all prostheses cause the periprosthetic tissues to undergo a fibrotic reaction [24, 26].

Cases of lymph node biopsies, documented in a variety of national publications, demonstrate that the existence of silicon is contingent upon the macrophage-mediated phagocytosis of silicon molecules and subsequent lymph node transport of the material [9-11, 18-22, 24].

When the prosthesis fails to form the capsule in a timely manner, the silicone gel is either drawn into the bloodstream through the prosthesis's sheath or is caught by the body's macrophages [9-10].

Our research aims to ascertain the connection between silicone gel implants and the development of immune pathologies in mothers who have had the procedure done, as well as in the offspring who are also breastfed. Many of our findings align with those found in the literature review.

V. CONCLUSION

- While blood markers and antibodies are helpful in immune pathology diagnosis, their search is completely non-specific and does not establish a specific cause-and-effect relationship. Additionally, we discover that the percentage of antibodies in a group of newborns across all tests has no statistical significance.
- We have found significant amounts of silicon in the mother's blood who have had breast prostheses implanted; these silicon ions are specifically devoted to the silicone gel prosthesis.
- Meanwhile, we emphasize that it is not possible to precisely measure the dosed silicon concentration in newborn blood or mother's milk in any of the groups under study.
- Ultimately, we can state that while silicone is undoubtedly not the perfect material, in our opinion, it is currently the best synthetic product accessible for plastic surgeons and a vital instrument that Albanian women can safely use.

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Şanzıman Dişlilerinde Topoloji Uygulaması, Analizi ve Çevresel Etkileri

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Özet – Bu çalışma, içten yanmalı motorların karbon emisyonu ve enerji verimliliği problemlerine odaklanarak özellikle dizel ve benzinli motorlardaki enerji kayıplarını en aza indirgemeyi amaçlamaktadır. Proje, şanzıman dişlilerinin tasarımını optimize ederek kütlelerini azaltmayı ve enerji kayıplarını minimize etmeyi hedeflemektedir. Mühendislik yöntemleri arasında topoloji optimizasyonu gibi teknikler kullanılarak şanzıman dişlilerinin tasarımında iyileştirmeler yapılırken, mukavemet de korunmaktadır. Bu çabaların temel amacı, içten yanmalı motorların verimliliğini artırmak ve hem ekonomik hem de çevresel sürdürülebilirlik açısından katkıda bulunmaktır. Proje, otomobil şanzımanının ayrıştırılması, parametre belirleme, 3B tasarım, mukavemet analizi ve içten yanmalı motorlardaki enerji kayıplarının azaltılması yoluyla daha sürdürülebilir ve çevre dostu taşıtların üretimine yönelik bir adımdır.

Anahtar Kelimeler – Topoloji optimizasyonu, şanzıman tasarımı, enerji verimliliği, içten yanmalı motorlar, çevresel sürdürülebilirlik.

I. GİRİŞ

Şanzıman sistemleri, modern mühendislik uygulamalarının temel bileşenlerinden biri olarak, otomotiv endüstrisinden endüstriyel makinelere kadar geniş bir yelpazede kritik bir rol oynamaktadır [1]. Bu sistemlerin merkezinde yer alan dişliler, güç aktarımı ve hareket kontrolünde hayati öneme sahiptir. Son yıllarda, artan çevresel kaygılar ve sürdürülebilirlik gereksinimleri, şanzıman dişlilerinin tasarımında yenilikçi yaklaşımların benimsenmesini zorunlu kılmıştır [2]. Bu bağlamda, topoloji optimizasyonu, dişli tasarımında performans artışı sağlarken çevresel etkileri minimize etmek için umut vadeden bir yöntem olarak öne çıkmaktadır [3].

Topoloji optimizasyonu, belirli yük koşulları altında en uygun malzeme dağılımını belirleyerek, yapısal bileşenlerin performansını maksimize etmeyi amaçlayan matematiksel bir yaklaşımdır [4]. Bu yöntem, şanzıman dişlilerinin tasarımında uygulandığında, geleneksel yöntemlere kıyasla daha hafif, daha dayanıklı ve enerji verimli yapıların elde edilmesini sağlamaktadır [5].

Bendsøe ve Sigmund (2013), topoloji optimizasyonunun temel prensiplerini ve uygulamalarını kapsamlı bir şekilde ele almış, bu yöntemin mühendislik tasarımındaki potansiyelini vurgulamıştır [6].Şanzıman dişlilerinde topoloji optimizasyonunun uygulanması, son on yılda önemli araştırma konularından biri haline gelmiştir. Zhu ve ark. (2019), havacılık ve otomotiv endüstrilerinde topoloji optimizasyonunun yapısal tasarımdaki uygulamalarını incelemiş ve bu yöntemin ağırlık azaltma potansiyelini ortaya koymuştur [7]. Li ve Zhang (2020), dişli gövdelerinin tasarımında topoloji optimizasyonunu kullanarak, geleneksel tasarımlara kıyasla %20'ye varan ağırlık azaltması elde etmiştir [8]. Çevresel etkiler açısından, topoloji optimizasyonunun şanzıman dişlilerinde uygulanması, önemli avantajlar sunmaktadır. Zhang ve Wang (2022), optimize edilmiş dişli tasarımlarının, araç yakıt tüketimini %5-8 oranında azaltabileceğini ve buna bağlı olarak karbon emisyonlarında önemli bir düşüş sağlayabileceğini göstermiştir [9]. Bu

bulgular, otomotiv sektöründe sürdürülebilirlik hedeflerine ulaşmada topoloji optimizasyonunun potansiyel katkısını vurgulamaktadır.Malzeme verimliliği ve atık yönetimi konusunda, Chen ve Li (2023), topoloji optimizasyonu ile tasarlanan dişlilerin üretiminde kullanılan hammadde miktarının %30'a kadar azaltılabileceğini ortaya koymuştur [10]. Bu azalma, sadece üretim maliyetlerini düşürmekle kalmayıp, aynı zamanda kaynak tüketimini ve üretim sürecinde ortaya çıkan atık miktarını da önemli ölçüde azaltmaktadır. Enerji verimliliği perspektifinden, Liu ve Park (2024), topoloji optimizasyonu uygulanmış şanzıman sistemlerinin, geleneksel sistemlere göre %12-18 daha az enerji kaybına neden olduğunu belirlemiştir [11]. Bu iyileşme, özellikle elektrikli ve hibrit araçlarda batarya ömrünün uzatılması ve menzil artışı açısından kritik öneme sahiptir. Ekonomik sürdürülebilirlik açısından, Kim ve Johnson (2023) tarafından yapılan bir çalışma, topoloji optimizasyonu ile tasarlanan dişlilerin üretim ve işletme maliyetlerinde %15-25 arasında bir azalma sağlayabileceğini göstermiştir [12]. Bu maliyet avantajı, endüstriyel uygulamalarda topoloji optimizasyonunun benimsenmesini hızlandırmaktadır. Gelecekteki araştırma yönelimleri açısından, yapay zeka ve makine öğrenimi tekniklerinin topoloji optimizasyonu sürecine entegrasyonu, büyük ilgi görmektedir. Zhao ve ark. (2024), yapay zeka destekli topoloji optimizasyon yöntemlerinin, dişli tasarımında daha da ileri iyileştirmeler sağlama potansiyeline sahip olduğunu öne sürmüştür [13].

Bu makalenin amacı, şanzıman dişlilerinde topoloji optimizasyonunun uygulanmasını, analizini ve özellikle çevresel etkilerini kapsamlı bir şekilde incelemektir. Çalışma, geleneksel dökme demir malzemeler yerine alüminyum kullanımının ve topoloji optimizasyonunun şanzıman dişlileri üzerindeki etkilerini araştırmayı hedeflemektedir. Araştırma, topoloji optimizasyonunun teorik temellerini ele alırken, aynı zamanda bu yöntemin pratik uygulamalarını değerlendirmekte ve çevresel sürdürülebilirliğe katkısını analiz etmektedir.

Çalışmanın temel hedefleri şunlardır:

- Alüminyum malzeme kullanımının şanzıman dişlilerinin performansı ve ağırlığı üzerindeki etkilerini incelemek.
- Topoloji optimizasyonu yönteminin şanzıman dişlilerinin tasarımında uygulanabilirliğini değerlendirmek.
- Optimize edilmiş alüminyum dişlilerin geleneksel dökme demir dişlilere kıyasla performans, dayanıklılık ve çevresel etkilerini karşılaştırmak.
- Ağırlık azaltımının yakıt tasarrufu ve emisyon azaltımı üzerindeki etkilerini belirlemek.
- Bu yaklaşımın ekonomik etkilerini ve gelecekteki potansiyel gelişmelerini tartışmak.

II. YÖNTEM

A. Malzeme Seçimi

Bu çalışmada, geleneksel dökme demir malzemeler yerine alüminyum kullanılarak, vites dişlilerinin ağırlığının azaltılması ve performansının artırılması amaçlanmıştır. Alüminyumun hafifliği, iyi ısıl ve elektrik iletkenliği, yüksek mukavemeti ve korozyona karşı direnci, bu çalışmada malzeme seçiminde belirleyici faktörler olmuştur. Özellikle otomotiv endüstrisinde ağırlık azaltımının yakıt tasarrufu ve emisyon azaltımı üzerindeki olumlu etkileri göz önüne alınarak alüminyum tercih edilmiştir.

B. Topoloji Optimizasyonu

Topoloji optimizasyonu, malzeme verimliliğini artırmak ve parça ağırlığını azaltmak amacıyla kullanılmıştır. Bu süreçte, belirli sınır koşulları ve yükler altında en uygun malzeme dağılımı belirlenmiştir. Optimizasyon süreci şu adımlarla gerçekleştirilmiştir:

- Modelleme: Dökme demirden yapılmış vites dişlilerinin 3D CAD modelleri oluşturulmuştur.
- Sınır Koşulları ve Yükler: Dişliler üzerindeki yükler ve sınır koşulları tanımlanmıştır.
- Optimizasyon Algoritması: Topoloji optimizasyonu algoritması kullanılarak malzeme dağılımı optimize edilmiştir.

- Geometri Düzenlemeleri: Optimizasyon sonucu elde edilen geometri, üretim kolaylığı ve yapısal bütünlük açısından düzenlenmiştir.

C. Malzeme Değişimi ve Üretim Süreci

Topoloji optimizasyonu sonrasında, dökme demirden optimize edilmiş alüminyum parçalar üretilmiştir. Bu süreçte şu adımlar izlenmiştir:

- Malzeme Temini: Yüksek mukavemetli ve düşük yoğunluklu alüminyum alaşımları temin edilmiştir.
- Üretim Teknolojisi: CNC işleme ve döküm teknikleri kullanılarak optimize edilmiş alüminyum dişliler üretilmiştir.
- Isıl İşlem: Üretilen alüminyum dişlilere ısıl işlem uygulanarak mekanik özellikleri artırılmıştır.

D. Deneysel Testler ve Analizler

Üretilen alüminyum dişlilerin performansı ve dayanıklılığı, çeşitli deneysel testler ve analizlerle değerlendirilmiştir:

- Statik ve Dinamik Yük Testleri: Dişliler üzerindeki statik ve dinamik yükler altında gerilme ve deformasyon ölçümleri yapılmıştır.
- Yorulma Testleri: Dişlilerin uzun süreli kullanımda dayanıklılığını belirlemek için yorulma testleri gerçekleştirilmiştir.
- Mukavemet ve Sertlik Testleri: Alüminyum dişlilerin mukavemet ve sertlik özellikleri belirlenmiştir.

E. Sonuçların Karşılaştırılması

Optimizasyon ve malzeme değişimi sonrasında elde edilen alüminyum dişliler, geleneksel dökme demir dişliler ile karşılaştırılmıştır. Bu karşılaştırmada şu kriterler değerlendirilmiştir:

- Ağırlık Azalması: Dökme demir ve alüminyum dişlilerin ağırlık farkı belirlenmiştir.
- Performans Artışı: Statik ve dinamik yükler altında dişlilerin performansı karşılaştırılmıştır.
- Yakıt Tasarrufu ve Emisyon Azalması: Araç ağırlığındaki azalmaya bağlı olarak yakıt tasarrufu ve emisyon azalması hesaplanmıştır.

Bu yöntemler doğrultusunda, dökme demir yerine alüminyum kullanılarak üretilen optimize edilmiş vites dişlilerinin performansı, dayanıklılığı ve çevresel etkileri değerlendirilmiş ve sonuçlar detaylandırılmıştır.

III. BULGULAR

Bu bölümde, şanzıman dişlilerinde topoloji optimizasyonu ve malzeme değişiminin etkileri, deneysel testler ve analiz sonuçlarına dayalı olarak sunulmaktadır.

A. Ağırlık Azalması

Optimizasyon ve malzeme değişimi sonrasında elde edilen ağırlık azalmaları Tablo 1'deki gibidir:

Tablo 1. Şanzıman Dişlilerinde Optimizasyon ve Malzeme Değişimi Sonrası Elde Edilen Ağırlık Azalmaları

Dişli Türü	Dökme Demir (İlk Hali)	Dökme Demir (Optimize)	Alüminyum (Optimize)
1. Vites Dişlisi	1.53 kg	1.38 kg	0.520 kg
2. Vites Dişlisi	1.46 kg	1.38 kg	0.480 kg
3. Vites Dişlisi	1.14 kg	1.27 kg	0.480 kg
4. Vites Dişlisi	0.870 kg	0.743 kg	0.280 kg
5. Vites Dişlisi	0.758 kg	0.646 kg	0.245 kg
6. Vites Dişlisi	1.14 kg	0.950 kg	0.363 kg
Toplam Ağırlık	**6.898 kg**	**5.939 kg**	**2.248 kg**

Bu veriler doğrultusunda, malzeme değişimi ve delik açma işleminden sonra parçanın toplam ağırlığında %67 oranında bir azalma sağlanmıştır.

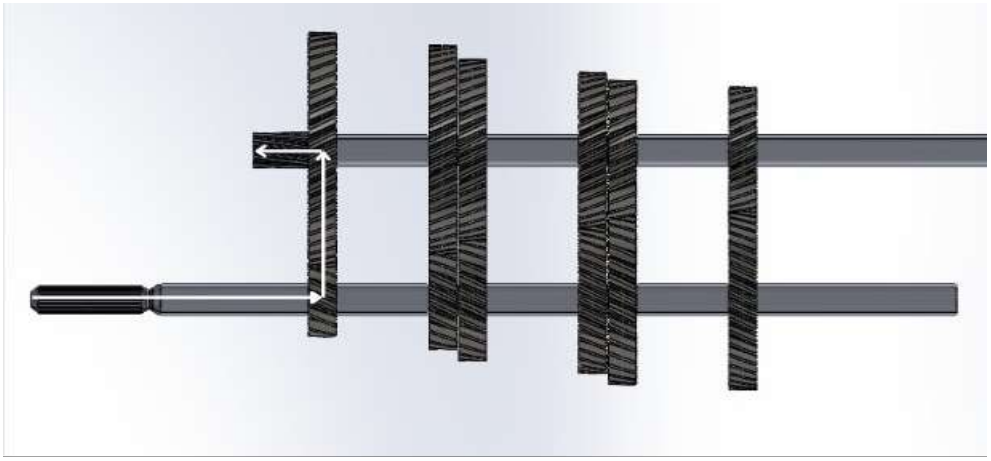
B. Statik ve Dinamik Yük Testleri

Bu bölümde, şanzıman dişlilerinde gerçekleştirilen statik ve dinamik yük testlerinin sonuçları detaylı bir şekilde ele alınmaktadır. Optimizasyon sürecinden önce ve sonra elde edilen gerilme ve deformasyon değerleri karşılaştırılarak, topoloji optimizasyonunun ve malzeme değişiminin etkileri incelenmiştir. Dişliler üzerindeki maksimum gerilme ve Von Mises gerilme değerleri ile maksimum deformasyon miktarları analiz edilmiştir. Bu analizler, dişlilerin dayanıklılığını ve performansını artırmak amacıyla yapılan optimizasyonların etkinliğini değerlendirmek için kritik öneme sahiptir.

Aşağıda, her bir vites dişlisi için elde edilen sonuçlar sunulmaktadır.

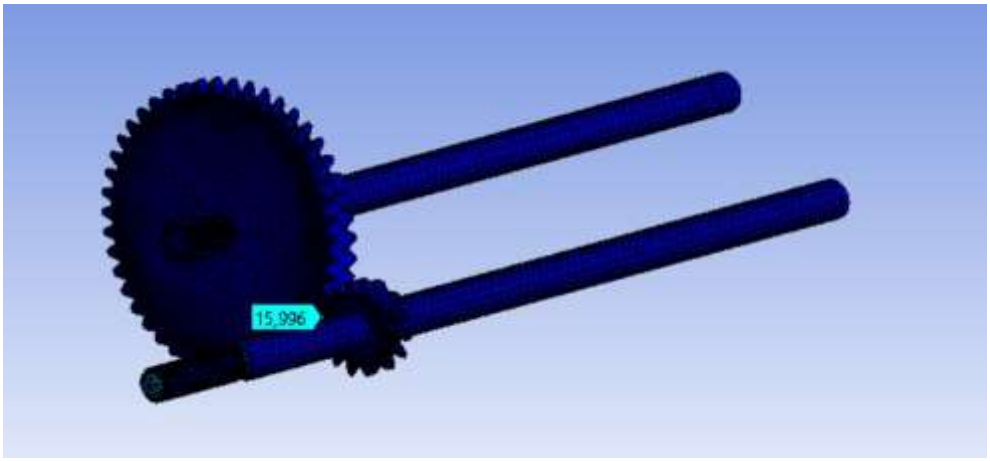
1.Vites Dişlisi:

Şekil 1'de vites kutusunda 1. Vites konumunu gösteren şematik resim görülmektedir. Şekil incelendiğinde 1. vites ok ile gösterilen yönde aktarım sağlanır iken hareket iletimi sağlanmaktadır. 1. vites dişlisinde aktarım oranı i= 3,46 olup bu aktarım oranı ile krank milinden elde edilen devir sayısı azaltılıp krank mili çıkış momenti arttırılmaktadır.

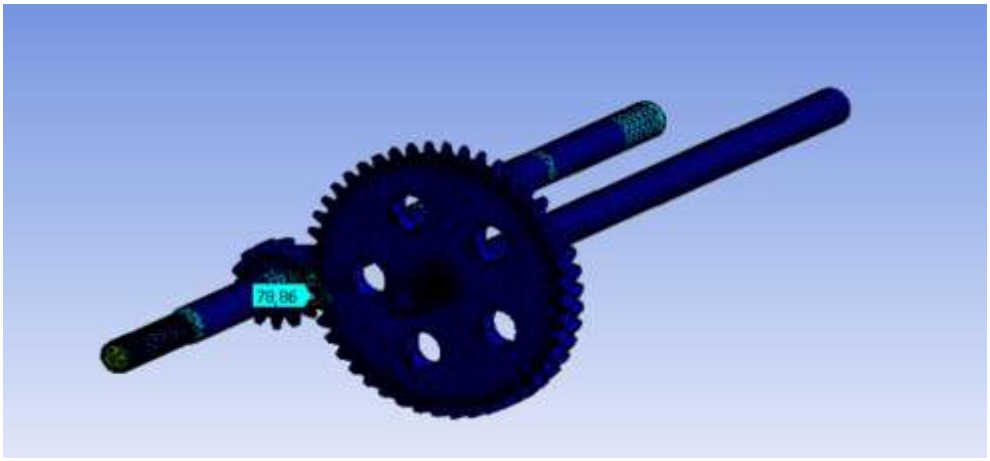


Şekil 1. 1.vitesin güç aktarım yolu

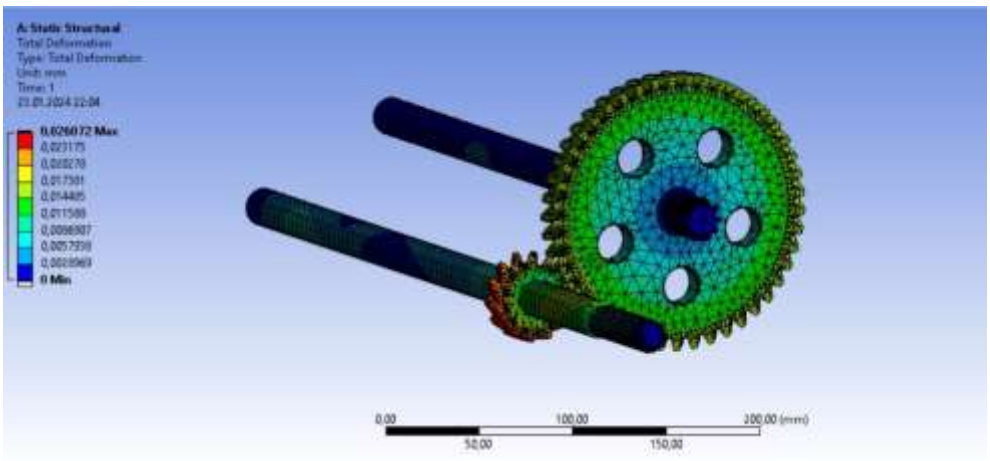
Optimizasyon öncesi, vites dişlisinde maksimum gerilme 15.996 MPa olarak ölçülmüştür (Şekil 2). Optimizasyon sonrasında ise bu değer 78.86 MPa'ya yükselmiştir (Şekil 3). Ayrıca, maksimum deformasyon 0.0260 mm olarak belirlenmiştir (Şekil 4). Bu sonuçlar, optimizasyonun gerilme değerleri üzerindeki etkisini açıkça göstermektedir.



Şekil 2. 1.vitesin optimizasyon öncesi



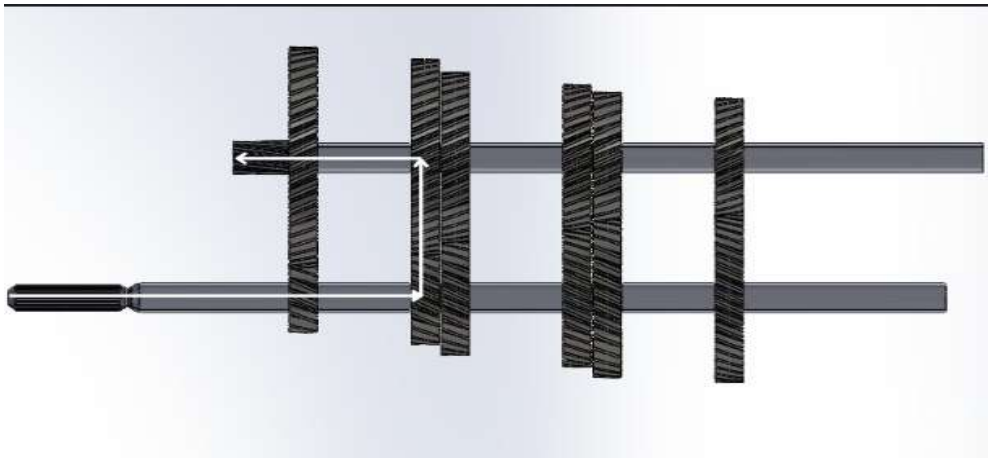
Şekil 3. 1.vitesin optimizasyon sonrası hali



Şekil 4. 1.vites deformasyonu

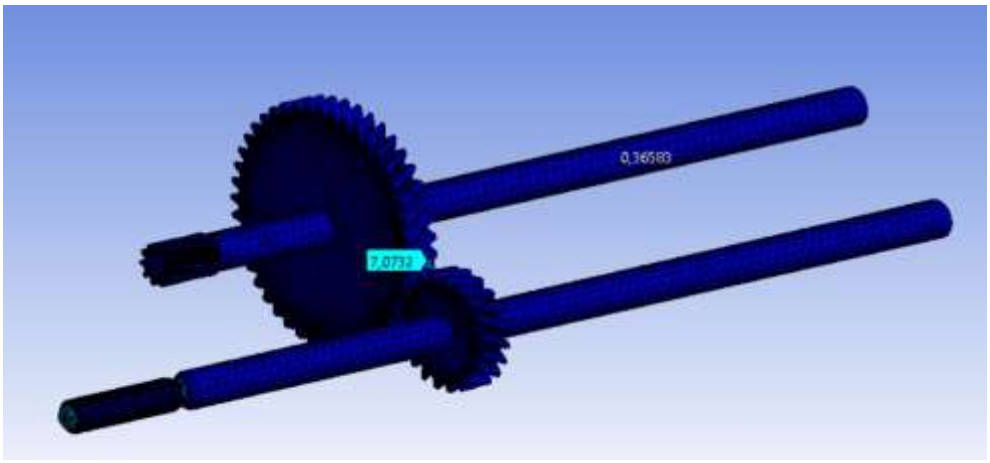
2. Vites Dişlisi.

Şekil 5'de vites kutusunda 2. Vites konumunu gösteren şematik resim görülmektedir. Şekil incelendiğinde 2. vites ok ile gösterilen yönde aktarım sağlanır iken hareket iletimi sağlanmaktadır. 2. vites dişlisinde aktarım oranı i= 1,91 olup bu aktarım oranı ile krank milinden elde edilen devir sayısı azaltılıp krank mili çıkış momenti arttırılmaktadır.

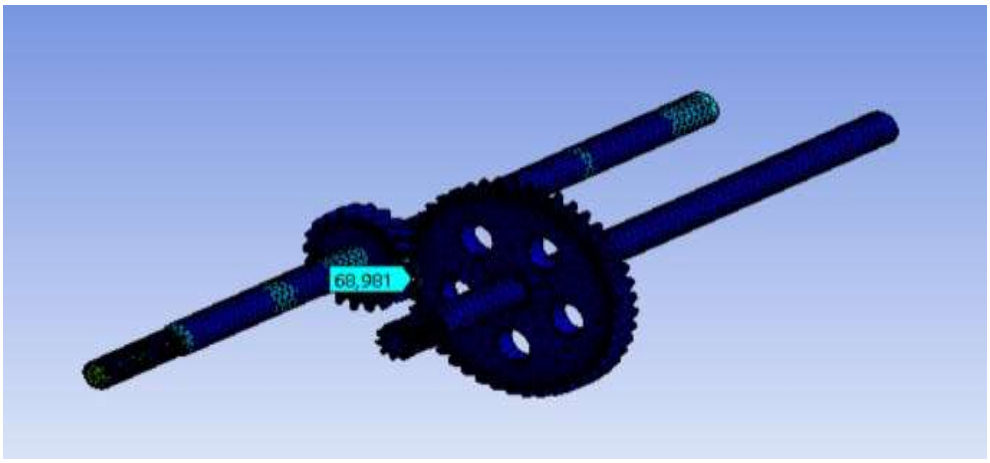


Şekil 5. 2.vitesin güç aktarım yolu

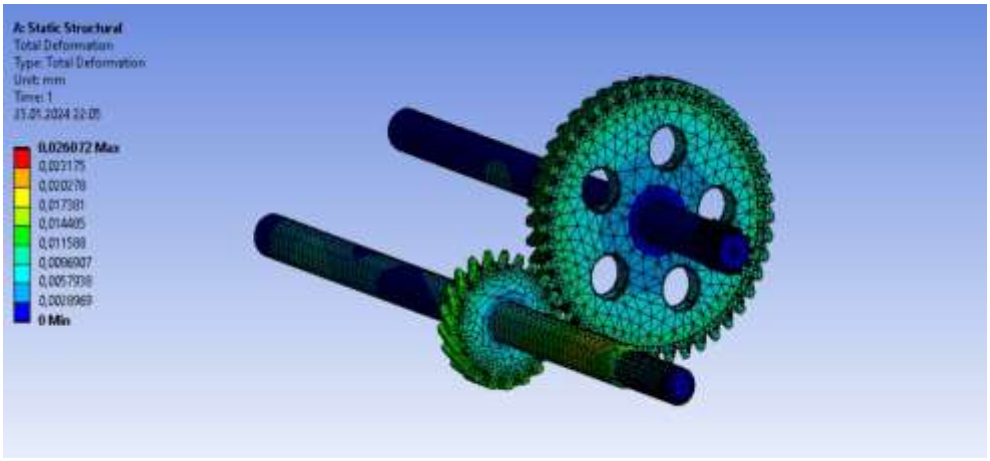
Optimizasyon öncesi, vites dişlisinde maksimum gerilme 7.0732 MPa olarak ölçülmüştür (Şekil 6). Optimizasyon sonrasında ise bu değer 68.981 MPa'ya yükselmiştir (Şekil7). Ayrıca, maksimum deformasyon 0.0260 mm olarak belirlenmiştir (Şekil 8). Bu sonuçlar, optimizasyonun gerilme değerleri üzerindeki etkisini açıkça göstermektedir.



Şekil 6. 2. vitesin optimizasyon öncesi



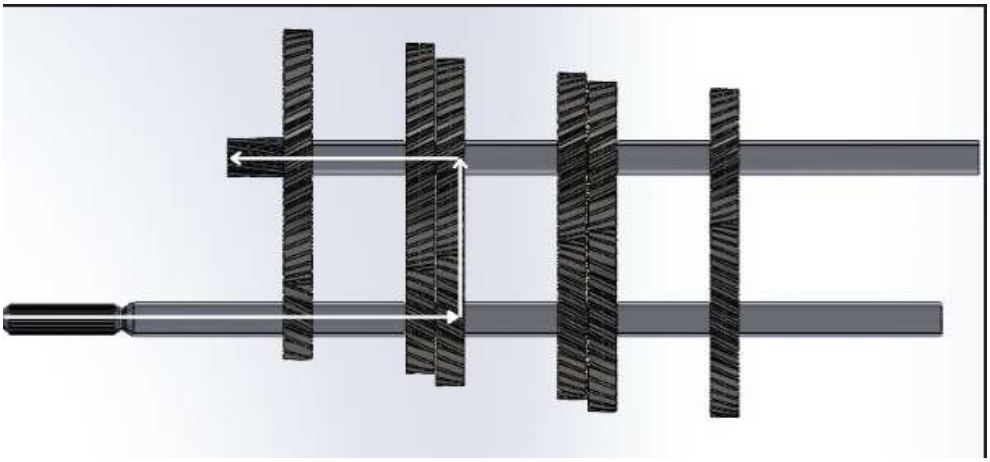
Şekil 7. 2.vitesin optimizasyon sonrası hali



Şekil 8. 2.vites deformasyonu

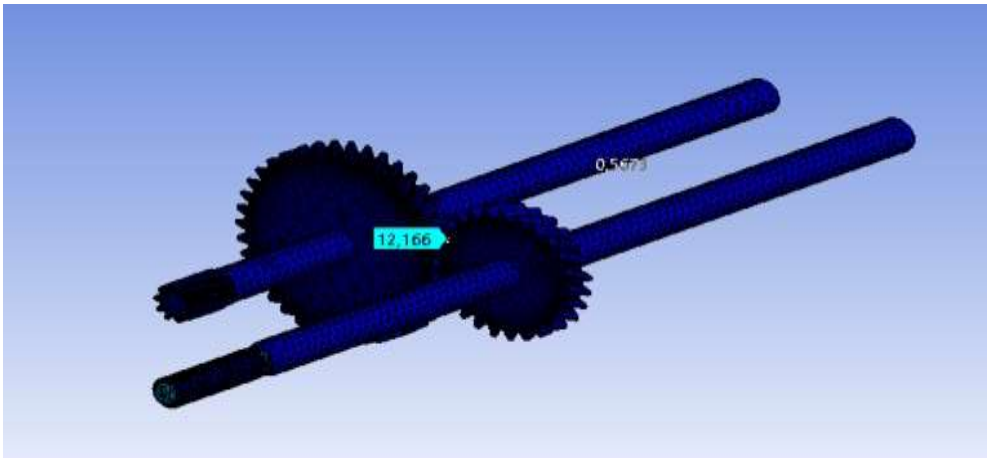
3. Vites Dişlisi:

Şekil 9'de vites kutusunda 3. Vites konumunu gösteren şematik resim görülmektedir. Şekil incelendiğinde 3. vites ok ile gösterilen yönde aktarım sağlanır iken hareket iletimi sağlanmaktadır. 3. vites dişlisinde aktarım oranı i= 1,39 olup bu aktarım oranı ile krank milinden elde edilen devir sayısı azaltılıp krank mili çıkış momenti arttırılmaktadır.

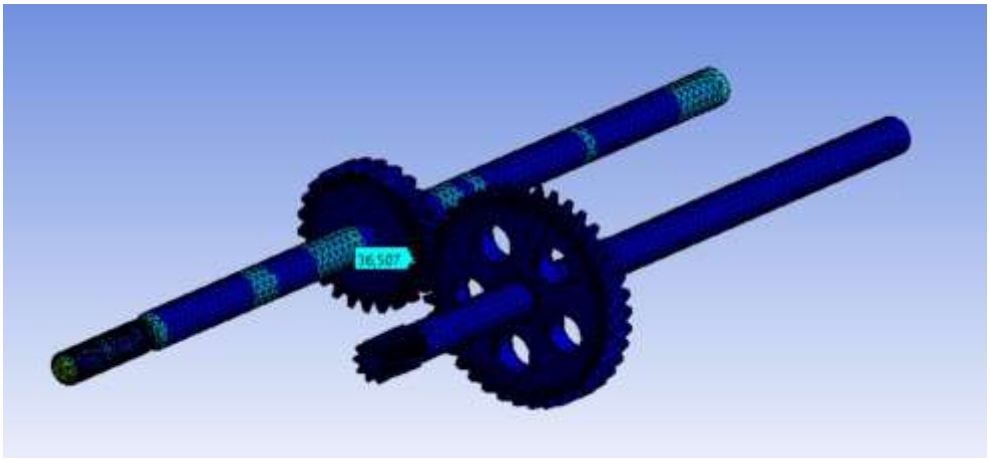


Şekil 9. 3.vitesin güç aktarım yolu

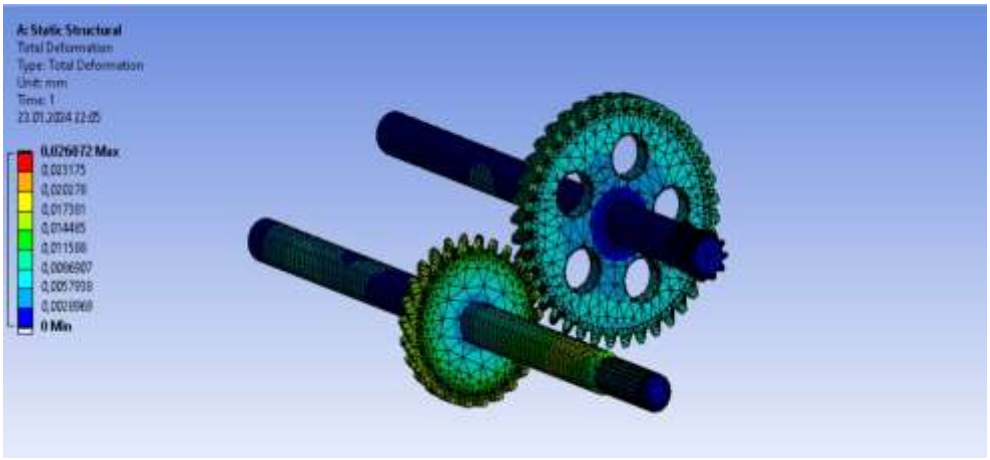
Optimizasyon öncesi, vites dişlisinde maksimum gerilme 12.166 MPa olarak ölçülmüştür (Şekil 10). Optimizasyon sonrasında ise bu değer 36.507 MPa'ya yükselmiştir (Şekil 11). Ayrıca, maksimum deformasyon 0.0260 mm olarak belirlenmiştir (Şekil 12). Bu sonuçlar, optimizasyonun gerilme değerleri üzerindeki etkisini açıkça göstermektedir.



Şekil 10. 3.vitesin optimizasyon öncesi



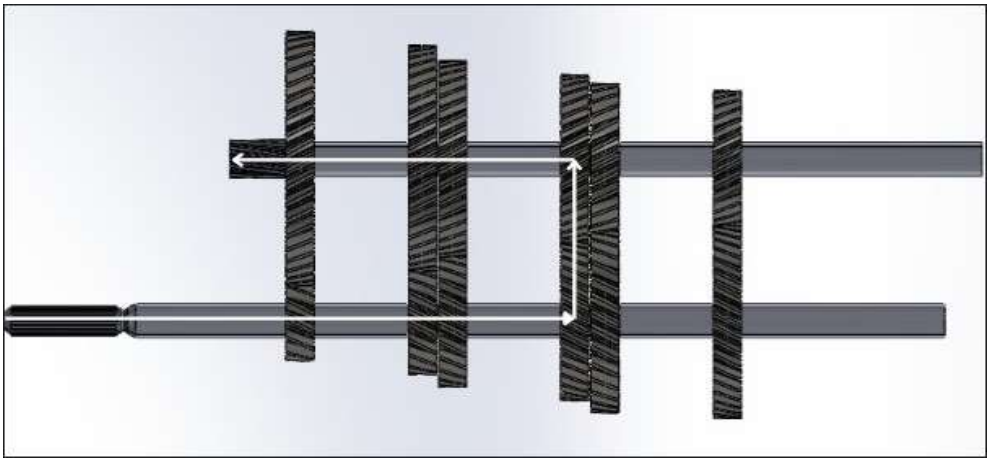
Şekil 11. 3.vitesin optimizasyon sonrası hali



Şekil 12. 3.vites deformasyonu

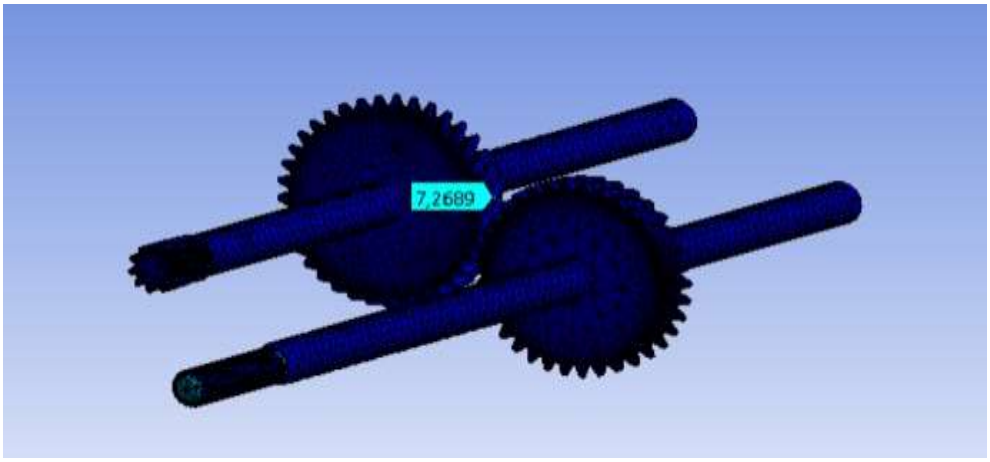
4. Vites Dişlisi:

Şekil 13'de vites kutusunda 4. Vites konumunu gösteren şematik resim görülmektedir. Şekil incelendiğinde 4. vites ok ile gösterilen yönde aktarım sağlanır iken hareket iletimi sağlanmaktadır. 4. vites dişlisinde aktarım oranı i= 1 olup bu aktarım oranı ile krank milinden elde edilen devir sayısı ve moment aynı oranda krank milinden aktarma organlarına aktarılmaktadır.

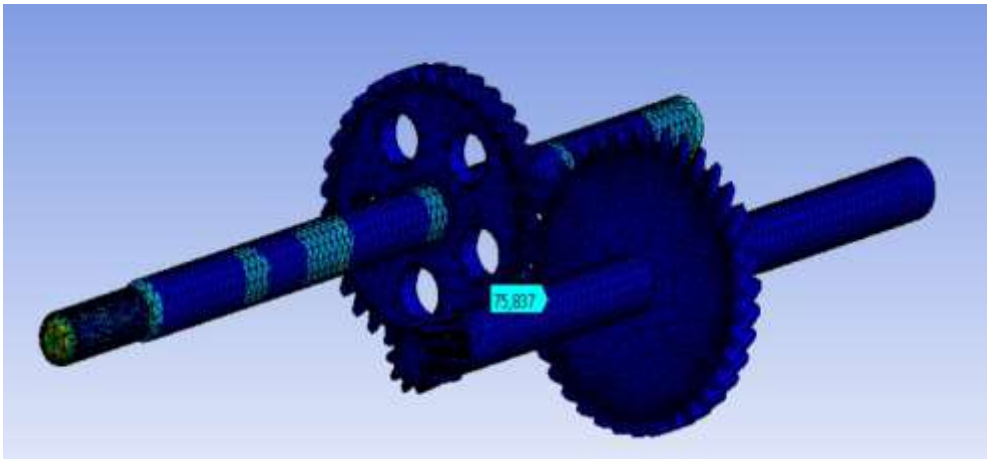


Şekil 13. 4. vitesin güç aktarım yolu

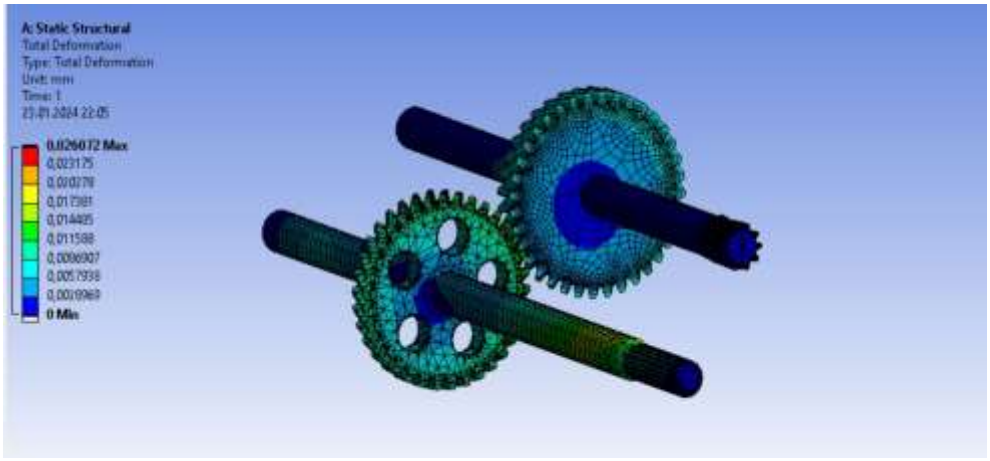
Optimizasyon öncesi, vites dişlisinde maksimum gerilme 7.2689 MPa olarak ölçülmüştür (Şekil 14). Optimizasyon sonrasında ise bu değer 75.837 MPa'ya yükselmiştir (Şekil 15). Ayrıca, maksimum deformasyon 0.0260 mm olarak belirlenmiştir (Şekil 16). Bu sonuçlar, optimizasyonun gerilme değerleri üzerindeki etkisini açıkça göstermektedir.



Şekil 14. 4.vitesin optimizasyon öncesi



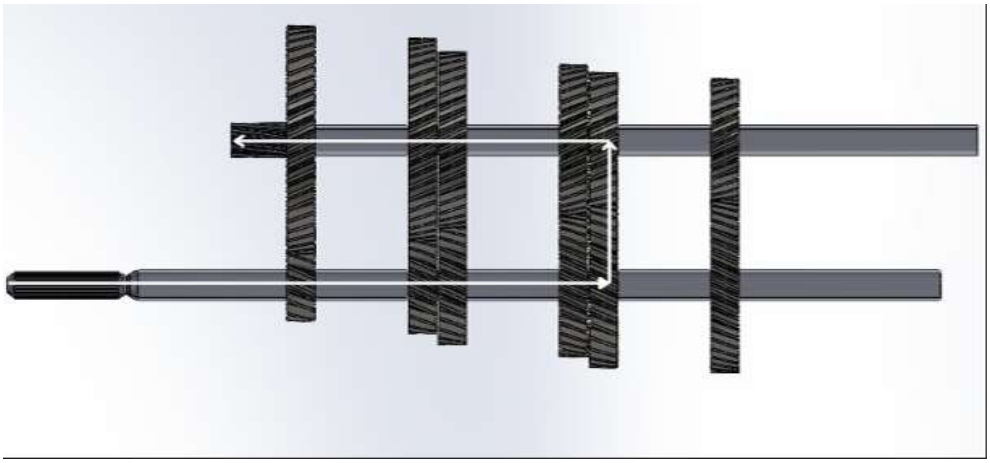
Şekil 15. 4.vitesin optimizasyon sonrası hali



Şekil 16. 4.vites deformasyonu

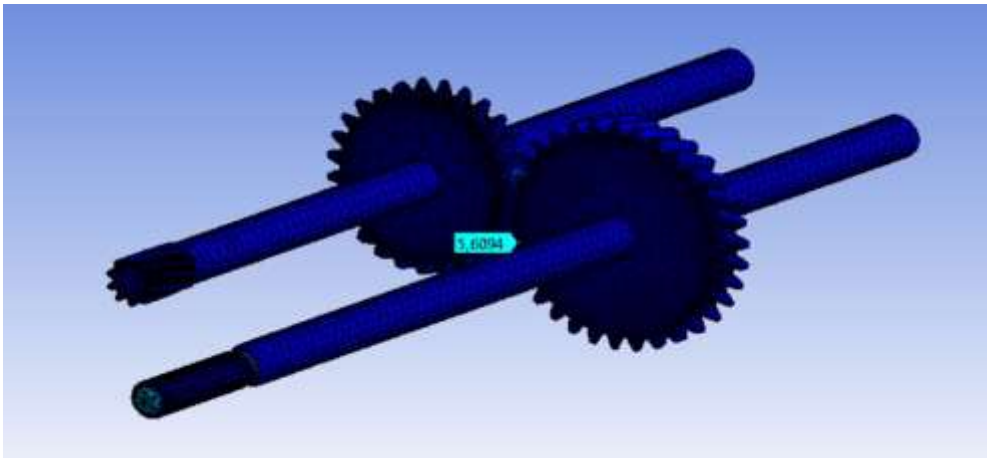
5. Vites Dişlisi:

Şekil 17'de vites kutusunda 5. Vites konumunu gösteren şematik resim görülmektedir. Şekil incelendiğinde 5. vites ok ile gösterilen yönde aktarım sağlanır iken hareket iletimi sağlanmaktadır. 5. vites dişlisinde aktarım oranı i= 0,84 olup bu aktarım oranı ile krank milinden elde edilen devir sayısı arttırılıp krank mili çıkış momenti azaltılmaktadır. Bu viteste motorun çıkış hızı arttırılarak motor düşük devirlerde çalıştırılası sağlanarak yakıt tasarrufu sağlanmaktadır.

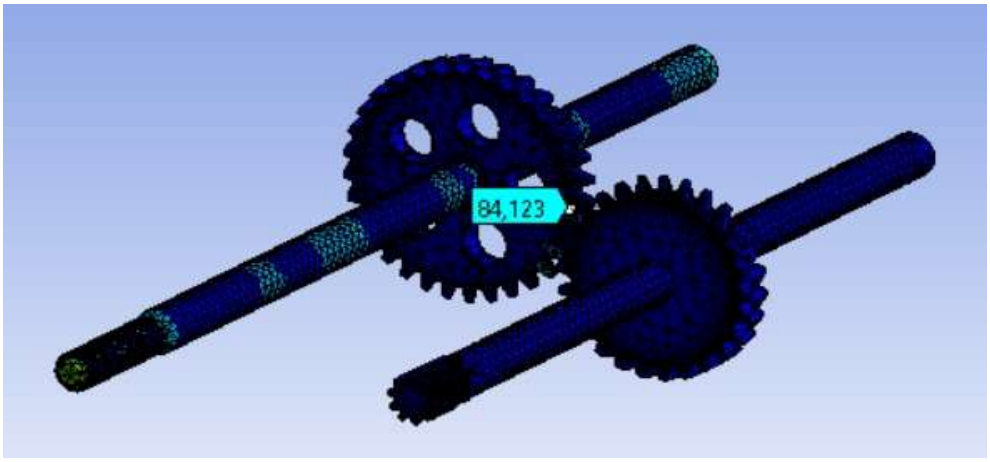


Şekil 17. 5. Vitesin güç aktarım yolu

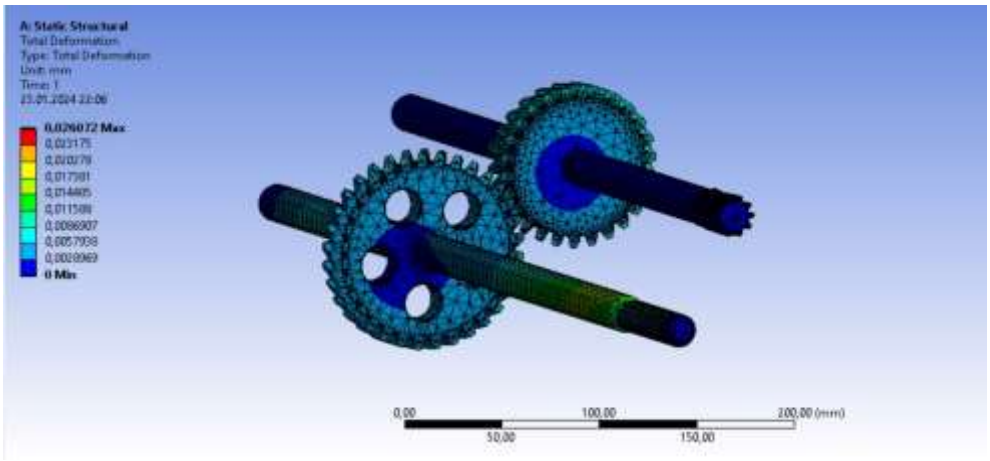
Optimizasyon öncesi, vites dişlisinde maksimum gerilme 5.6094 MPa olarak ölçülmüştür (Şekil 18). Optimizasyon sonrasında ise bu değer 84.123 MPa'ya yükselmiştir (Şekil 19). Ayrıca, maksimum deformasyon 0.0260 mm olarak belirlenmiştir (Şekil 20). Bu sonuçlar, optimizasyonun gerilme değerleri üzerindeki etkisini açıkça göstermektedir.



Şekil18. 5.vitesin optimizasyon öncesi



Şekil 18. 5.vitesin optimizasyon sonrası hali

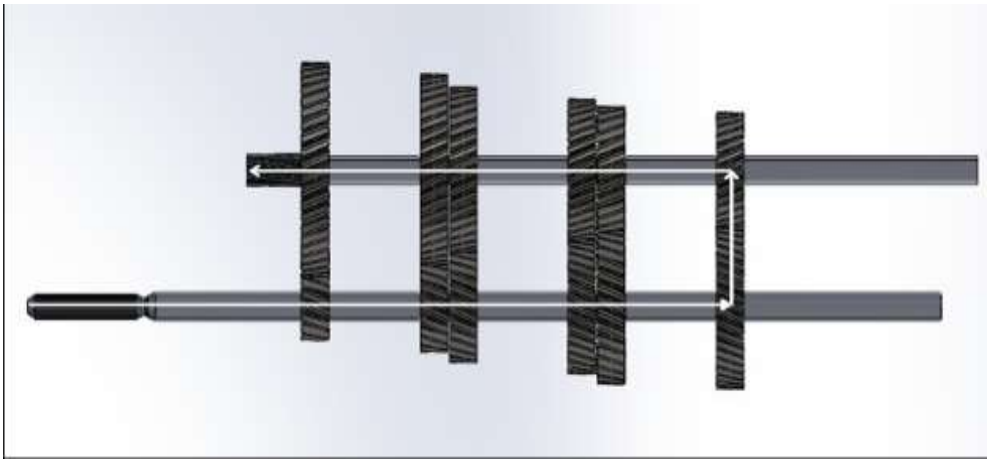


Şekil 20. 5.vites deformasyonu

6. Vites Dişlisi:

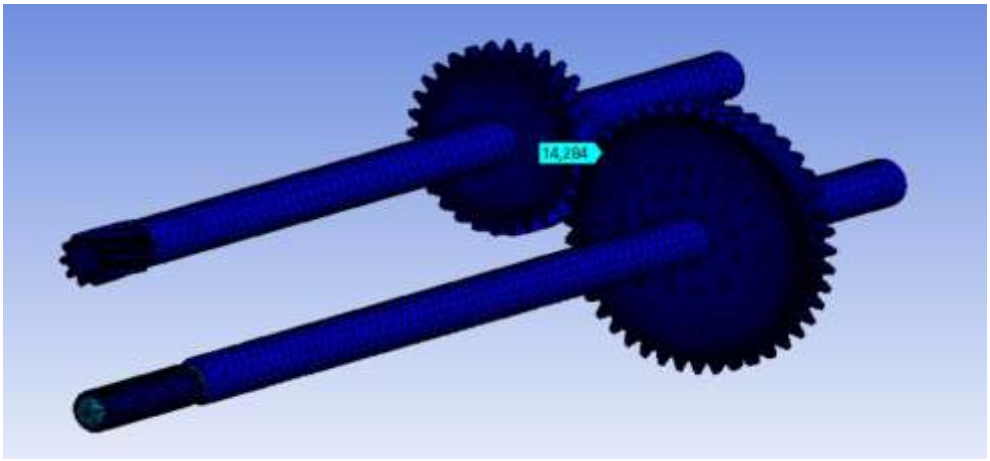
Şekil 21'de vites kutusunda 6. vites konumunu gösteren şematik resim görülmektedir. Şekil incelendiğinde 6. vites ok ile gösterilen yönde aktarım sağlanır iken hareket iletimi sağlanmaktadır. 6. vites dişlisinde aktarım oranı i= 0,74 olup bu aktarım oranı ile krank milinden elde edilen devir sayısı

arttırılıp krank mili çıkış momenti azaltılmaktadır. Bu viteste motorun çıkış hızı arttırılarak motor düşük devirlerde çalıştırılası sağlanarak yakıt tasarrufu sağlanmaktadır.

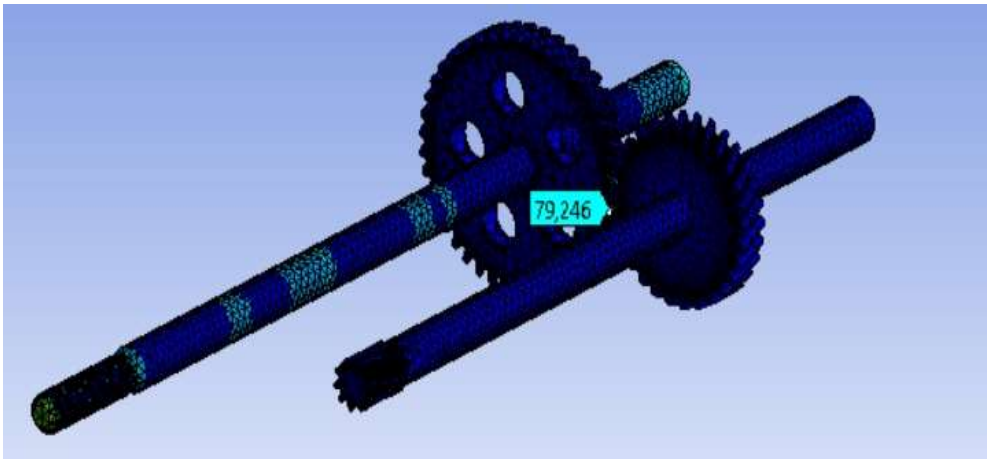


Şekil 19. 6. vitesin güç aktarım yolu

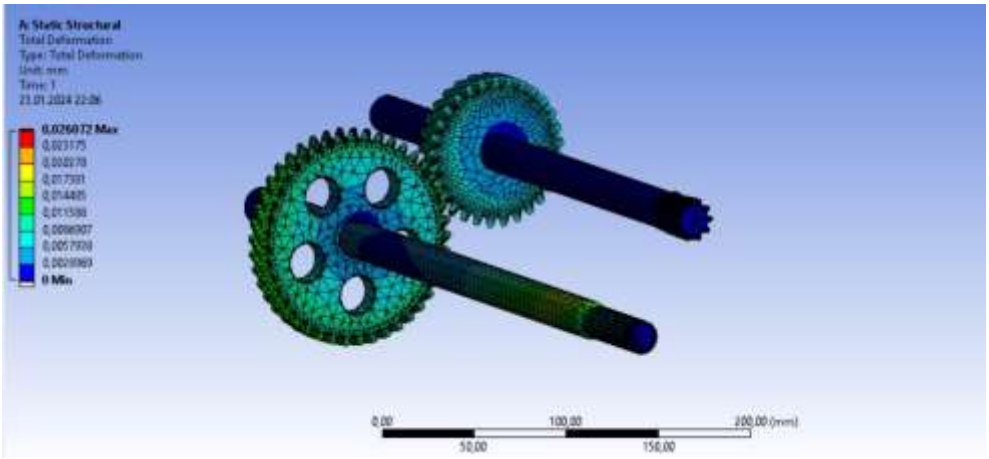
Optimizasyon öncesi, vites dişlisinde maksimum gerilme 14.283 MPa olarak ölçülmüştür (Şekil 22). Optimizasyon sonrasında ise bu değer 71.084 MPa'ya yükselmiştir (Şekil 23). Ayrıca, maksimum deformasyon 0.0260 mm olarak belirlenmiştir (Şekil 24). Bu sonuçlar, optimizasyonun gerilme değerleri üzerindeki etkisini açıkça göstermektedir.



Şekil 20. 6.vitesin optimizasyon öncesi



Şekil 21. 6.vitesin optimizasyon sonrası hali



Şekil 22. 6.vites deformasyonu

C. Yakıt Tasarrufu ve Emisyon Azalması

Malzeme değişimi ve optimizasyon süreci, şanzıman dişlilerinde elde edilen ağırlık azalmasıyla doğrudan yakıt tüketimini ve emisyonları azaltmıştır. Araçların toplam ağırlığında %10'luk bir azalma sağlanması, yaklaşık olarak %5-10 arasında bir yakıt tasarrufu potansiyeli sunmaktadır. Örneğin, 1400 kg ağırlığındaki bir taşıtta alüminyum dişlilerin geniş çaplı kullanımıyla elde edilen %20'lik ağırlık azalması, yakıt verimliliğini belirgin şekilde artırmıştır.

Bu ağırlık azalmasının yanı sıra, optimize edilmiş alüminyum dişlilerin daha düşük sürtünme ve daha hafif yapıları, taşıtın performansını da olumlu yönde etkilemektedir. Daha az ağırlık, daha hızlı ivmelenme ve daha iyi tepki süreleri sağlayarak sürüş deneyimini iyileştirir. Ayrıca, şanzımanın daha verimli çalışması, motorun gücünü daha etkin bir şekilde tekerleklere ileterek yakıtın daha verimli kullanılmasını sağlar.

D. Ekonomik ve Çevresel Etkiler

Topoloji optimizasyonu, şanzıman dişlilerinin tasarımında kullanılan alüminyum gibi hafif malzemelerin geri dönüşüm potansiyeliyle önemli ekonomik ve çevresel avantajlar sağlamaktadır. Alüminyumun geri dönüşümü, ham maddeden üretim için gereken enerjinin sadece %5'ini gerektirir ve bu da üretim sürecinin enerji yoğunluğunu önemli ölçüde azaltır. Ayrıca, geri dönüşüm süreci atık miktarını azaltarak çevresel etkileri minimize eder ve doğal kaynakların korunmasına katkı sağlar. Optimize edilmiş şanzıman dişlileri, sadece yakıt tasarrufu sağlamakla kalmaz, aynı zamanda karbon emisyonlarını da önemli ölçüde azaltır. Daha hafif malzemelerin kullanılmasıyla, otomobillerin çevresel ayak izi azalır ve doğal kaynakların daha sürdürülebilir bir şekilde kullanılmasına katkıda bulunur. Bu hem çevresel hem de ekonomik sürdürülebilirlik açısından önemli bir adımdır.

Ekonomik açıdan bakıldığında ise, geri dönüşümün sağladığı maliyet avantajları üretim süreçlerini daha verimli hale getirir ve uzun vadede işletme maliyetlerini düşürür. Bu nedenle, alüminyum gibi geri dönüşüm potansiyeli yüksek malzemelerin kullanımı hem ekonomik hem de çevresel sürdürülebilirlik açısından önemli bir strateji olarak öne çıkmaktadır.

Özetle, şanzıman dişlilerinde yapılan malzeme değişimi ve topoloji optimizasyonu hem yakıt tasarrufu hem de emisyon azalımı sağlayarak içten yanmalı motorlu araçların daha çevre dostu hale gelmesini sağlar. Daha hafif ve daha dayanıklı malzemelerin kullanımı, otomobil endüstrisinde enerji verimliliği ve çevresel etkilerin minimize edilmesi için önemli bir strateji sunar.

E. Yorulma Testleri

Yorulma testleri, şanzıman dişlilerinde kullanılan alüminyumun uzun vadeli dayanıklılığını değerlendirmek amacıyla gerçekleştirilmiştir. Bu testler, optimize edilmiş alüminyum dişlilerin dökme demir dişlilere göre önemli ölçüde daha yüksek yorulma dayanımına sahip olduğunu ortaya koymaktadır.

Yüksek yorulma dayanımı, alüminyum dişlilerin daha uzun ömürlü ve daha güvenilir olduğunu göstermektedir, bu da otomobil şanzımanlarında performansın ve dayanıklılığın artırılmasına olanak tanır.

F. Mukavemet ve Sertlik Testleri

Alüminyum dişlilerin mekanik özelliklerini değerlendirmek amacıyla yapılan mukavemet ve sertlik testleri, dökme demire göre alüminyumun daha yüksek mukavemet ve sertlik değerlerine sahip olduğunu göstermektedir. Bu sonuçlar, alüminyum dişlilerin daha dayanıklı ve performans açısından üstün olduğunu ortaya koymaktadır. Alüminyumun bu mekanik özellikleri, şanzıman dişlilerinde kullanıldığında daha az aşınma ve daha uzun ömürlü bir performans sağlar.

Bu bulgular, şanzıman dişlilerinde topoloji optimizasyonu ve malzeme değişiminin, ağırlık azalımı, performans artışı ve çevresel etkilerin minimize edilmesi açısından önemli avantajlar sunduğunu göstermektedir. Alüminyum dişlilerin kullanımı hem dayanıklılığı artırırken hem de yakıt tüketimini azaltarak çevresel sürdürülebilirliği destekler. Bu çalışma, otomotiv endüstrisinde ileriye dönük sürdürülebilirlik çabalarına önemli bir katkı sağlamaktadır.

IV. SONUÇ VE ÖNERİLER

Bu çalışma, şanzıman dişlilerinde yapılan topoloji optimizasyonu ve malzeme değişiminin sunduğu önemli sonuçları detaylı bir şekilde incelemiştir.

İlk olarak, optimizasyon süreci ve malzeme değişimi sonrasında şanzıman dişlilerinin toplam ağırlığında %67'lik bir azalma sağlanmıştır. Bu azalma, taşıtın genel ağırlığını ve dolayısıyla yakıt tüketimini belirgin bir şekilde düşürerek önemli yakıt tasarrufu potansiyeli sunmaktadır. Örneğin, dökme demir dişlilerden alüminyum dişlilere geçiş, 1400 kg ağırlığındaki bir taşıtta %20'lik bir ağırlık azalması sağlamış ve böylece %5-10 arasında yakıt tasarrufu sağlamıştır.

İkinci olarak, yapılan testler optimize edilmiş alüminyum dişlilerin dökme demir dişlilere göre daha yüksek yorulma dayanımına sahip olduğunu ortaya koymuştur. Bu durum, alüminyum dişlilerin uzun vadeli performans açısından avantajlı olduğunu ve daha yüksek mukavemet ile sertlik değerlerine sahip olduğunu göstermektedir. Mekanik özelliklerinin üstünlüğü, şanzıman dişlilerinin dayanıklılığını artırırken performansını da iyileştirmektedir.

Son olarak, alüminyumun geri dönüşüm potansiyeli, malzeme seçimi açısından ekonomik ve çevresel sürdürülebilirlik sağlamaktadır. Geri dönüşüm süreci, üretim maliyetlerini düşürürken enerji tasarrufu sağlayarak çevresel etkileri minimize etmektedir.

Bu bağlamda, şanzıman dişlilerinde yapılan topoloji optimizasyonu ve malzeme değişiminin taşıt ağırlığını azaltma, performansı artırma ve çevresel etkileri minimize etme potansiyelini göstermektedir. Gelecekteki çalışmalar, bu tür yenilikçi yaklaşımların daha geniş ölçekte uygulanabilirliğini ve taşıtların sürdürülebilirliğini artırma potansiyelini daha da araştırmalıdır.

Bu çalışma sonucunda elde edilen bulgular doğrultusunda şu önerilerde bulunulabilir:

- Taşıtlarda kullanılan şanzıman dişlilerinde malzeme seçimi ve topoloji optimizasyonu süreçlerinin daha geniş kapsamlı olarak değerlendirilmesi ve yaygınlaştırılması.
- Yakıt tasarrufu ve emisyon azalımı sağlayan malzeme ve tasarım değişikliklerinin otomotiv endüstrisi tarafından teşvik edilmesi.
- Alüminyum gibi hafif ve yüksek performanslı malzemelerin kullanımının artırılması için araştırma ve geliştirme çalışmalarına devam edilmesi.
- Bu öneriler, taşıtların performansını artırmak, çevresel etkileri minimize etmek ve ekonomik olarak sürdürülebilir çözümler sunmak adına önemli bir adım olabilir.

TEŞEKKÜR

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Wax Deposition during the Transportation of Waxy Crude Oil

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Abstract **–** A viscous and waxy petroleum flow is theoretically modelled by a simple conservation equation system where the wax layer thickness is expressed as function of duct distance and time. The flow parameters are written depending on these independent variables but also on the Reynolds and the Peclet numbers. For this, simulation of laminar and turbulent flow regimes is numerically performed in order to predict the pipeline obstruction problem.

Keywords – Wax deposition; deposition onset point, laminar and turbulent regimes, heat and mass transfer

I. INTRODUCTION

Wax deposition during transportation of waxy crude oil is a significant issue affecting the efficiency and safety of pipelines. This occurrence occurs when the temperature of the oil falls below its wax appearance temperature (WAT), resulting in the precipitation of waxy components and their adhesion to the inner walls of the pipeline. The behavior of wax deposition can be significantly different under laminar and turbulent flow conditions. This phenomenon was studied as a mass transfer problem under chemical, thermodynamic or hydrodynamic aspect. For this, many authors have considered wax deposit under some situations. Jessen and Howell [1] have observed that molecular diffusion is the main deposit mechanism. The paraffin deposit mechanism has been also considered by Burger et al. [2] in an Alaska petroleum pipeline. They have emphasized that the deposit mechanism is caused by both molecular diffusion and shear stress dispersal. Brownian diffusion and gravity effects are estimated unimportant.

Some theoretical works have been performed in order to model the wax deposit phenomenon in heavy oil pipelines. So, considering the fluid conservation equations and the Fick's diffusion law, Svendsen [3] has obtained a time paraffin deposit evolution, by resolving this equation set. Basing their model on the radial paraffin deposit, Souza Mendes and Braga [4] have performed a dimensionless theoretical model followed by a numerical simulation of the considered problem. They have considered only the case of constant pressure variation Δp for a variable fluid volume rate Q. In their work Leiroz and Azevedo [5] have studied the wax deposition phenomena in stagnant fluid under laminar flow. Respective numerical models have been also developed. However, results comparisons have showed a relative poor predicting capability, especially for the case of the wax deposition under laminar flow. Also, assuming that mass transport occurs in thin boundary layer, during the flow, Correra et al [6] have developed a mathematical model where the physical parameters (diffusivity and solubility) can be predicted by the use of experimental data. Boucetta et al. [7] they conducted a detailed mathematical analysis of the deposition problem, examining the impact of paraffin porosity on flow parameters. Their study focused on the thickness of the paraffin deposit, the longitudinal temperature distribution, and the evolution of the flow.

Therefore the purpose of this paper is to analyze the flow regime effect on the flow parameters, especially on the onset point of paraffin deposition.

II. THEORETICAL MODELLING

Two flow regions can be distinguished: the first begins at x=0 (figure 1) and finishes at $x=x_d$, in which the product is in contact with pipe wall where the temperature riches the cloud point. In this region, the fluid is not saturated and the paraffin does not precipitate. Analytical study of this region can be performed by the heat fluid flow equations. The second region concerns the domain limited by $x_d<x<L$ where the wax is assumed saturated. Also the bulk temperature depends on time and the pipe long ($T_b=T_b(x,t)$). Consequently the deposit beginning point x_d is also x and t depending.

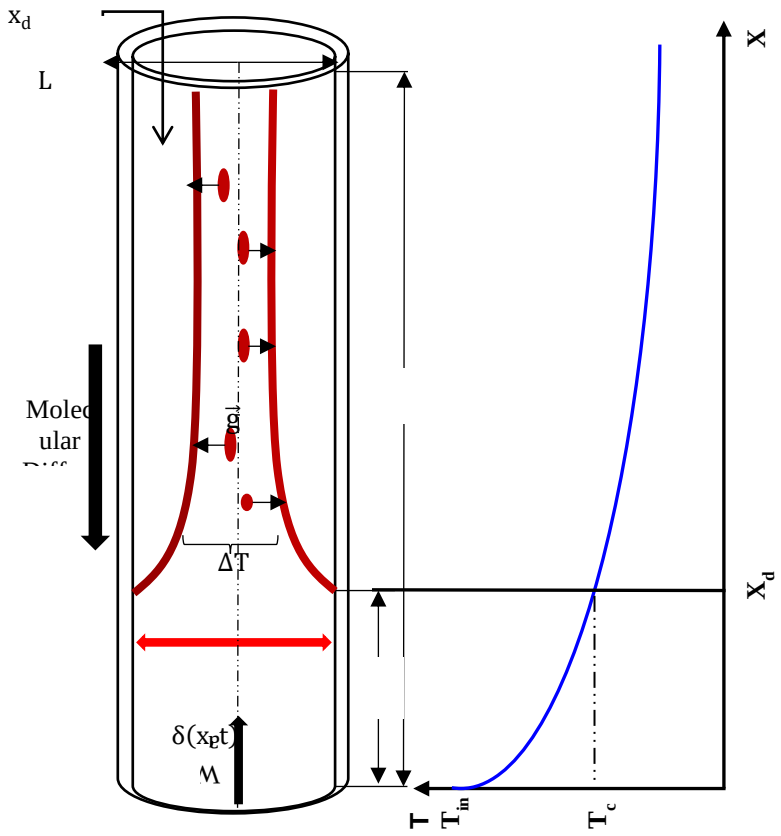

Fig. 1 Schematic of the problem

A. *Momentum equation:*

Neglecting the second order non linear terms and taking into account the radial deposit thickness repartition $(d = 2[R - \delta])$, integration of the momentum equation gives the differential pressure:

$$\Delta p = p_{in} - p_{atm} - \rho g H = \frac{\rho Q^2}{4\pi^2 R^4} \int_0^{L^*} \frac{f}{(1-\delta^*)^5} dx^* \qquad (1)$$

Where, $f = (x,t)$ is the shear friction factor, R is the pipe radius and ρ the constant fluid density. In this equation, p_{in} is the input pressure and p_{atm} the atmospheric pressure.

The following dimensionless form of the parameters is adopted:
$L^* = L/R$ long, $x^* = x/R$, axial coordinate and $\delta^* = \delta/R$ pipe wall thickness.
The expression for the friction factor becomes, for laminar and turbulent flows:

- For laminar flow (Re < 2000)

$$f = \frac{64}{Re} \tag{2}$$

- For turbulent flow (1200<Re < 100000) using the Blasius equation

$$f = 0.316Re^{-0.25} \tag{3}$$

B. Energy balance

As discussed earlier, heat transfer plays a major role in the deposition process. Applying the principle of conservation of energy to control volume

$$\rho Qc\frac{dT_b}{dx} = 2\pi RU(T_0 - T_b) \tag{4}$$

Where *U* is the overall heat transfer coefficient, can be rewritten in the following dimensionless form

$$U^* = \frac{UR}{k_i} = \left[\frac{2k_i/_{k_i}}{Nu_0} + \frac{k_i}{k_w}\ln\left(\frac{R_0}{R}\right) + \frac{k_i}{k_d}ln\left(\frac{1}{1-\delta^*}\right) + \frac{2}{Nu_i}\right]^{-1} \tag{5}$$

Equation (4) can be integrated, we get

$$\theta = \frac{T_b - T_0}{T_{in} - T_0} = exp\left[-\frac{2\pi Rk_i}{\rho Qc}\int_0^{x^*} U^*\,dx^*\right] = exp\left[-\frac{4}{Pe_0\dfrac{Q}{Q_0}}\int_0^{x^*} U^* dx^*\right] \tag{6}$$

Defining the Peclet number for circular pipe

$$Pe = \frac{2\rho Qc}{\pi Rk_i} \qquad and \quad Pe = Pe_0\frac{Q}{Q_0} \tag{7}$$

The relation (6) gives also the paraffin deposit point x_d^*, because in the space $0 \le x^* \le x_d^*$, δ^* (which equal zero in the $x^* < x_d^*$ region) and U^* are not space depending. Then its integration gives:

$$x_d^* = \frac{ln\left(\dfrac{T_{in} - T_0}{T_c - T_0}\right)}{4U^*|_{\delta^*=0}} Pe_0\, Q/Q_0 \tag{8}$$

C. Thickness paraffin deposit calculation

Expressing the radial continuity equation in terms of paraffin mass flux at liquid-deposit interface and using the Fick's law for molecular diffusion, the local deposition thickness time variation takes the following form:

$$\frac{\partial\delta^*}{\partial t^*} = \begin{cases} 0, & if\ 0 \le x^* \le x_d^* \\ \dfrac{S^*U^*}{(1-\delta^*)}\theta & if\ x_d^* \le x^* \le L^* \end{cases} \tag{10}$$

Where the dimensionless solubility coefficient, S^*, is defined by $S^* = \frac{S(T_{in}-T_0)}{\rho_d}$

D. Method of Resolution

Considering the initial conditions $\delta^*(x^*, 0) = 0$, the equation system (10) is resolved by a forth order Runge Kutta method. The main parameters, which are the volume rate (Q/Q_0), the axial temperature $\theta(x^*, t^*)$, written in an integral form, are numerically calculated by a height order Newton Côtes procedure (Demidovich [8]).

III. RESULTS

a) **b)**

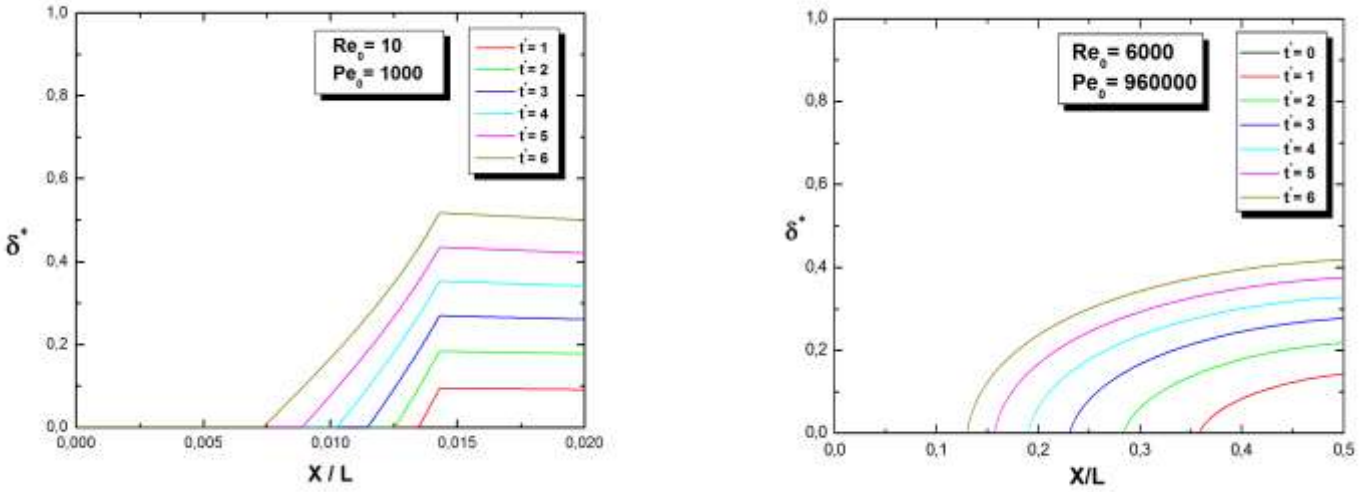

Fig. 2 Longitudinal distribution of the thickness: a) Re_0=10, b) Re_0= 6000

a) **b)**

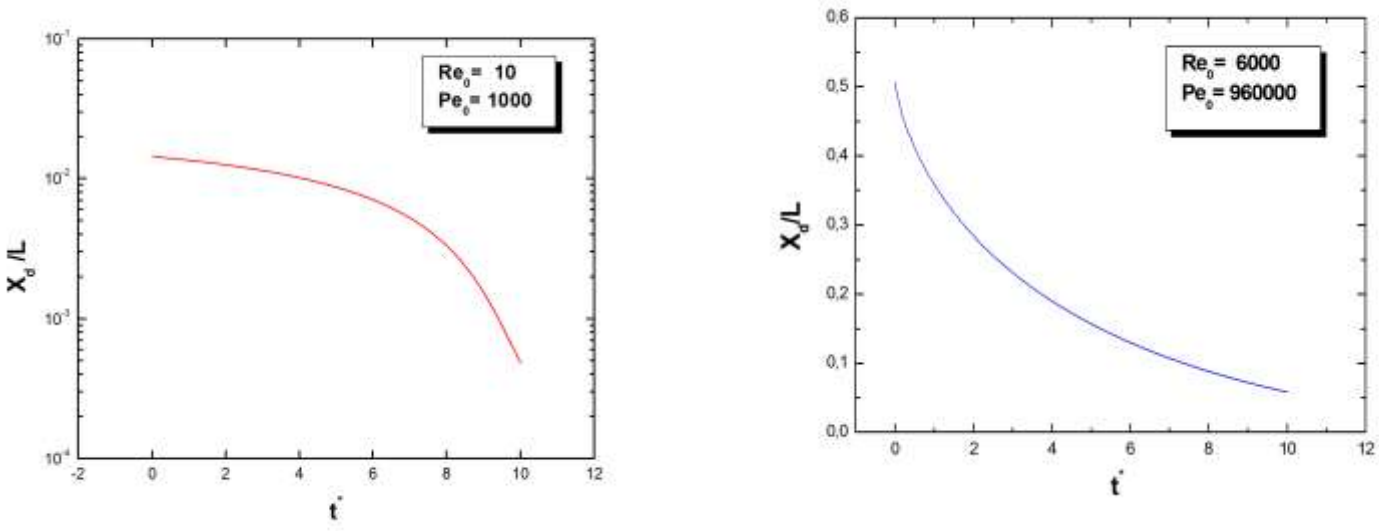

Fig. 3 Deposition onset point versus time : a) Re_0 = 10, b) Re_0 = 6000

Figures 2a, and 2b show the variation of the wax deposition thickness as a function of the dimensionless

length of the pipeline for laminar flow (Reynolds number Re_0 = 10 and Peclet number Pe_0 = 1000) and for turbulent flow (Reynolds number Re_0 = 6000 and Peclet number Pe_0 = (Reynolds number Re_0 = 6000 and Peclet number Pe_0 = 960000). For the high value of the Peclet number (Pe_0 =960000), it is observed that the deposited paraffin layer covers a significant length compared to that of the smaller Peclet value (Pe_0 =1000). This can be explained by the fact that if the Peclet number is small, the fluid flow is relatively slow (laminar flow), and forced convection is weak. If the flow velocity is relatively low, the fluid cools down quickly, but the amount of deposited wax is minimal. On the other hand, it is also noteworthy that when the Peclet number is high, the fluid velocity is high (turbulent flow), and therefore the heat transfer by forced convection increases, causing the fluid to cool over a long distance. This allows many paraffin crystals to appear, precipitating onto the pipeline wall under the influence of molecular diffusion, resulting in a significant amount of wax deposition in this case. Physically, the phenomenon of (forced) convection predominates.

We have plotted the evolution of the deposition onset point (X_d/L) as a function of time (Figures 3a and 3b). In laminar flow, where the fluid moves smoothly in parallel layers, the velocity of the fluid is relatively low. This can lead to quicker cooling of the fluid as it moves through the pipeline. Consequently, the onset point for paraffin deposition can be relatively closer to the pipeline inlet in laminar flow due to the faster temperature drop (X_d/L= 0.007-0.013). Turbulent flow, characterized by chaotic and high-velocity fluid motion, can result in a slower temperature drop as the fluid mixes vigorously. Therefore, the onset point for paraffin deposition may be far from the pipeline inlet in turbulent flow (X_d/L= 0.13 - 0.36).

IV. CONCLUSION

Turbulent flow tends to delay or prevent the onset of paraffin deposition due to constant agitation that hinders the accumulation of paraffin crystals on the pipeline walls. On the other hand, laminar flow can promote the formation of low-velocity zones near the walls, which may lead to a higher likelihood of paraffin deposition. However, it's important to note that reality can be much more complex, as many other factors come into play, including fluid composition, pipeline properties, temperature, pressure, and operational conditions.

The flow regime in pipelines, whether it's laminar or turbulent, has a significant influence on the onset point of paraffin deposition. The onset point of paraffin deposition refers to the temperature at which the first paraffin crystals begin to form and deposit on the inner walls of the pipeline. It's important to consider these flow regime effects when dealing with paraffin deposition in pipelines, as they can impact the operational temperature range, maintenance requirements, and overall efficiency of the pipeline system

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Investigation of the Apoptotic and Anticarcinogenic Potential of *Hypericum perforatum* in Thyroid Cancer at the Molecular Level

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Abstract – Cancer is the second leading cause of death globally, following cardiovascular diseases. Thyroid cancer, the most prevalent endocrine malignancy, originates in the thyroid gland, affecting the lower neck. The adverse effects of traditional treatments have driven researchers toward herbal alternatives. It is very important to understand the biological effects and mechanisms of plants. *Hypericum perforatum* is famous for its rich phenolic content and various properties such as antiviral, antioxidant, antiallergic and antitumor effects. Recent research has highlighted its ability to inhibit cancer cell growth. This study aims to investigate the anticarcinogenic effects of *Hypericum perforatum* on the human thyroid cancer TT cell line at a molecular level. To elucidate its effects, LC-MS/MS was used to profile active compounds, alongside qRT-PCR, Western blot, and apoptosis analyses. Cell imaging techniques were employed to observe changes in thyroid cancer cells treated with *Hypericum perforatum*. This comprehensive approach seeks to enhance understanding and harness herbal treatments in cancer care. Our results demonstrate that *Hypericum perforatum* significantly altered the gene and protein expressions of Caspase-3, Caspase-12, BcL-2, Apoe, Clu and Bax, involved in apoptosis pathways. Moreover, *Hypericum perforatum* increased late apoptosis in TT cells by 18.92% compared to controls, showing activity localized in the cell cytoplasm. Gene, protein, and apoptosis studies unveiled the molecular mechanisms of *Hypericum perforatum* 's cytotoxic effects on TT cells, supporting its anticarcinogenic properties against thyroid cancer. These findings may pave the way for new and effective cancer treatment strategies.

Keywords – Hypericum perforatum, Thyroid cancer, Anticarcinogenic effects, Gene expression, Apoptosis.

I. INTRODUCTION

Cancer is the most common disease that causes death worldwide and usually occurs when mutations in somatic cells spread to other parts of the body and is associated with genetic changes [1]. The thyroid gland is an organ located under the neck and regulates metabolism. This gland produces hormones that control a person's energy production and play many roles.Thyroid cancer is the uncontrolled growth and proliferation of cells in this gland, forming cancerous tumors. *Hypericum perforatum* is a perennial herb with bright yellow flowers and long, thin leaves [2]. Finding appropriate and safe strategies for treating thyroid cancer is critical. This plant is widely used in traditional and complementary medicine and attracts attention with its rich phenolic content and biological activities. Clinical studies have shown that the plant is effective in nervous system diseases such as Alzheimer's and stroke, wound healing, depression treatment and skin diseases. *Hypericum perforatum* has antitumor, antidepressant, antiviral, antifungal and antibacterial effects due to its flavonoid and phenolic acid diversity[3]. Additionally, the anti-inflammatory and antioxidant properties of this herb make it a potential candidate for the treatment of various chronic diseases. Recent

research has also revealed the growth-inhibiting effects of *Hypericum perforatum* on cancer cells, making it a promising ingredient in cancer treatment.

II. Materials and Method

A. Analysis of Phenolic and Flavonoid Profile of Hypericum perforatum Methanol Extract by LC-MS/MS

Hypericum perforatum methanol extract (HPME) was dissolved in ethanol-water (50:50 v/v) mixture and refluxed for 1 h using a volumetric flask. Then, 50 µL of *Hypericum perforatum* was diluted with methanol. The resulting final solution was added to the vial of the autosampler and transferred to the cuvette. Samples in the autosampler were kept at 15°C throughout the experiment.

B. Cell Imaging Studies

To determine where HPME localized in human thyroid cancer TT cells, coverslips were placed in 6-well plates and 2×10^4 cells were seeded on each coverslip. Cells were incubated for 1 hour. Then, 1 mL of growth medium was added to the cells and incubated. Cells were then incubated with HPME at IC_{50} for 45 min. It was then imaged with the fluorescent cell imaging system ZOE, Bio-RAD.

C. Determination of mRNA Expression by qRT-PCR

To examine the effects of HPME on human thyroid cancer TT cells, 24-well plates were plated and cells were treated with HPME up to IC_{50}. RNA isolation was performed. The resulting RNAs were dried and then used for cDNA synthesis. Expressions at the mRNA level were performed with a Quantitative Real-Time PCR device and normalized using the GAPDH reference gene.

D. Western Blot Studies

TT cells were seeded in petri dishes at the required density. Cells were treated with HPME at IC_{50} concentration and incubated at 37°C and 5% CO_2 for 48 h. Protein isolation was done. The concentrations of the resulting proteins were determined using the BSA standard. The effects of HPME on the protein expressions of GAPDH, BcL-2, Bax, Caspase-12, Apoe, Clu, which interact with the apoptosis signaling mechanisms that play an active role on the thyroid cancer TT cell, were determined by Western Blot. After SDS-PAGE, transfer to the membrane was performed. After the transfer was completed, the proteins on the gel were transferred to the PVDF membrane. ECL solution was prepared for imaging. The areas of protein bands were calculated with Image J software.

E. Apoptosis Studies

For apoptosis studies, TT cells were seeded in 6-well plates at the required density and cells were treated with HPME and incubated at IC50. After incubation, cells were removed from the plate by chemical means. Growth medium was added to the cells and centrifuged. After centrifugation, the supernatant was discarded and the pellet was dissolved with Binding Buffer. Then, Annexin V-APC and 7-AAD dyes were added to the cells and incubated. Binding Buffer was added later. Apoptosis and necrosis rates were measured using flow cytometry.

F. Statistical analysis

Statistical analysis was performed using GraphPad Prism 8.1v software (San Diego, California, USA). Mean values and standard deviations (SD) of independent experimental sets were performed by analysis of variance (ANOVA) and Student's t-test analysis. Statistical significance level $p<0.0001$***; $p<0.001$**; $p<0.05$* was accepted.

III. RESULTS

The chemical composition of methanol extract obtained from aerial parts of *Hypericum perforatum* was analyzed using LC-MS/MS Agilent 6460 Triple Quad. As a result of these analyses, 14 metabolites were found in *Hypericum perforatum*: quercetin, ascorbic acid, hesperidin, neohesperidin, p-coumaric acid, protocatechuic acid, catechin, trans-cinnamic acid, hydroxybenzoic acid, vanillic acid, routine, naringin, o-coumaric acid and coumarin. The most abundant metabolite is quercetin flavonoid (Figure1).

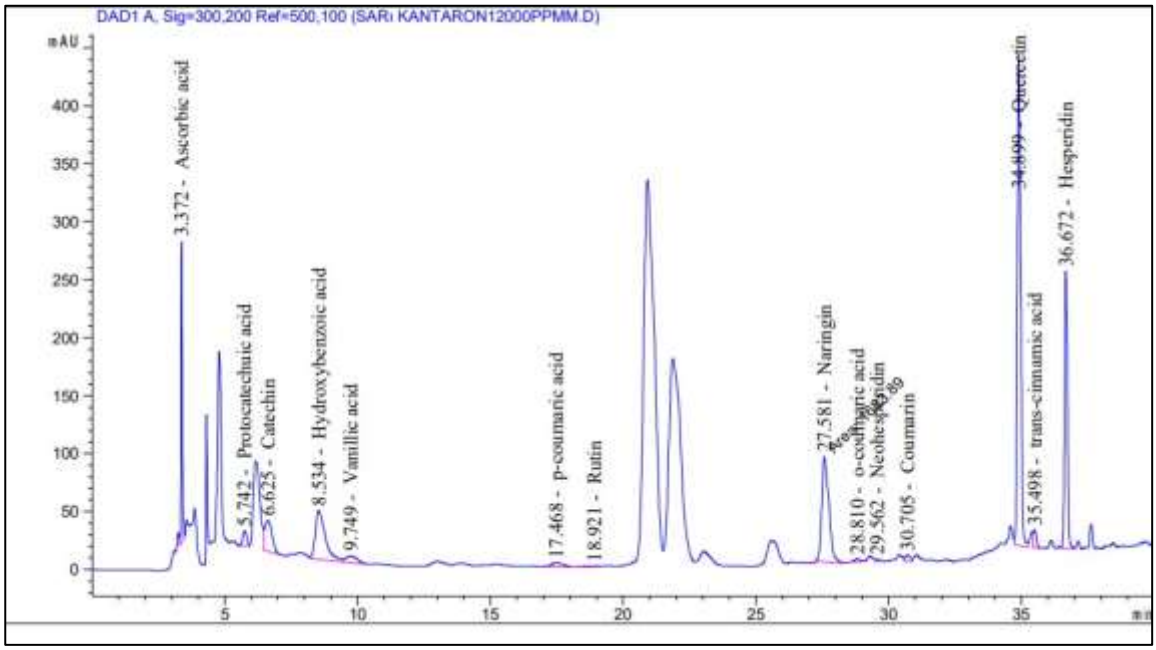

Fig. 1 Chromatograms of *Hypericum perforatum* recorded by LC-MS/MS.

Fluorescence imaging studies have revealed that HPME exhibits fluorescence at the red wavelength and is localized in the cytoplasm of cells. These findings demonstrate the presence of HPME in the cytoplasm as well as a significant fluorescence activity in the red spectrum (Figure 2).

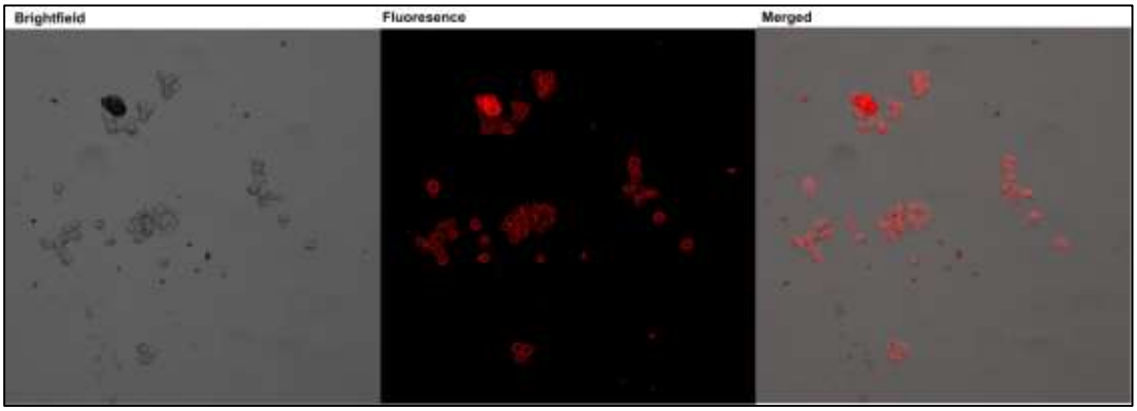

Fig. 2 Cell imaging of HPME in TT cells. They represent the bright-field image, fluorescence image, and overlapping image, respectively.

mRNA expressions of TT thyroid cancer cells treated with HPME were determined by qRT-PCR method. qRT-PCR was performed using Caspase-3, Caspase-12, BcL-2, Bax, Apoe, Clu genes, which are frequently encountered in *Hypericum perforatum* TT thyroid cancer cells and play an active role in apoptosis, and GAPDH as a reference gene. Looking at the results, the expression of Bax (11.37 fold), Caspase-12 (18.9 fold), Caspase-3 (5.5 fold) gene expression increased, while the mRNA expression of Apoe (95.27%), Clu (95.13%) and BcL-2 (71.46%) genes increased. It was observed that their expression decreased (Figure 3).

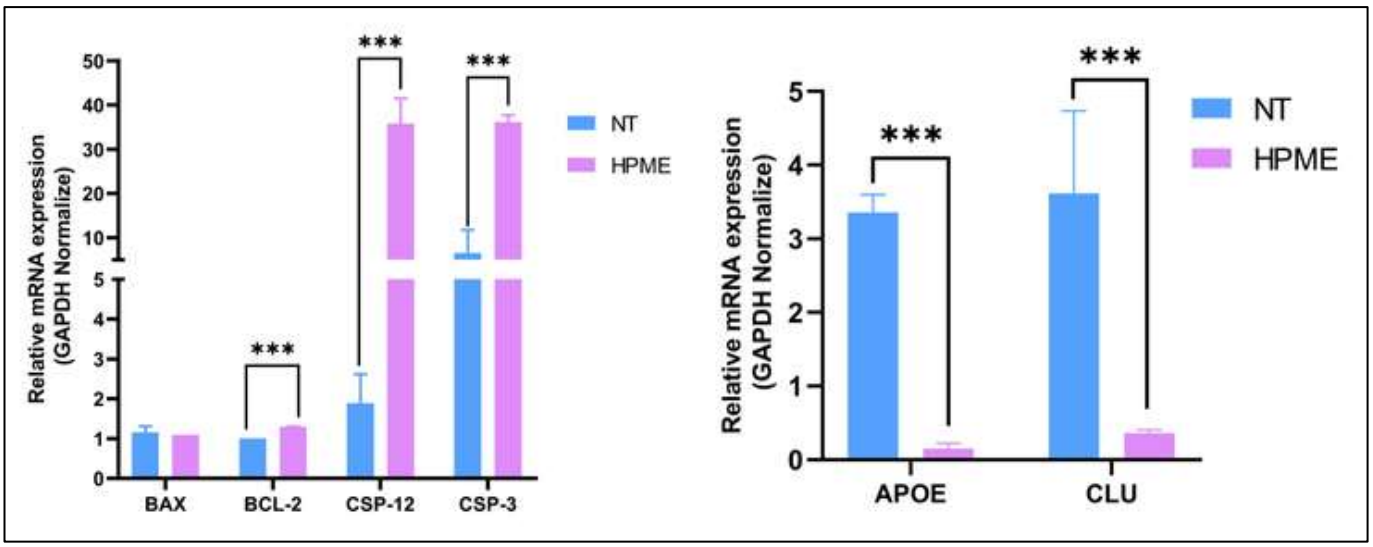

Fig. 3 Data presented as mean ± standard deviation (SD)., **p<0.01, ***p<0.001 compared to the control group. HPME: *Hypericum perforatum* methanol extract; NT: non-treatment;; CSP-3: caspase-3; CSP-12: caspase-12.

The expression of Caspase-12, Bax, BcL-2, Apoe, and Clu proteins, which have critical roles in the apoptosis and thyroid cancer pathway, in thyroid cancer TT cells of HPME were determined using the Western Blot method. In this study, HPME was applied to cells with IC_{50} value, and GAPDH protein was used as a reference. The intensity of protein bands was analyzed using Image J software. As a result of the HPME application, a 3.45-fold increase in the expression of Bax protein and a 1.17-fold increase in the expression of Caspase-12 protein was observed. On the other hand, a decrease of 40.17%, 68.49%, and 46.55%, respectively, were detected in the expression of Apoe, Clu, and BcL-2 proteins (Figure 4).

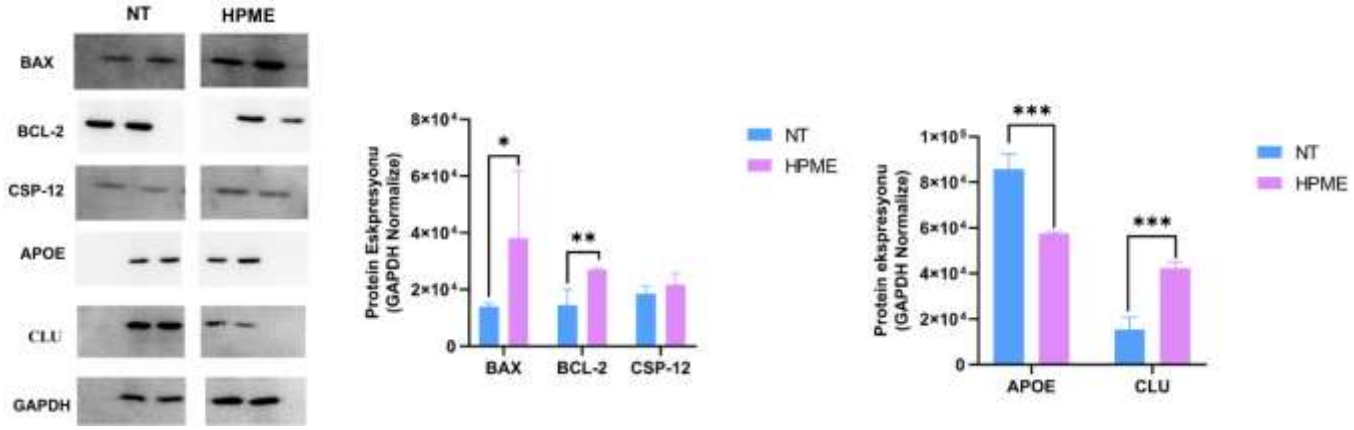

Fig. 4 Protein bands and protein expressions of CSP-12, BcL-2, Bax, CLU, and APOE in TT cells.

In order to reveal the cell death mechanism, the effects of HPME-treated human thyroid cancer TT cells on apoptosis were examined using flow cytometry. The findings showed that HPME markedly triggered apoptosis in cancerous cells. As shown in Figure 5, HPME was found to increase late apoptosis in TT cells by 18.92%.

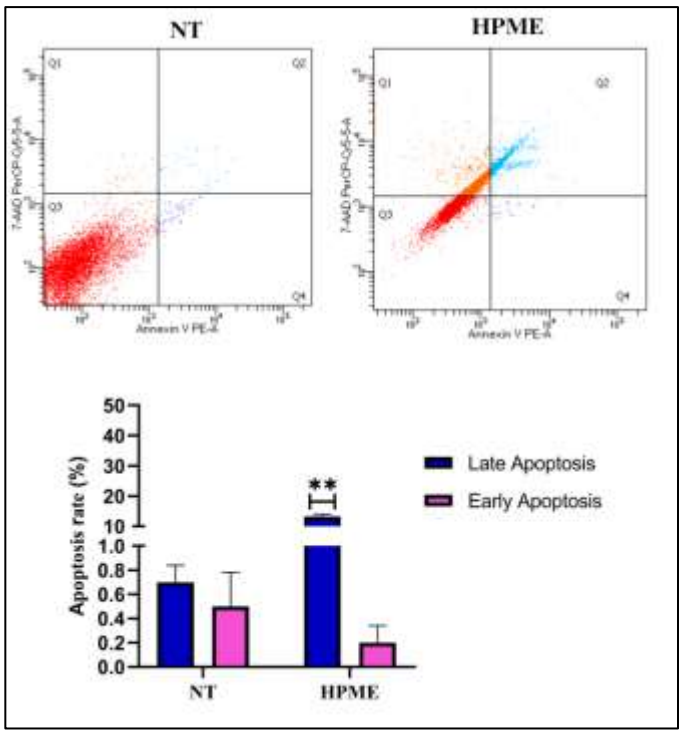

Fig. 5 Annexin staining with V-APC and 7-AAD after 48 hours. Graph of late apoptosis and early apoptosis rate of HMPE in TT cells compared with the control group (Graphs are mean ± Std. Dev. Representative of at least 3 independent experiments. Based on t-test analyses, ***; P < 0.0001,* *;p <001).

DISCUSSION

The increase in thyroid cancer incidence in recent years is associated with routine screenings and greater use of common diagnostic tests [4]. However, the limitations and side effects of existing treatments have led patients to seek various treatment options. This situation reveals the need to research and develop new and alternative treatment approaches. In this context, *Hypericum perforatum* is a plant rich in antioxidants such as phenolics and flavonoids. In addition to being a widely known antidepressant agent, it has also been confirmed to have anticancer effects. methanol extract was used to examine the anticancer properties of *Hypericum perforatum*, and in the quantitative analysis performed by LC-MS/MS, it was determined that quercetin was dominant among 14 phenolic compounds. Furthermore, after direct treatment of TT cells with HPME, confocal microscopy imaging revealed that HPME exhibited a fluorescence effect at the red wavelength and was localized in the cytoplasm of TT cells. When genes with prognostic importance were examined in thyroid cancer cells, it was found that Caspase-12 showed a significant increase and this increase was associated with endoplasmic reticulum (ER) stress. Flavonoid compounds in HPME play an important role in inducing ER stress, regulating Ca^{2+} expression, and thus promoting apoptosis. APOE (Apolipoprotein E) and Clu (Clusterin) genes have important effects on thyroid cancer prognosis. A decrease in APOE expression was observed. It has been determined that this situation prevents proliferation and metastasis. Thanks to its anti-apoptotic properties, Clu helps cells avoid programmed cell death and thus promotes the survival and proliferation of cancer cells. Overexpression of APOE has been associated with aggressive biological behavior and poor prognosis in various tumor types. In summary, it is stated in the literature that genes such as CLU, BcL-2, Caspase-3, Caspase-12, APOE and Bax have important prognostic roles in thyroid cancer cells. These findings are compatible with existing knowledge and solidify its place in the literature.

IV. CONCLUSION

Genes such as Caspase-12, Caspase-3, BcL-2, Bax and APOE, CLU play important prognostic roles in thyroid cancer cells. The findings are consistent with the existing literature and strengthen the knowledge in the literature. HPME has been shown to positively modulate gene and protein expressions associated with proliferation and apoptosis of thyroid cancer cells. Observations indicate that HPME has an antioxidant effect on human thyroid cancer. This suggests that it has the potential to stop the growth of thyroid cancer cells by increasing apoptosis by regulating Caspases. These findings highlight the importance of investigating potential therapeutic effects.

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Basınçlı sulama sistemleri uygulamaları

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Özet – Tarımsal sulama açısından en önemli olgulardan birisi suyun kaynaktan alınıp sulanacak alana iletilmesidir. Ancak günümüz koşulları değerlendirildiğinde sadece suyun kaynaktan alınıp sulanacak alana iletilmesi yeterli değildir. Suyun en az kayıpla iletilmesi ve bitki kök bölgesine bitkinin ihtiyaç duyduğu kadar suyun verilmesi gerekmektedir. Bunun nedeni, hem nüfusun hızla artması ve kaynakların yetersiz kalacağı endişesi hem de küresel iklim değişikliğinden kaynaklanan olumsuz etkilerin oluşmasıdır. Bu araştırmada Türkiye'de tarım alanlarında uygulanan basınçlı sulama sistemlerinin önemine değinilmiştir. Ayrıca son yıllarda basınçlı sulama sistemleri ve borulu su taşıma sitemlerinin kullanım düzeyi incelenmiştir. Özellikle DSİ tarafından açılan su taşıma sistemlerinde kanaletli sistemler yerine borulu sistemler ve yüzeysel sulama yöntemleri yerine basınçlı sulama sistemlerine son yıllarda ağılık verildiği gözlemlenmiştir. Ancak hâlâ basınçlı sulama yöntemleri ve borulu su taşıma yapıları istenilen düzeyde tarım alanında kullanılmamaktadır. Tarımsal sulama yöntemleri incelendiğinde, basınçlı sulama yöntemlerinin kullanıldığı tarım alanlarında kullanılan sulama suyundan büyük miktarda tasarruf sağlandığı görülmektedir. Ancak değişen iklim şartları ve nüfus artışları göz önüne alındığında tarım alanlarında kullanılan sulama suyundan daha fazla tasarruf edici önlemler alınması gerekmektedir. Bu çalışmanın amacı basınçlı sulama yöntemlerinin Türkiye'deki uygulamasına genel bir değerlendirme ve uygulanmakta olan basınçlı sulama yöntemlerinin genel bir değerlendirmesini yapmaktır.

Anahtar Kelime: Basınçlı sulama yöntemleri, damla sulama, yağmurlama sulama

Pressurized irrigation system applications

Abstract – One of the most important facts in terms of agricultural irrigation is the taking of water from the source and conveying it to the area to be irrigated. However, considering today's conditions, it is not enough to just take water from the source and deliver it to the area to be irrigated. Water should be transmitted with minimal loss and the plant root area should be given as much water as the plant needs. The reason for this is both the rapid increase in population and the concern that resources will be insufficient, as well as the negative effects resulting from global climate change. In this research, the importance of pressurized irrigation systems applied in agricultural areas in Turkey is mentioned. Additionally, the usage level of pressurized irrigation systems and piped water transportation systems has been examined in recent years. It has been observed that in recent years, especially in the water transportation systems opened by DSI, emphasis has been given to piped systems instead of canal systems and pressurized irrigation systems instead of surface irrigation methods. However, pressurized irrigation methods and piped water transport structures are still not used in agriculture at the desired level. When agricultural irrigation methods are examined, it is seen that a large amount of irrigation water is saved in agricultural areas where pressurized irrigation methods are used. However, considering the changing climate conditions and population increases, more saving measures need to be taken for irrigation water used in agricultural areas. The aim of this study is to make a general evaluation of the application of pressurized irrigation methods in Turkey and to make a general evaluation of the pressurized irrigation methods being applied.

Keywords – Pressurized irrigation methods, drip irrigation, sprinkler irrigation

I. GİRİŞ

Tarımsal sulama yönetiminde, suyun en az kayıpla araziye iletilmesi ve bitkinin kök bölgesine ihtiyacı kadar verilmesi son derece önemlidir. Çünkü, son on yıllarda iklim değişikliği neticesinde yaşanan kuraklık, tarıma ayrılan suyun azaltılması yönünde baskı oluşturmaktadır. İklim değişikliği, küresel olarak su kaynakları üzerinde olumsuz etkiler meydana getirmektedir. İklim değişikliği neticesinde özellikle bazı bölgelerde sıcaklık artışlarına bağlı olarak yağışlı gün sayılarının azalması beklenmektedir (Türkeş vd., 2000). Bu durum bize bitkinin ihtiyaç duyduğu su miktarının doğal yağışlarla karşılayamayacağı sonucunu doğurmaktadır. Aynı zamanda, sıcaklıkların artması ve yağışların azalması su kaynaklarındaki buharlaşma miktarlarının da artmasına neden olmaktadır. Buda su kaynaklarının (nehirler, göller, akarsular vs.) kurumasına ya da akış miktarlarının azalmasına neden olabilmektedir. İlave olarak, nüfus artışı ve beraberinde tarım alanlarının imara açılması üretim alanlarını kısıtlamaktadır. Bu durum mevcut olan su kaynaklarını optimum düzeyde kullanılacak yöntemlerin tercih edilmesini zorunlu hâline getirmektedir.

Su kaynaklarını optimum düzeyde kullanılacak yöntemlerde; su iletim sistemlerinin açık sistemler yerine kapalı borulu sistemlerin tercih edilmesi ve sulama yöntemlerinin seçiminde de yüzeysel sulama yöntemleri yerine basınçlı sulama yöntemlerinin tercih edilmesi gerekmektedir. Böylece su kaynaktan alınıp sulanacak olan bitkinin kök bölgesine en az kayıpla iletilmiş olur ve buna bağlı olarak su tasarrufu sağlanmış olur. Harran ovasında yapılan araştırmada damla sulama sisteminin karık sulama sistemine göre önemli düzeyde su tasarrufu sağladığı ve önemli verim artışı elde ettiği tespit edilmiştir. Aynı zamanda yapılan araştırmada bitkilerin su kullanım etkinlikleri basınçlı sulama yöntemlerinde daha yüksek olduğu saptanmıştır (Çetin vd., 2010). Yapılan bir başka araştırmada da Aydın ili Karacasu ilçesi Ataeymir beldesinde yüzey sulama yönteminden damla sulama yöntemine geçildiğinde, ekili arazilerin bir bölümünde sağlanan en yüksek verim artışı %21-30 arasında değiştiği saptanmıştır (Nalbantoğlu, 2014). Bu verilen bilgilerden de anlaşılacağı gibi basınçlı sulama yöntemleri hem su tasarrufu sağlayıp su kullanım etkinliğini arttırmakta hem de yüzeysel sulama yöntemlerine göre birim alandan elde edilen verimi arttırmaktadır.

Basınçlı sulama yöntemleri teknik bilgi ve deneyim isteyen ekonomik maliyeti yüksek sulama yöntemleridir. Özellikle ilk kurulum masraflarının yüksek olması, uygulanmasındaki en büyük dezavantajıdır. Ancak, verim artışıyla birlikte sulamada su kaynaklarının daha verimli bir şekilde kullanılmasına olanak sağladığı için, son on yıllarda üreticiler tarafında basınçlı sulama yönteminin kullanımında artışlar görülmektedir. Yılmaz (2023) tarafında yapılan bir çalışmada 2006 ve 2021 yılları arasında basınçlı sulama sistemlerine yapılan düşük kredi veya hibe desteklerinin basınçlı sulama sistemlerinin Türkiye genelinde %136 ve Ankara ili genelinde %59 oranında arttığı saptanmıştır. Buradan basınçlı sulama sistemlerine yapılacak olan hibe ve kredi desteğinin basınçlı sulama sistemlerinin yaygınlaşmasında etkili olduğu görülmektedir.

Basınçlı sulama sistemlerinde önemli bir diğer nokta ise uygulayıcının yeterli teknik bilgiye sahip olmamasıdır. Bunun için teknik bilgiye sahip kişilerin uygulayıcılara gerekli eğitimleri vermesi gerekir (Yolal ve Değirmenci, 2020). DSİ'nin sulama hizmeti götürdüğü bir sahada yapılan araştırmada, işletilen ve devredilen sulamalarda net sulama suyu ihtiyacı 4589 m^3/ha iken, verilen su miktarı 10553 m^3/ha belirlenmiştir. Bu rakamlar sulama suyu ihtiyacının iki katından fazla su kullanıldığını göstermektedir (Çetin vd., 2010).

Sulama suyu, bitkinin ihtiyacı olan kısmının toprağa verilecek şekilde planlanmalıdır. Basınçlı sulama yöntemlerindeki temel amaç tam olarak bunu sağlamaktır. Ancak, uygulamadaki hatalardan dolayı sulama suyunun bitki kök bölgesine verilmesinde istenen su tasarrufu sağlanamamaktadır.

Bu çalışmanın amacı, Türkiye'de basınçlı sulama yöntemlerinde geçmişten günümüze kadar yapılan uygulamalarla birlikte verim miktarı, sulanan tarım alanı gibi parametrelerin değişimi ele alınmıştır. Ayrıca, son yıllarda gelişim gösteren, bazı basınçlı sulama sistemleri üzerine yapılan akademik çalışmalar da değerlendirilmiştir.

II. TÜRKİYE'DE BASINÇLI SULAMA SİSTEMİ

Basınçlı sulama sistemleri kullanılırken, verilen suyun yönetimi etkin bir su tasarrufu sağlamak açısından büyük önem taşımaktadır. Bu amaçla geliştirilmiş birçok sulama sistemleri de mevcuttur. Toprağın su içeriğini, sıcaklığı, hava nemini, yağış vb. takip etmek için sensörlerden aldıkları verileri bilgisayar ortamına aktarıp sulama zamanlaması ve verilecek olan sulama suyu miktarı akıllı sistemler aracılığıyla belirlenebilmektedir.

Basınçlı sulama yöntemleri genel olarak:

- Yağmurlama sulama,
- Damla sulama,
- Toprakaltı damla sulama ve
- Mikro yağmurlama şeklinde dört yönteme ayrılabilir.

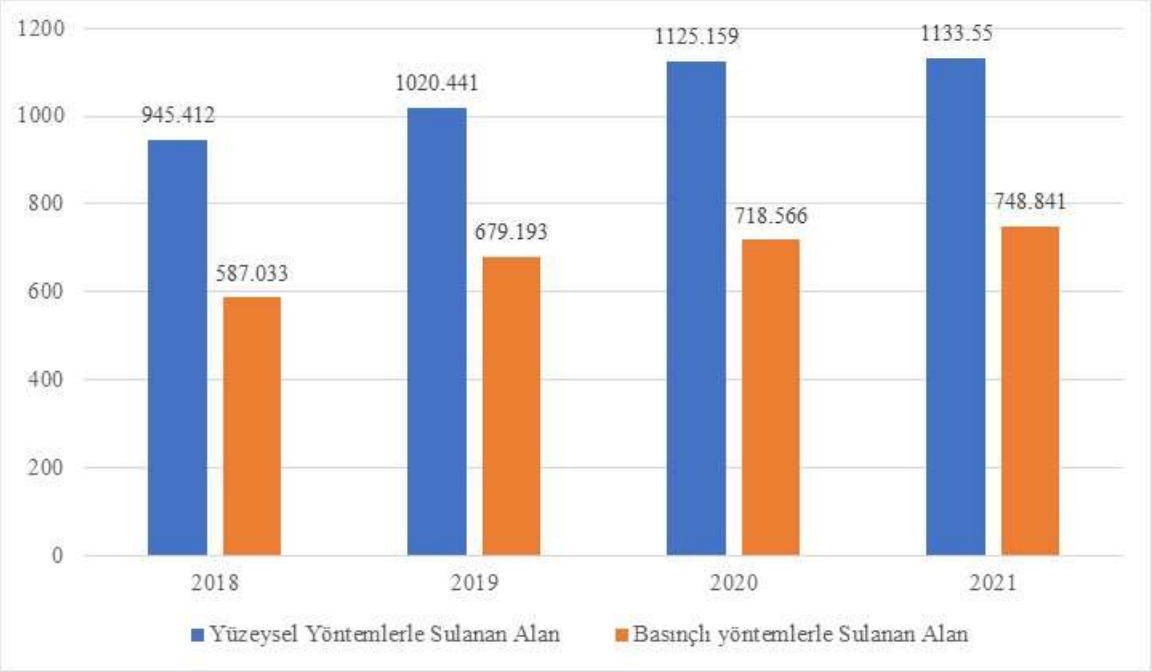
Bu yöntemlerin en büyük avantajı yüksek sulama randımanı elde edilmesidir. Özellikle damla sulama yönteminde doğru bir işletim sayesinde %80'lere, yağmurlama sulama yönteminde ise %70'lere varan sulama randımanı elde edilebilmektedir (Tülücü, 2003). Günümüzde bu söz konusu sulama randımanı değerleri daha da yukarılara çıkarılabilir. Ancak, yüksek sulama randımanı elde edilebilmesi için sulama projelerinin doğru planlanması ve uygulanması gerekmektedir. Kullanılan malzemenin kalitesi, toprak etütleri, su kalitesi ve yapılan hidrolik hesaplar bu noktada çok büyük önem taşımaktadır.

Türkiye'de yapılan tarımsal sulama sistemlerini incelediğinde; DSİ'ce geliştirilen sulamalarda uygulanan sulama sistemleri 2021 yılı istatistiklerine göre toplam sulanan alanın %34'ü klasik sistemler %35'i kanaleti sistemler ve %31'i borulu sistemlerden oluşmaktadır. Tablo 1'de belirtildiği gibi son yıllarda borulu (basınçlı) sulama sistemlerinde artış gözlemlenmektedir (DSİ, 2022). Borulu sulama sitemleriyle sulama suyu iletiminde, diğer sistemlere göre neredeyse hiç su kaybı yaşanmamaktadır. Bu nedenle sulama sistemlerinde borulu su iletim sistemlerine öncelik verilmelidir.

Tablo 1: DSİ'nin geliştirtiği sulamalarda uygulanan sulama sistemleri (DSİ, 2022)

Yıllar	**Sulama Sistemlerine Göre Sulama Alanı**						
	Klasik Sistem		**Kanaletli Sistem**		**Borulu Sistem**		**Sulama Alanı**
	ha	%	ha	%	ha	%	ha
2018	866.106	35,4	927.768	38,0	649.729	26,6	2.443.603
2019	872.884	34,8	923.357	36,9	708.587	28,3	2.504.828
2020	896.591	34,2	927.349	35,3	799.968	30,5	2.623.908
2021	908.883	33,6	929.300	34,3	870.736	32,1	2.708.919

DSİ'ce geliştirilen sulamalarda, uygulanan sulama yöntemlerine göre sulanan alanları incelediğinde, 2021 yılı içinde toplam sulanan alanın %40'ı basınçlı sulama yöntemleriyle, %60'ı da yüzeysel sulama yöntemleriyle sulanmaktadır (DSİ, 2022). Şekil 1'de görüldüğü gibi DSİ'nin geliştirdiği sulamalarda son yıllarda basınçlı sulama yöntemlerinin uygulanmasında artış gözlemlenmektedir. Ancak, benzer şekilde yüzeysel sulama yöntemlerinde de artış gözlemlenmektedir. Bu durumun en büyük sebebi basınçlı sulamanın ilk yatırım masraflarının fazla olması ve bitki su ihtiyacı fazla olan bitkilerin yetiştirilmesidir. Bu durumun önüne geçilmesi için basınçlı sulama yatırımları için hibe ve kredi desteklerinin atması gerekmektedir.



Şekil 1. Yıllara göre DSİ'ce geliştirilen sulamalarda uygulanan sulama yöntemleri

Su ihtiyacı fazla olan bitkiler için de basınçlı sulama yöntemleriyle yetiştirilme olanakları araştırılmalıdır. Örneğin, Mersin Tarsus'da Çolak vd. (2022)'nin yaptığı bir araştırmada Çeltik bitkisi üzerine yapılan damla sulama yöntemi uygulamasında, tava sulama yöntemine %14 ve %19.5'lik verim azalışına karşılık sulama suyundan %49'luk su tasarrufu sağlamışlardır. Nar vd. (2018) tarafından yapılan bir diğer çalışmada damla sulama yöntemi belirli bir verim kaybına karşılık yüksek su tasarrufu sağlamışlardır. Yapılan bazı araştırmalardan da görüldüğü gibi basınçlı sulama sistemlerinin kullanımı yüksek su tasarrufu sağlamaktadır. Ancak, basınçlı sulama yöntemleri teknik bilgi gerektiren yöntemlerdir. Bu konuda çiftçiler bilinçlendirilmelidir. Aksi taktirde yüksek maliyet yapılmasına karşın beklenen su tasarrufu ve bitkide verim sağlanamaz.

Türkiye'de son yıllarda Şekil 1'de de görüldüğü gibi basınçlı sulama yöntemlerinin tercih edilmesinde ve kapalı-borulu sistemlerin kullanılmasında artış gözlemlenmektedir. Bu durum sulama randımanın artmasına da katkı sağladığı söylenebilir. Basınçlı sulama yöntemleri içerisinde, avantajlarının nispeten daha yüksek olduğu düşünülen, en önemlilerinde biri damla sulama diğeri ise yağmurlama sulama yöntemleridir.

III. DAMLA SULAMA YÖNTEMİ

Damla sulama yöntemi sulama amaçlı kullanılacak olan sulama suyu, kaynaktan alıp bitkinin kök bölgesinde damlalar hâlinde verilerek ıslatılması prensibine dayanmaktadır. Bu yöntemde bitkinin ihtiyacı olan sulama suyu bitkiyi strese sokmadan düşük basınçla (yaklaşık 1.5-2 atm) verilmesi amaçlanmaktadır. Damla sulamanın en büyük avantajlarından birisi, kullanılan sulama suyu miktarından büyük ölçüde tasarruf sağlanmasıdır. Damla sulama yönteminde sulama randımanı %80'lerin üzerine çıkabilmektedir. Basınç regülatörü kullanılan sistemlerde bu oran %90'a kadar ulaşabilmektedir. Sulama randımanının yüksek olmasıyla hem sulama suyundan tasarrufu edilmiş hem de toprağı fazla sulamadan dolaya taban suyu yükselmesi tuzlulaşması gibi problemlerin önüne geçilmiş olmaktadır (Yıldırım, 2013). Damla sulama yöntemi diğer sulama yöntemlerine göre de yüksek randımana sahiptir. Karaca ve Selenay (2001) yürüttükleri bir çalışmada damla sulama yönteminin karık sulama yöntemine göre toplam sulama suyunun %40 daha az kullanıldığını saptamışlardır. Ayrıca, yıllık toplam gider olarak damla sulama sisteminin karık sulamaya göre daha ekonomik olduğunu saptamışlardır.

Damla sulama yönteminin bilinen büyük dezavantajı ilk yatırım maliyetlerinin yüksek olmasıdır. Ayrıca, damla sulama yöntemlerinde bakım yeterli düzeyde yapılmaz ise damlatıcı tıkanıklıkları meydana gelmektedir. Buna ilave olarak, toprak sürekli nemli kaldığı için nemden etkilenen kök hastalıklarına yol açabilmektedir. Bu nedenle üreticilerin maliyet yükleri düşürülmeli ve sistemin, bitkilerin sürekli denetimi ve bakımı yapılmalıdır. Damla sulama yöntemi kendi içerisinde yüzey altı (toprak altı) ve yüzey üstü (toprak üstü) olmak üzere iki farklı uygulaması bulunmaktadır. Birincisi toprak üstünde (Şekil 2; Netafim, 2024a) bitkini kök bölgesine damla halinde verilmesi diğeri ise toprak altından (Şekil 3; Netafim, 2024b) bitkinin kök bölgesine sulama suyunun sızdırılarak verilmesi şeklindedir.

Şekil 2. Toprak üsttü damla sulama sistemi (Netafim, 2024a)

Şekil 3. Toprakaltı damla sulama (Netafim, 2024b)

Toprak altı damla sulama sistemi özellikle araştırmacılar tarafından, son yıllarda yoğun bir şekilde ele alınmaktadır. Orta vd. (2019) tarafından Tekirdağ koşullarında yazlık ve kışlık çim bitkilerinin sulanmasında kullanılan yağmurlama sulama ve toprak altı damla sulama yöntemlerinin karşılaştırılması üzerine bir çalışma yürütmüşlerdir. Toprak altı damla sulama yöntemi ile sulanan sıcak iklim çim bitkisi yağmurlama sulama yöntemi ile sulanan serin iklim çim bitkine göre %40 daha az sulama suyu ihtiyacı talep ettiğini saptamışlardır. Carus (2019)'un Urfa'da yaptığı bir başka çalışmada toprak altı damla sulama yöntemiyle beş çim çeşidi (Lolium Perenne L., Poa pratensis, Festuca arundinacea L., Bermuda grass ve Festuca rub rubra) karışımını kullanarak yaptıkları araştırmada, belirlenen kullanılabilir sulama suyu miktarının %75'nin kullanıldığında istenilen çim kalitesine ulaşılabildiğini saptamışlardır.

Toprak altı damla sulama sisteminin tasarımında özellikle dikkat edilmesi gereken konu ise tıkanmayı önleyici damlatıcıların kullanılması, toprak bünyesi özellikleri, bitki türü gibi parametreler ile lateral derinliği ve aralığı doğru bir şekilde belirlenmelidir. Ayrıca, sistem toprak altında olduğundan su kaçağı tıkanma vs. olup olmadığını tespit etmek için sürekli olarak su sayaçlarını izlenmesi gerekmektedir (Netafim, 2024b).

IV. YAĞMURLAMA SULAMA YÖNTEMİ

Yağmurlama sulama yöntemi, pompa biriminin yardımıyla kaynaktan alınan sulama suyu borular vasıtasıyla sulanacak araziye taşınıp belirli kuralları gözeterek, yağmurlama başlıklarının araziye sulama suyunu püskürtmesi şeklinde tasarlanan sulama yöntemidir. Bu yöntemde dikkat edilmesi geren en önemli husus, kullanılan başlığın yağmurlama hızının, toprağın infiltrasyon hızından düşük olması gerektiğidir. Damla sulama yönteminde olduğu gibi taban suyunun yüksek olduğu yerlerde ve bozuk arazi şartlarında kullanılabilmektedir. Ayrıca, yüzeysel sulama yöntemlerine göre doğru bir işletimle daha yüksek sulama suyu randımanı (%70) elde edilebilmektedir (Yıldırım, 2013).

Yağmurlama sulama yönteminin dezavantajları olarak ilk sırada ilk tesis masraflarının yüksek olması söylenebilir. Buna ilave olarak, rüzgâr hızının yüksek olduğu alanlarda homojen bir sulama uygulaması gerçekleşemez (Yıldırım, 2013). Bu nedenle sulama suyu kayıpları fazla olmaktadır. Bunun önlemini almak için seçilen yağmurlama başlıkları ve başlıkların sıra aralıkları (özellikle rekreasyon alanları projelerinde) büyük önem taşımaktadır (Orta, 2017).

Yağmurlama sulama sistemleri:

- Sabit sistemler,
- Yarı sabit sistemler ve
- Hareketli sistemler olmak üzere üç farklı biçimde uygulaması mevcuttur.

Sabit sistemler boru hatlarının tamamen toprağa gömülüdür.

Yarı sabit sistemler ise boru bölümlerinden sadece ana boru hattının toprağa gömülü olduğu, lateral hatlarının sökülüp takılabildiği sistemlerdir.

Hareketli yağmurlama sistemleri ise sistemin tüm unsurlarının hareket eden bir mekanizmaya bağlı olduğu ve belirlenen alanda bağlı oldukları mekanizmayla hareket eden sulama sistemidir.

V. SONUÇ VE ÖNERİLER

Dünyada ve Türkiye'de son yıllarda tarımsal sulama yöntemlerinden basınçlı sulama yöntemlerine yönelim artmaktadır. Bunun en önemli nedeni, su kaynaklarının kıt olması ve buna ters orantılı olarak nüfusun sürekli artış göstermesidir. Ayrıca, hem dünyada hem de Türkiye'de toplam kullanılabilir suyun büyük bölümü tarım sektöründe kullanılmaktadır. Bu nedenle bu sektördeki suyu kullanırken tasarruf edici önlemler alınması gerekmektedir. Türkiye'de son yıllarda basınçlı sulama yöntemlerine ağırlık verilmektedir. Ancak, bu durum hâlâ istenilen ölçüde değildir. Bunun nedeni hem bu yöntemlerin ilk yatırım masraflarının yüksek olması ve üreticilerin bu konularda yeterli bilgi düzeyine sahip olmamasıdır.

Basınçlı sulama yöntemlerinin kullanılması sulama suyundan tasarruf etmekte yeterli değildir. Yöntemin bilimsel esaslara göre uygulanması ve verilen suyun kullanılan bitkinin sulama suyu ihtiyacına göre belirlenmesi gerekmektedir.

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Türkiye'de tarımsal sulama ve su potansiyeli

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Özet – İnsanlık tarihi yerleşik hayata geçtiğinden beri yerleşim yerlerini genellikle nehir kenarlarına kurulmuştur. Kurulan yerleşim yerlerinin tarımsal ve içme-kullanma amaçlı su ihtiyacı çoğunlukla bu nehirlerden sağlanmıştır. Ancak, bu suyun nehirden yerleşim yerine taşınması gerektiğinden su taşıma kanallarına ihtiyaç oluşmuştur. Dolayısıyla insanlık yerleşik yaşama geçtiğinden beri tarımsal sulama ve su taşıma şebekeleri vazgeçilmez bir unsuru oluşturmuştur. Türkiye su sıkıntısını önemli ölçüde yaşayan bir ülkedir. Gelecek yıllarda bu sorunun daha da artması beklenmektedir. Bu durumun önüne geçmek için tarımsal sulama amaçlı basınçlı sulama yöntemleri geliştirilmiştir. Ancak, basınçlı sulama yöntemleri; yüzeysel sulamaya göre yüksek randıman sağlasa da doğru bir şekilde uygulanmadığı taktirde fazla sayıda su kullanımına neden olur. Bu yüzden basınçlı sulama yöntemlerinin de uygulama sahasındaki bitkinin suda yararlanma oranıyla ilgili çalışmalara gereksinim duyulmaktadır. Bu çalışma Türkiye'deki sulu tarım uygulamaları ve su potansiyeli ile ilgili genel bir değerlendirmeyi kapsamaktadır. Ayrıca, DSİ tarafından sulamaya açılan tarım arazileri, sulama oranı, yıllık kullanılan yüzey suyu miktarı, yıllara göre düşen yağış miktarı ve sulama randımanı verileri kullanılarak tarım alanlarında kullanılan sulama suyu etkinliği ile ilgili genel bir değerlendirme yapılmıştır. Böylece Türkiye'de tarımsal sulamada kullanılan sulama suyu miktarının etkin kullanımı irdelenmiştir. Tarımsal sulamada, sulama suyu randımanı son yıllarda azda olsa artış göstermiştir.

Anahtar Kelime: İklim değişikliği, kuraklık, tarımsal sulama, su iletimi

Agricultural irrigation and water potential in Turkey

Abstract – Since human history began with settled life, settlements have generally been established along river banks. The water needs of the established settlements for agricultural and drinking purposes were mostly met from these rivers. However, since this water had to be transported from the river to the settlement, water transport channels were needed. Therefore, since humanity moved to settled life, agricultural irrigation and water transportation networks have become an indispensable element. Turkey is a country experiencing significant water shortage. This problem is expected to increase further in the coming years. To prevent this situation, pressurized irrigation methods have been developed for agricultural irrigation. However, pressurized irrigation methods; although it provides higher efficiency than surface irrigation, it causes excessive water usage if it is not applied correctly. Therefore, there is a need for studies on the water utilization rate of the plant in the application area of pressurized irrigation methods. This study covers a general evaluation of irrigated agriculture practices and water potential in Turkey. In addition, a general evaluation was made regarding the efficiency of irrigation water used in agricultural areas using data on agricultural lands opened to irrigation by DSI, irrigation rate, amount of surface water used annually, rainfall amount by year and irrigation efficiency. Thus, the effective use of the amount of irrigation water used in agricultural irrigation in Turkey was examined. In agricultural irrigation, irrigation water efficiency has increased slightly in recent years.

Keywords – Climate change, drought, agricultural irrigation, water transmission

I. GİRİŞ

İnsanlık tarihinde kurulan yerleşim yerlerinde, tarımsal sulama ile içme-kullanma amaçlı su ihtiyacı çoğunlukla akarsulardan sağlanmıştır. Yerleşim yerleri de akarsu gibi su kaynağına yakın yerlerde bulunmaktadır. Bu durumda suyun kaynağında alınıp yerleşim yerine iletilmesi gerektiğinden su taşıma kanallarına gereksinim olmuştur. Bundan dolayı, insanlık yerleşik yaşama geçtiğinden beri tarımsal sulama ile içme-kullanma amaçlı suyun iletilmesinde, su taşıma şebekeleri vazgeçilmez bir unsur olmuştur.

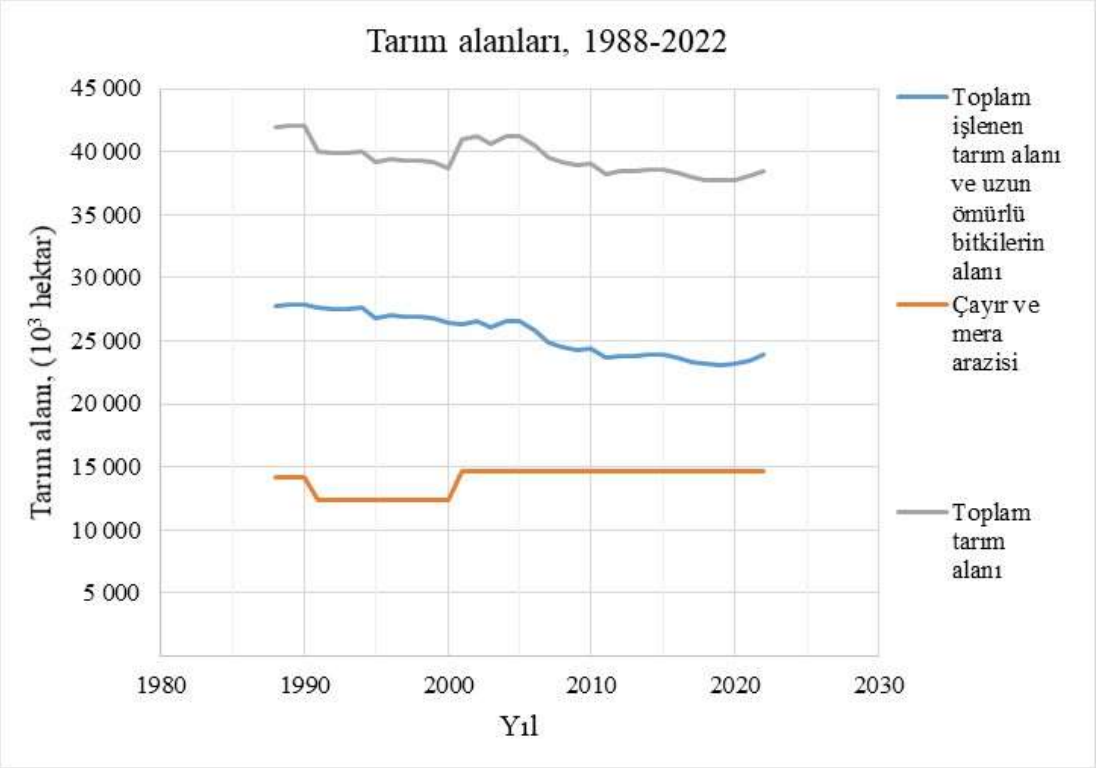
Tarımsal sulama ve içme-kullanma amaçlı yapılan su taşıma yapılarının tarihin farklı dönemlerinde birçok uygarlıkta örneği vardır. Örneğin; M.Ö. 1000 yılında Urartu uygarlığı tarım alanlarının sulanması için baraj, gölet, kanal gibi sulama tesisleri inşa ettikleri arkeollojik kazılarla saptanmıştır (Üzen ve Çetin, 2012; Ananymous, 2010a). Yine, M.Ö. 2000 yılında Girit adasında Knossos sarayında ters sifon olarak isimlendirilen sistemin kullanıldığı saptanmıştır. Bu sistemin su kemerlerine alternatif olarak vadileri aşmak için kullanıldığı anlaşılmıştır. Benzer şekilde, M.Ö. 200 yıllarında Bergama krallığı, kaynaktan aldığı suyun vadileri aşması için ters sifon yöntemini kullandığı tespit edilmiştir (Bildirici, 2002). Antik Roma döneminde Seleucia ad Calycadum kentinde su kaynağından kent merkezine kadar su ihtiyacının karşılanması amacıyla 8 km uzunluğunda su taşıma kanalı inşa edilmiştir (Karabekiroğlu ve Yalçın, 2022; Bildirici, 2009). Antik Mısır, anadolu topraklarında yaşamış Sümerler, Hititler gibi uygarlıklarda da benzer su taşıma yapıları, sulama yöntemleri görülmektedir.

Su taşıma yapılarıyla sulama yöntemleri tarih boyunca tarımsal sulama ve insanların genel ihtiyaçlarının karşılanması için gerekli olmuştur. Türkiye Cumhuriyeti'nin ilanından itibaren tarımsal sulama incelendiğinde; ilk yapılan projelerden olan Çubuk barajı inşaatı ile Ankara ve Bursa ovası sulamaya açılmıştır. Yine bu dönemlerde Bursa'da Gölbaşı barajı ve Niğde'de Gebere barajı inşaatı başlamıştır. Bu dönemde tarımsal sulama amaçlı birçok baraj, gölet ve sulama tesisleri yapılmıştır. Bu projeler 1950'li yıllardan sonra daha çok hız kazanmış ve daha kapsamlı hâle gelmiştir. Özellikle 1954 yılında Devlet Su İşleri Genel Müdürlüğü (DSİ) kurulduktan sonra Seyhan, Sarıyar, Kemer, Demirköprü ve Hirfanlı barajlarının inşaatı bitirilmiştir (Üzen ve Çetin, 2012). Türkiye'de uygulamaya sokulan en önemli sulama projeleri arasında Güney Anadolu Projesi (GAP) yer almaktadır. Bu proje toplam 9 ili kapsayan, Fırat ve Dicle nehirlerinden faydalanarak oluşturulan, barajlarla bölgede sulu tarımı yaygınlaştırıp ekonomiyi kalkındırmak amaçlanmıştır.

II. TÜRKİYE'DE SULU TARIM ARAZİLERİNİN ZAMANSAL DEĞİŞİMİ

Türkiye 78 milyon hektar yüz ölçümüne sahiptir. Bu alanın yaklaşık 28.05 milyon hektarı tarım arazisi olarak nitelendirilebilmektedir. Bunun 24 milyon hektarını işlenebilen tarım arazileri oluşturmaktadır. Bu tarım alanının geri kalanını ise çayır ve mera arazileri oluşturmaktadır. Türkiye İstatistik Kurumunun verilerinden faydalanarak, 1988 ile 2022 yılları arasında tarım arazilerindeki değişim Şekil 1'de verilmiştir (TÜİK, 2022).

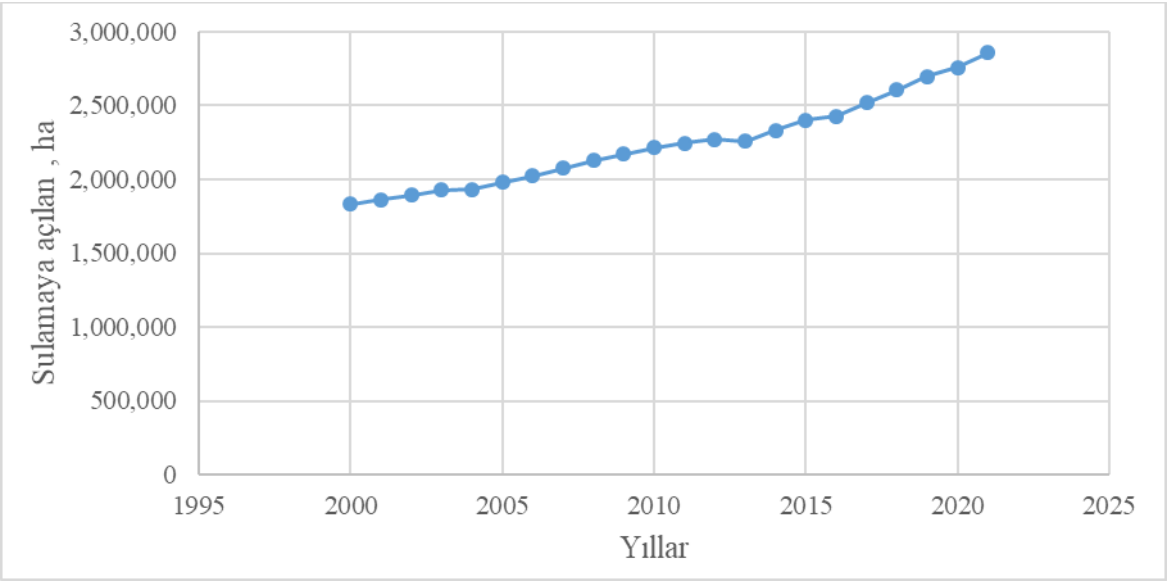
Şekil 1 incelediğinde; toplam tarım alanı, toplam işlenen tarım alanı yıllar geçtikçe azalma eğiliminde olduğu görülmektedir. Çayır ve mera arazilerinde ise önemli bir değişiklik yaşanmamıştır. İşlenebilir tarım arazileri 1989 yılında 28 milyon hektar iken, 2022 yılın 24 milyon hektara gerilemiştir. Dolayısıyla tarımsal işletmeciliğin yapıldığı araziler son 30 yılda yaklaşık %14 oranında azalma göstermiştir (TUİK, 2022). Bunun nedeni tarım arazilerinin yerleşime açılması, parçalı arazi yapısı veya köyden kente göç nedeniyle tarım arazilerinin boş bırakılması gibi etkenler gösterilebilir (Bayar, 2004).



Şekil 1. Türkiye'nin yıllara göre tarım alanlarının değişimi

Türkiye'nin toplam su potansiyeli; yerüstü ve yeraltı toplam net kullanılabilir su miktarı 112 milyar m^3'tür. Bunun 57 milyar m^3'ü kullanılabilir nitelikte olup bu suyun 44 milyar m^3'ü tarım sektöründe kullanılmaktadır. Buradan da görüldüğü gibi kullanılabilir su miktarı içerisinde en büyük payı (yaklaşık %77) tarım alanları oluşturmaktadır. Bu noktadan hareketle DSİ tarım alanlarında kullanılan suyun azaltılmasını hedeflemektedir (DSİ, 2022).

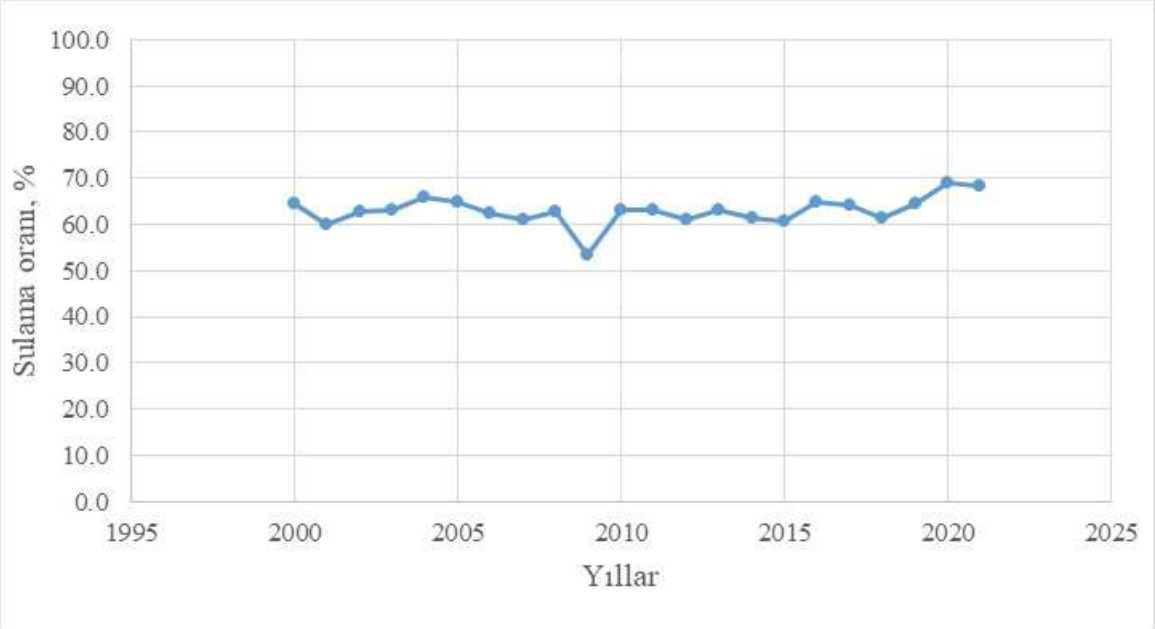
Türkiye'nin sulanabilir tarım arazileri değerlendirildiğinde, günümüzde 24 milyon hektar tarım arazisinin 8.5 milyon hektarı sulanabilecek nitelikte olup, 6.65 milyon hektarı sulamaya açılmıştır (DSİ, 2022). DSİ'nin sulamaya açtığı tarım arazileri Şekil 2'de verilmiştir.



Şekil 2. Yıllara göre DSİ tarafından sulamaya açılan tarım arazileri (DSİ, 2022)

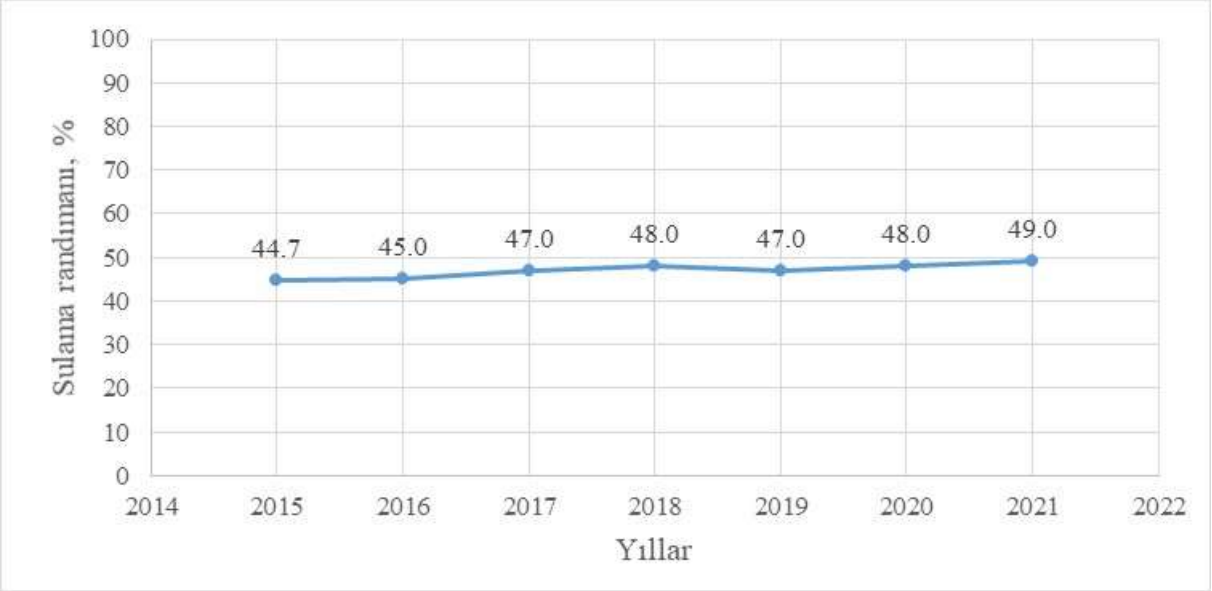
Şekil 2 incelediğin, 2021 yılında sulamaya açılan tarım arazisi 2000 yılında sulamaya açılan tarım arazisine göre %36 artış göstermiştir. Sulamaya açılan tarım arazilerinin artış hızlarını incelediğinde, 2000 ile 2015 yılları arasında sulamaya açılan tarım arazisi %23 artış göstermişken, 2021 ve 2015 yılları arasında %16 artış göstermiştir. Dolayısıyla söz konusu yıllar arasında son 6 yıllık periyotta sulamaya açılan tarım arazileri önemli ölçüde artış göstermiştir. DSİ'ce sulamaya açılan bu tarım arazileri DSİ tarafından tarife uygulanan ve DSİ tarafından inşa edilen ve çeşitli kuruluşlara devredilen sulama alanlarının toplamından oluşmaktadır.

DSİ'nin istatiksel raporlarından sulama oranları incelendiğinde, sulamaya açılan alanların yıllara göre yaklaşık %60'nın sulanabildiği görülmektedir (DSİ, 2022). Yıllara göre sulama oranı değişimi Şekil 3'te görülebilir.



Şekil 3. DSİ tarafından işletilen veya devredilen sulamaların yıllara göre sulama oranı değişimi (DSİ, 2022).

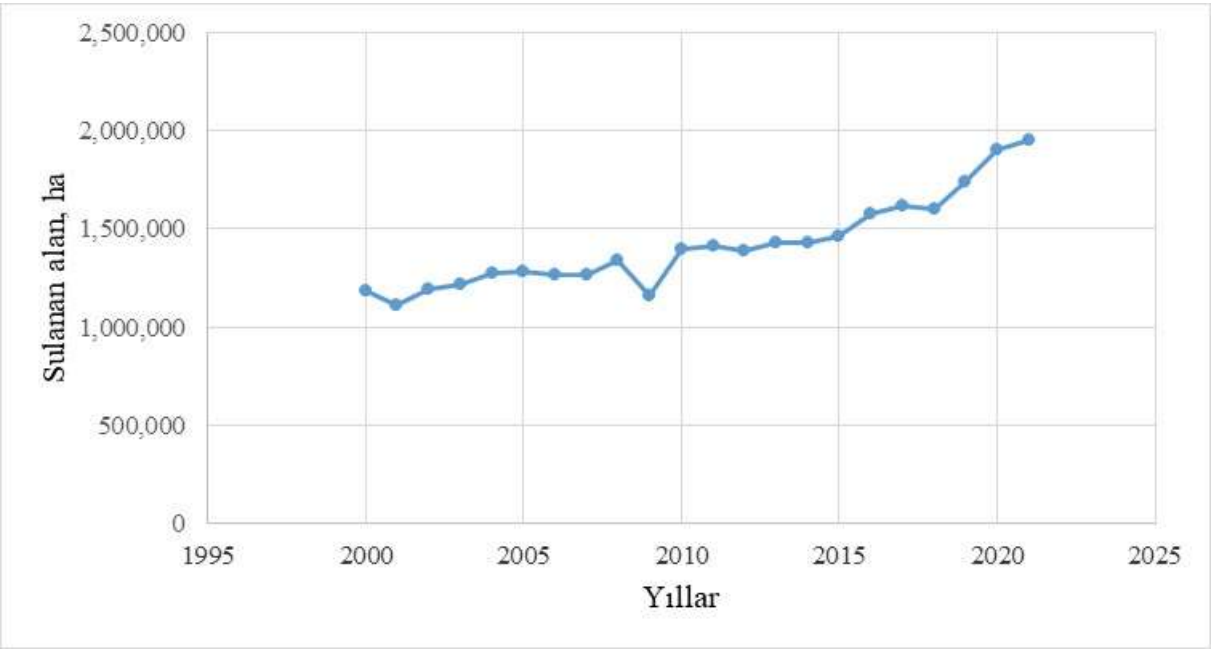
DSİ işletmelerince açılan sahada sulama randımanları Şekil 4'de verilmiştir. Şekil 4 incelendiğinde sulama randımanının yıllara göre artış gösterdiği görülmektedir. Özellikle 2015 ve 2021 yıllarını kıyasladığı zaman, sulama randımanının yaklaşık %9 civarında artış gösterdiği görülmektedir. Bu durum bitkinin sudan yararlanma oranını nispeten arttıracak önlemlerin alındığı değerlendirmesi yapılabilir. DSİ 2021 yılı faaliyet raporu incelendiğinde sulama alanlarında, sulama randımanı %49 olarak saptanmıştır. DSİ tarafından bu değerin sonraki yıllarda %50 seviyesine çıkartılması planlanmıştır (DSİ, 2022).



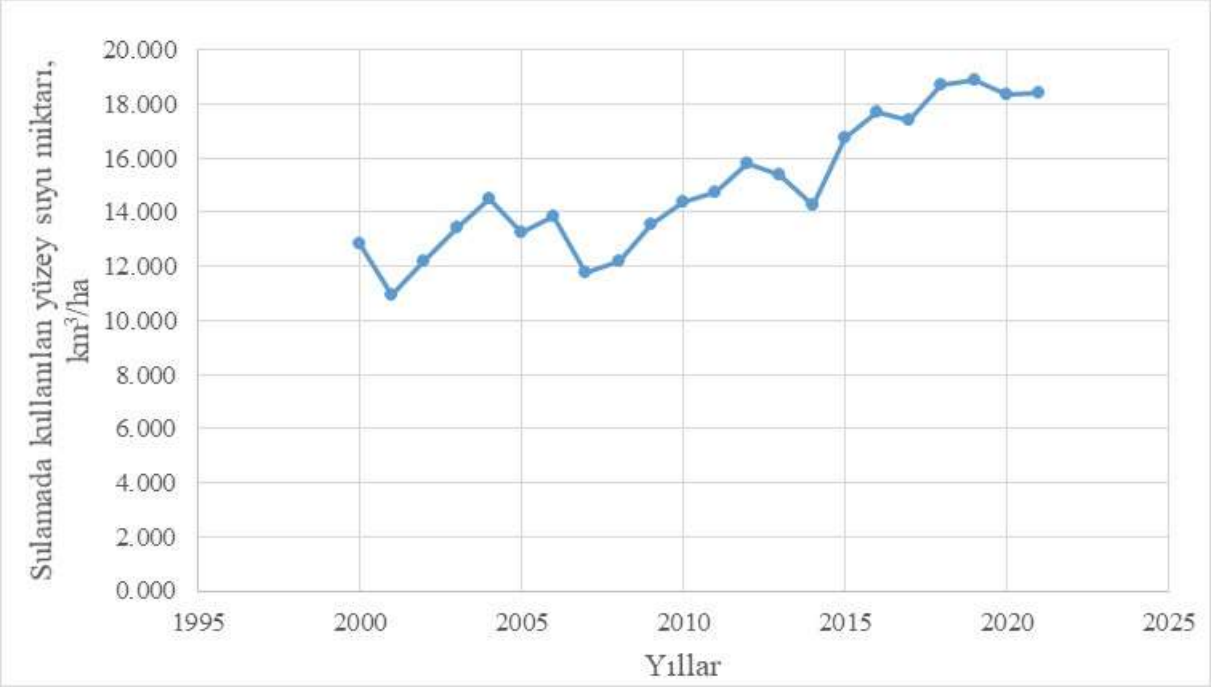
Şekil 4. DSİ'ce İşletilen veya devredilen sulama tesislerinin yıllara göre ortalama sulama randımanı (DSİ, 2022)

DSİ tarafından sulamaya açılan tarım arazileri içerisinde sulanan alanı incelediğin (Şekil 5), 2000 yılından, 2021 yılına kadar sulanan tarım arazilerinde %43'lük bir artış gözlemlenmektedir. Özellikle 2015 ile 2021 yılları arasında %25 oranında bir artış gözlemlenmiştir. Şekil 6'da belirtilen yıllara göre tarım alanlarında sulama için kullanılan yüzey suyu miktarı değişiklik göstermiştir. Meteoroloji genel müdürlüğünün yayınladığı uzun yıllık yağış grafiği (Şekil 7) incelendiğinde son yıllarda yağış miktarında düşüş gözlemlenmektedir (MGM, 2023). Bu durum birim alana uygulanan sulama suyu miktarını doğrudan etkilemektedir.

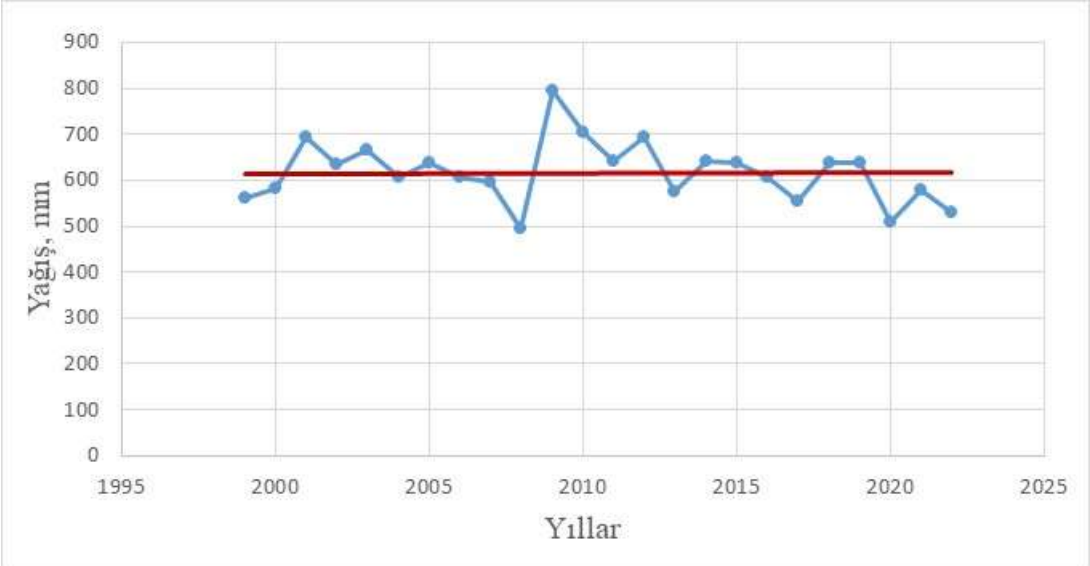
Yıllık yağış miktarı grafiği (Şekil 7) ve sulama için kullanılan yüzey suyu miktarı (Şekil 6) incelendiğinde yıllık toplam yağışlar 600 mm'nin altına düştüğü yıllarda yüzey suyundan yararlanıldığı sulama suyu miktarlarında bir sonraki yılda düşüş gözlemlenmiştir. Bu durum düşüş gözlemlenen yağış miktarıyla yüzey suyu arasında bir orantı olduğunu göstermektedir.



Şekil 5. DSİ işletmeleri tarafından yıllara göre sulanan alan (DSİ, 2022)



Şekil 6. DSİ tarafından işletmeye açılmış sulama sahalarında yıllara göre kullanılan yüzey suyu miktarı

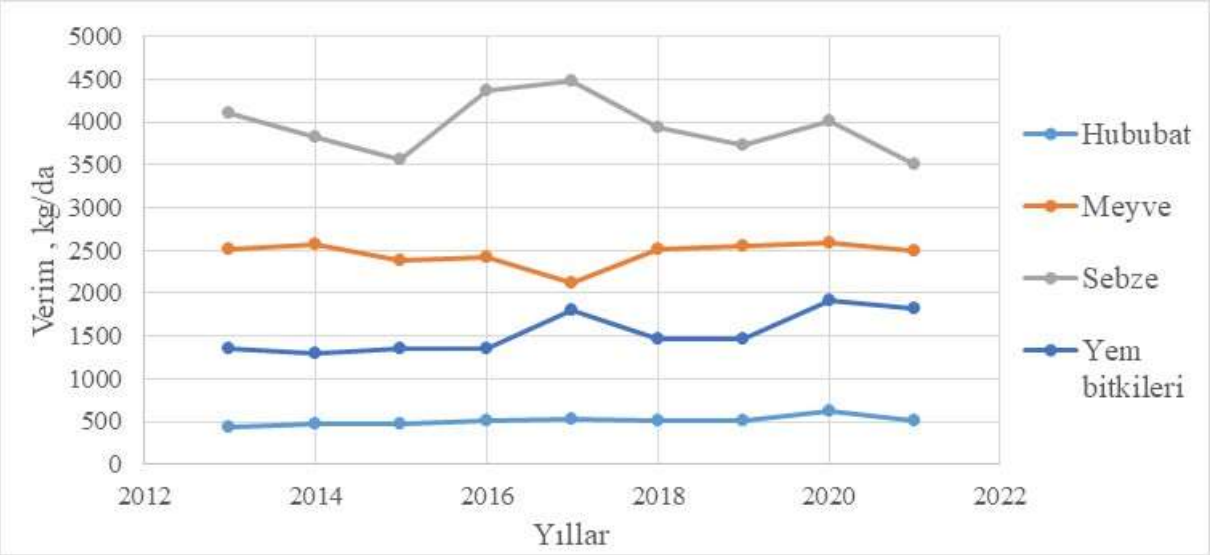


Şekil 7. Türkiye'nin yıllara göre yağış miktarının değişimi (MGM, 2023)

Şekil 7 incelediği zaman, birim alana düşen su miktarının değişkenlik gösterdiği görülmektedir. 2000 yılından 2021 yılına kadar yaklaşık %30'luk bir azalma meydana gelmiştir. Bunun en büyük nedeni Şekil 7'de belirtildiği gibi yıllık düşen yağış miktarıyla doğrudan orantılıdır. Verilen iki şeklide incelediğinde, yağış miktarının düştüğü yıl birim alana düşen sulama suyunda da düşüşler gözlemlenmektedir. Özellikle son yıllarda yıllık düşen yağış miktarının 600 mm'nin altına düşmesiyle birim alana düşen su miktarında önemli ölçüde azalmalar gözlemlenmiştir.

DSİ (2022) verilerine göre hububat, meyve, yem bitkisi ve sebze gruplarının verim değerleri incelendiğinde 2013 ve 2021 yılları arasında bu ürün gruplarının büyük çoğunluğunda verim değerlerinde

önem düzeyde bir değişiklik olmadığı gözlemlenmiştir. Şekil 8 incelediğinde sebze gruplarının verim dağılımı düzensiz şekilde gerçekleşmiştir.



Şekil 8. Türkiye genelinde DSİ'nin açmış olduğu sulama alanlarında yetiştiriciliği yapılan bitki gruplarının verim değerleri (DSİ, 2022).

Verilen şekiller genel olarak incelediğinde, tarım arazilerinde yıllar içerisinde genel olarak bir azalma söz konusudur. Ayrıca, özellikle 2015 ve 2021 yılları arasında toplam düşen yağış değeri 600 mm'nin altına gözlemlenmektedir. Aynı zamanda da birim alana uygulanan sulama amaçlı yüzey suyu miktarında da azalmalar saptanmıştır. Ancak, 2015 -2021 yılları arasında sulamaya açılan alan oranında ciddi bir artış söz konusudur. Aynı zamanda sulama açılan alanın sulanma oranı da yaklaşık %60 civarında olduğu saptanmıştır. Bu bilgiler değerlendirilecek olursa; tarım alanı, yağış ve sulama amaçlı birim alana uygulanan yüzey suyu düşüşüne rağmen, sulamaya açılan alanda artış söz konusudur. Bu durumu sulama randımanında bir artış olduğunu göstermektedir. Bu noktadan hareketle Şekil 4 incelediğinde, DSİ'ce işletilen veya devredilen sulama tesislerinin yıllara göre ortalama sulama randımanında 2013 – 2015 yılları arasında bir artış yaşandığını gözlemlenmektedir. Şekil 8'deki bazı bitki türlerinin verim değerlerini incelediğinde verim değerlerinin, kullanılan türlere göre değişkenlik gösterdiği görülmektedir. Ancak, tüm bu verilen bilgilerin daha sağlık bir değerlendirme yapabilmesi için en azından sulanan ve ekonomik değeri yüksek bitkilerin verilen sulama suyundan yararlanma oranları ve bu bitkilerin sulama yöntemi belirtilirse sulama randımanı veya tarım alanlarındaki sudan tasarrufun gerçekten edilip edilmediği noktasında daha detaylı bir değerlendirme yapılabilir.

III. SONUÇ VE ÖNERİLER

Türkiye üç tarafı denizlerle çevrili olmasına rağmen su azlığı çeken ülkeler kategorisine girmektedir. Nüfusun artmasıyla birlikte iklim değişikliklerinin olumsuz etkilerini göz önüne aldığında, ilerleyen yıllarda su kıtlığı çeken ülkeler arasına girme tehlikesi bulunmaktadır (DSİ, 2020).

Türkiye'nin toplam kullanılabilir su potansiyelinin yaklaşık %77'si tarım alanlarında kullanılmaktadır (DSİ, 2020). Bu nedenle tarım alanlarında kullanılan bu suyun etkin kullanılması gerekmektedir. Türkiye'nin tarım alanları, iklimi ve sulama uygulamaları incelediğinde, tarım alanları yıldan yıla azalış göstermektedir. Ancak, DSİ tarafından açılan sulama işletmelerinde artış görülmektedir. Bu durum tarım alanları azalış göstermiş olsa da, sulamaya önem verildiğini göstermektedir.

MGM (2022)'nin belirttiği verilere göre Türkiye'nin yağış miktarı son üç senedir 600 mm'nin altında yer almaktadır. Buna paralel olarak son yıllarda, sulama amaçlı kullanılan yüzey suyu miktarında da azalışlar görülmektedir. Bu durum sulama yönetiminin iyi yapılması gerektiğini bize göstermektedir.

Bu bilgiler ışığında genel olarak bir değerlendirme yapılacak olursa; Türkiye'de yağış rejiminde azalma, buna paralel olarak yüzey suyu miktarında da azalmalar görülmektedir. Tarım alanlarında azalmalar söz konusudur. Ancak, buna rağmen sulamaya açılan alanlarda artış görülmektedir. Bitkinin sudan yararlanma oranının arttığını bize göstermektedir.

DSİ (2022)'nin verim değerleri alınan bitkilerin yıllar içerisinde çok büyük değişiklikler meydana gelmediği, bunun basınçlı sulama yöntemlerinin ve sistemlerinin yaygınlaşması olarak gösterilebilir. Bunu nedeni sulamaya açılıp sulanan tarım alanlarında sulama randımanının yükselişte olduğu olarak görülmektedir.

DSİ'nin açtığı sulama işletmelerinde yıllara göre sulanan alan oranı %60 civarındadır. Aynı şekilde, sulanan alanların sulama suyu randımanı da son yıllarda azda olsa artış göstermektedir. Son yıllarda yağışların düşmesiyle paralel olarak yüzey suyu miktarında da belirli ölçüde düşüşler meydana gelmektedir. Bu durumun aşılması açısından daha az su kullanılan sulama yöntemleri tercih edilmelidir.

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Effect of ZrB_2 and Nd_2O_3 Ceramic Additives on Electrical Properties of Pure Copper

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Abstract **–**In this study, composites structures were obtained by reinforcing two different ceramic properties into 99.9% commercial purity copper (Cu). It is aimed to investigate the electrical resistivity and conductivity behaviours of these composites. For this purpose, ZrB_2 and $Nd2O_3$ particles, one boride and the other oxide ceramic, were added. Composites were doped separately at 5%, 10% and 20% weight ratios by powder metallurgy method and 6 different copper based composite materials were produced. Electrical resistivity of the composite samples were measured and conductivity values were calculated. According to the measurement results, it is seen that the electrical conductivity values increase slightly when ZrB_2 and Nd_2O_3 additives are added. Changes in conductivity values were examined as the doping ratios increased. In general, it was observed that resistivity values decreased and conductivity values increased with the addition of additives.

Keywords – Copper, ZrB2, Nd2O3, Powder metallurgy, Composite, Electrical property

I. INTRODUCTİON

Copper and its alloys are materials with good electrical and thermal resistance, high corrosion and oxidation resistance. However, despite these properties, they are not preferred much due to their poor tribological and mechanical properties. Due to these disadvantages, Cu matrix alloys are produced by adding various reinforcing elements into Cu. The resulting Cu matrix composites stand out among structural materials with their high thermal and electrical properties as well as their superior mechanical and tribological properties [3]. Composite structures containing Cu can be successfully produced by many different methods such as spark plasma sintering method [4], displacement reactions method [5], mechanical alloying and hot pressing [6], powder metallurgy [7] etc. When the studies carried out are examined, additives such as SiC, Al_2O_3, graphene, B4C, W, fly ash in the form of ceramic, metallic and industrial waste were reinforced into the Cu matrix. It is aimed to improve the physical, electrical-thermal and mechanical properties of these composite structures [6,7,8].

In recent years, studies on the reinforcement of rare earth elements in composite structures have been included in the literature. Vinci et al. reported the effects of rare earth oxides Y_2O_3, La_2O_3 and CeO_2 on metal matrix composites [9]. In another study, Lu et al. investigated the effects of TiB + TiC + Nd_2O_3 ceramics in Ti based composite structures by powder metallurgy method [10]. Due to their hard and thermally stable structure, rare rare earth oxides are reported to be homogeneously dispersed in the titanium matrix and improve the thermal stability and mechanical properties of titanium matrix metal composites [11-12].

Oxides of rare earth elements have high thermodynamic stability and thermal expansion coefficients. Thus, they can be used as dispersion reinforcement phases and secondary phases to reinforce metal matrices. Due to these properties, they improve the mechanical properties of composite structures. In addition, since they have larger atomic radii than other metal oxides, they have lower solubility and diffusion rates in the matrix. This leads to high strength and high thermal and electrical conductivity. Since some rare earth oxides are P-type conductors, their reinforcement into copper alloys or copper matrix composites such as Y_2O_3 has been reported to significantly improve the electrical properties of composites [13-19].

In this study, different ratios of ZrB_2 and Nd_2O_3 ceramics were reinforced into pure Cu by powder metallurgy method. The electrical properties of the composite structures produced after homogeneous mixing, pressing and sintering were investigated.

II. MATERIALS AND METHOD

In this study, 99.9% commercial purity copper powder with a particle size of 325 mesh was used as the matrix material. ZrB_2 and Nd_2O_3 powders were used as additives.

In the production of copper based and ceramic doped composite materials, ZrB_2 and Nd_2O_3 particles in the determined weight ratios were weighed and mixed into Cu. The mixing process was carried out in a rotary drum mechanical mixer for 2 hours at a speed of 250 rpm by placing a steel ball at a rate of 10 times the weight of the powder mixtures in the mixing container. Then the powder mixtures were pressed with a compression pressure of 700 MPa and 14 mm diameter test specimens were obtained. The powder metallurgy production process was completed by sintering the obtained compact samples at 950 □C temperature for 90 min. Digital microscope images of the Cu based ZrB_2 and Nd_2O_3 based composite samples and their microstructures are given in Figure 1.

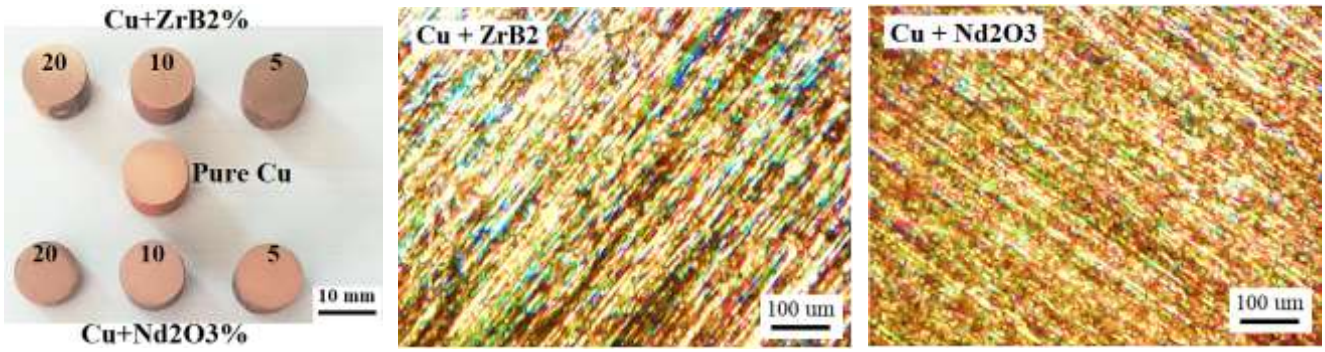

Fig. 1 Cu-based ZrB_2 and Nd_2O_3 doped composite samples and internal structure images of composites

In the second part of the study, resistivity measurements were performed to determine the electrical properties of Cu based composite structures. KEITHLEY 2430 brand device was used in the measurements. 2-probe conductivity measurement method was used for electrical conductivity measurements. This measurement method is based on Kirchoff ohm law. According to this law, when voltage is applied to a sample, a current flows through it. According to this current value, the resistance value of the material is found. In the measurement based on this principle, a voltage of 4V was applied to the samples. Then the current flowing through the material under this voltage was measured. According to the current value found, the resistance value of the material was calculated. The electrical resistivity values of the material were calculated from the resistance values found. While finding the resistivity values, the cross-sectional area and length of the material were taken into consideration. Changes in these values will affect the resistance value. After finding the electrical resistivity, the electrical conductivity value was calculated.

III. RESULTS AND DISCUSSION

Electrical measurements of Cu based Nd_2O_3 and ZrB_2 doped composite samples are given in Figure 2 and Figure 3.

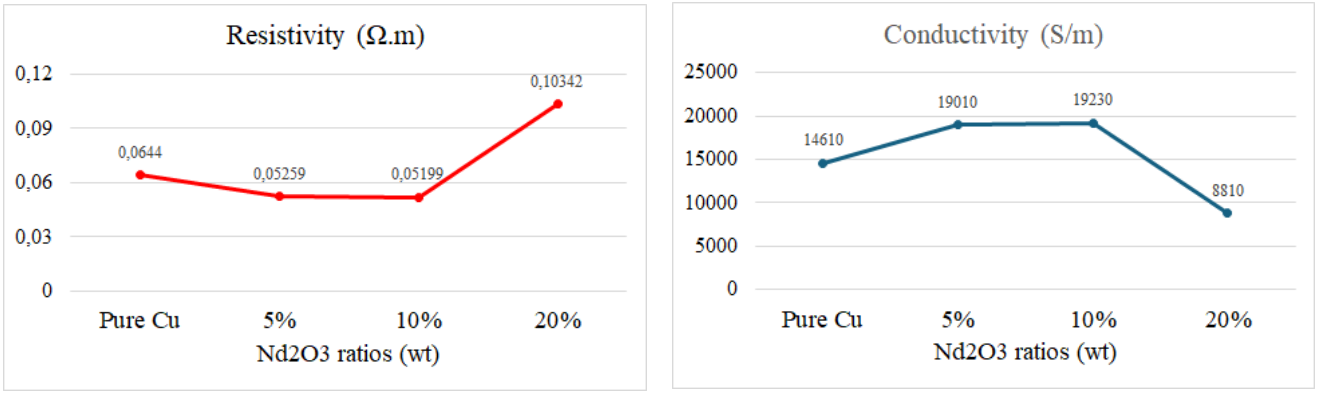

Fig. 2 Nd2O3 katkılı kompozitlerin elektriksel özdirenç ve iletkenlikleri

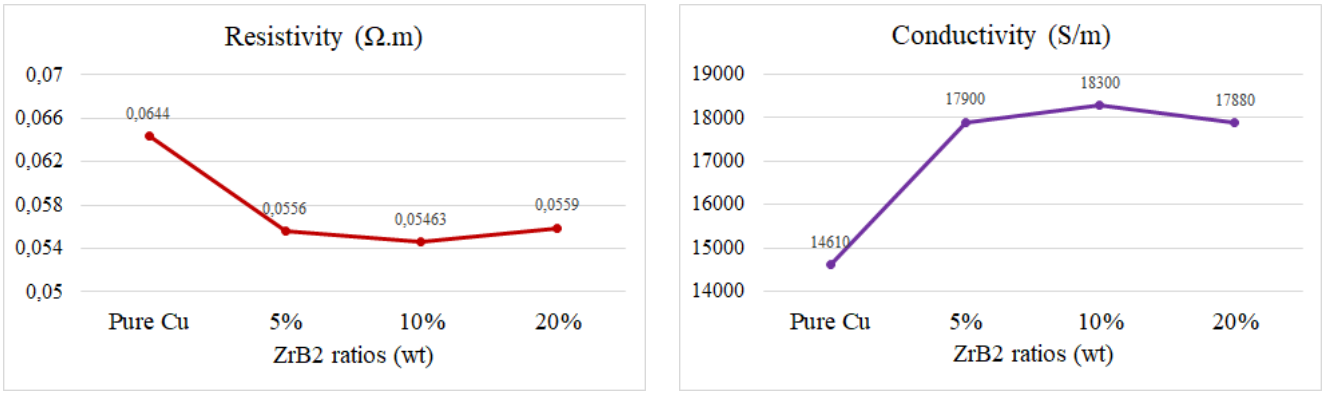

Fig. 3 Electrical resistivity and conductivity of ZrB_2 doped composites

When the graphs in Figure 2 are analysed, it is seen that the electrical conductivity decreases as the additive increases. When 5% and 10% Nd_2O_3 doping was added, the electrical conductivity and resistivity values of the material did not change much. When 20% Nd_2O_3 doping was added, the conductivity value was noticeably affected. The increase in the doping ratio allowed Nd_2O_3 to penetrate more into the copper. Thus, the good conductivity values of copper decreased. While electron flow on copper became more comfortable, Nd_2O_3 showed an insulating property. Thus, the electrical resistivity value increased and the conductivity value decreased [20].

When the graphs in Figure 3 are examined, it is seen that the electrical conductivity increases as ZrB_2 increases. When ZrB_2 is added at 5% and 10%, it is seen that the electrical conductivity increases and the resistivity value decreases. As ZrB_2 is added, it is seen that the copper contacts each other more and the electrons move freely. This situation caused the conductivity to increase. When the additive is 20%, this ratio in the material has reached the saturation point. The conductivity value did not increase further and a conductivity value close to the 10% additive ratio was found [21]. In order to evaluate the two different additives used in the study together, the graphs in Figure 4 are given.

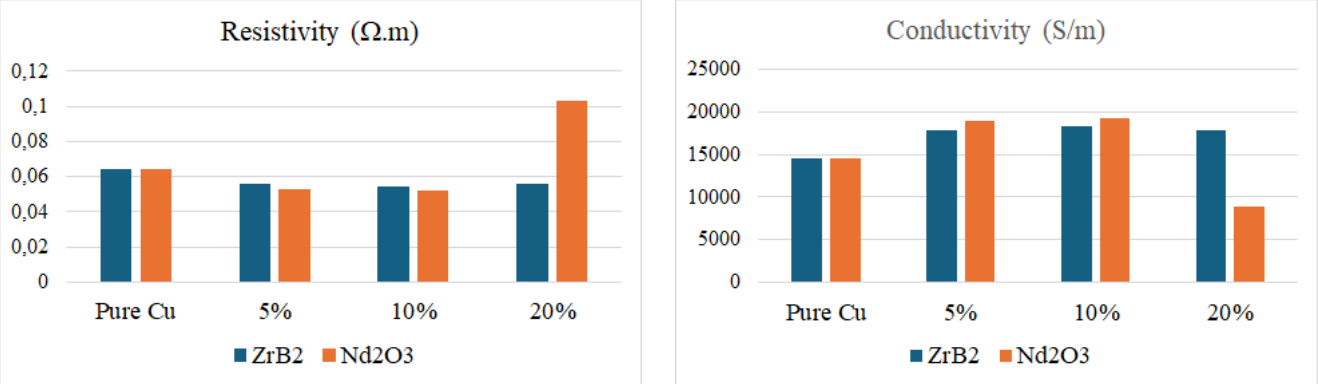

Fig. 4 Comparison of electrical resistivity and conductivity of Nd_2O_3 and ZrB_2 doped composites

When Figure 4 is analysed, it is seen that the electrical conductivity values increase slightly when 5% and 10% ZrB_2 and Nd_2O_3 additives are added. When 20% of ZrB_2 was added, the electrical conductivity of ZrB2 increased and the electrical conductivity of Nd_2O_3 decreased. In this case, Nd_2O_3 negatively affected the electrical conductivity. The reason for this is that the material forms an insulating layer in copper. ZrB_2, on the other hand, did not adversely affect the conductivity too much because it reached a saturation in the material.

IV. CONCLUSION

In this study, 6 different copper based composite materials were produced by doping ZrB_2 and Nd_2O_3 particles into 99.9% commercial purity copper (Cu) at 5%, 10% and 20% weight ratios separately by powder metallurgy method. The electrical conductivity and resistivity values of the new composites formed as a result of this production were compared. When Nd_2O_3 additives were added at 5% and 10%, the electrical conductivity and resistivity values of the material did not change much. When Nd_2O_3 additive was added at 20%, the conductivity value was noticeably affected. When ZrB_2 dopant was added at the rates of 5% and 10%, it is seen that the electrical conductivity increased and the resistivity value decreased. As the additive is added, it is seen that the copper contacts each other more and the electrons move freely. This situation caused the conductivity to increase.

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The Brief Review of Data Imputation Methods in The Presence of Missing Observations

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Abstract – In biological studies, missing data is a common issue that complicates statistical analyses. Despite this challenge, the goal is to draw accurate conclusions about a specific population. Initially, parametric models were used to handle missing data, but recently, non-parametric and semi-parametric methods have gained attention. These methods help address the limitations of parametric models by allowing the data to guide model selection. While non-parametric methods may not always be as efficient as parametric ones, assuming an incorrect model can lead to misleading conclusions. Therefore, it is crucial to carefully evaluate the chosen model to ensure accurate data interpretation and avoid errors. In this mini review, data assignment methods in the presence of missing observations will be briefly discussed.

Keywords – Missing Observations, Data Imputation, MCAR, MNAR.

I. INTRODUCTION

In the field of biological studies, which encompasses epidemiological, genetic, and breeding studies, researchers often encounter situations where observations are missing, presenting a common challenge that can complicate statistical analyses. Despite the occurrence of missing data, the fundamental objective of statistical analysis remains unchanged: to draw accurate and efficient conclusions about a specific population of interest. The presence of missing values introduces a layer of complexity to the analytical process, particularly in the initial phases where addressing missing data involves the application of parametric models, as demonstrated in the seminal works of Afifi and Elsahoff in 1966 and Ibrahim in 1990. Nonetheless, there has been a noticeable trend towards the adoption of non-parametric and semi-parametric methodologies in order to mitigate the limitations imposed by the assumptions inherent in parametric models.

The utilization of nonparametric and semi-parametric modeling techniques is subject to differing viewpoints within the research community. Silverman (1985) argues that an initial nonparametric estimation may propose a suitable parametric model, such as linear regression, while allowing the data to play a role in the model selection process. Conversely, Box (1980) presents an alternative perspective, asserting that established facts or data form the foundation for a preliminary model, which then guides the analysis and may trigger a cycle of model enhancement driven by data-derived insights, facilitating the acquisition of further data. This iterative approach underscores the complementary relationship between non-parametric methods in identifying appropriate parametric models, as evidenced in the works of Hastie and Tibshirani in 1987, Simonoff in 1996, and Hart in 1997.

Overall, non-parametric and semi-parametric methodologies may not demonstrate the same efficacy as model-based strategies when a specific model is presumed and deemed suitable. However, if the assumed model does not align with the underlying data generation process, the resulting conclusions could be misleading and potentially detrimental to the data interpretation. This underscores the critical importance of rigorously evaluating the suitability of the selected model in statistical analysis to prevent erroneous deductions and misinterpretations.

Missing Data Approach

In real datasets, it is quite common to have observations with missing values for one or more input features. The first issue in dealing with this problem is to determine whether the missing data mechanism distorts the observed data. If missing data are not handled correctly, missing data can pose serious problems for statistical analysis (Collins et al., 2001). Little and Rubin (1987) and Rubin (1987) basically distinguish between three missing data mechanisms.

The Missing Data Mechanisms

Missing Completely at Random, MCAR, denotes a situation in which there exists no discernible connection between the occurrence of missing data and any values within the dataset, whether they are observed or missing. In this scenario, the missing data points are essentially a random subset of the overall data, with no underlying systematic pattern that would render certain data more susceptible to being missing compared to others. This lack of relationship ensures that the missingness is purely by chance and not influenced by any specific variables or characteristics.

Within the realm of Missing at Random, MAR, a different scenario unfolds where a systematic link is present between the likelihood of data being missing and the observed values within the dataset, excluding the missing data. This implies that while the missing data displays a certain pattern in relation to the observed data, there is no direct association with the missing values themselves.

The determination of whether an observation is missing hinges not on the nature of the missing values themselves, but rather on the attributes of the individual's observed variables. For instance, in a situation where men exhibit a higher probability of disclosing their weight compared to women, the variable of weight would fall under the Missing at Random category.

On the other end of the spectrum lies Missing Not at Random, MNAR, where a clear relationship emerges between the likelihood of a value being missing and the actual values it represents. This type of scenario may manifest when individuals with lower levels of education are absent from the education data, or when the most ill participants are more inclined to withdraw from the study, thereby affecting the dataset.

MNAR, or "non-ignorable" missing data, necessitates a modeling of the missing data mechanism itself as part of the data analysis. In such cases, a model must be constructed to account for why the data is missing and to predict the likely values that are absent within the dataset.

The classifications of "Missing Completely at Random" and "Missing at Random" both fall under the category of 'ignorable', as they do not require any specific information about the missing data to be incorporated during the data analysis process. This distinction highlights the importance of understanding the nature of missing data mechanisms in order to appropriately address them during data analysis.

Most procedures designed to address missing data exhibit robust performance in cases where missing values conform to the Missing Completely at Random (MCAR) pattern, although only a limited number of techniques have demonstrated effectiveness in handling Missing Not at Random (MNAR) values to a

satisfactory degree, as noted by Schafer and Graham (2002). Generally speaking, the strategies employed to manage missing values presuppose one of these distinctive missing-data mechanisms and are selected by scholars based on their interpretation of the mechanism at play in the dataset.

A. Missing observation imputation methods

Some of the most widely used strategies employed in addressing missing data instances encompass mean substitution (MS), listwise deletion (LD), pairwise deletion (PD), multiple imputation (MI), maximum likelihood (ML), pattern mixture models (PMM), and selection models (SM). Furthermore, an alternative method known as random forest analysis (RF) is also utilized for managing missing values and has experienced a surge in popularity in recent times. The examination of the principles, assumptions, as well as the advantages and disadvantages associated with these methodologies will constitute the primary focus of the forthcoming investigation.

A.1. Ad-hoc methos

Mean Substitution (MS)

In the technique known as mean substitution (MS), which stands as one of the most rudimentary approaches for addressing missing data, the strategy involves replacing the missing values in the target variable y with the mean value derived from the observed y values. Consequently, this process leads to the creation of a comprehensive dataset encompassing all necessary information. The fundamental assumption underlying the application of MS is that the missing values adhere to the Missing Completely at Random (MCAR) pattern. However, it is essential to note that even when this assumption holds true, the utilization of MS may yield inaccurate estimates for various statistical parameters. Nevertheless, in cases where the missing data indeed follow a MCAR pattern, there exists no discernible systematic distinction between missing and observed data points. Following this method for each variable, the act of substitution ensures that the mean of the missing values aligns with the mean derived from the completed dataset. The merits associated with employing mean substitution are manifold, encompassing its straightforward nature, ease of implementation, and facilitation of comprehensive data analysis resulting in the formation of a complete dataset. Nonetheless, it is crucial to acknowledge that by assigning identical mean values to all individuals with missing data pertaining to the variable of interest, there is a tendency for the data points to cluster around the central value. Consequently, this clustering phenomenon leads to a reduction in the variance observed in the completed dataset compared to the actual variance as outlined by Little and Rubin in 1987. Furthermore, the utilization of mean substitution also induces a reduction in covariance and correlation values in tandem with the decrease in variance, ultimately introducing bias into parameter estimates even when assuming a scenario of completely random data loss. This bias becomes more pronounced as the extent of data loss within the dataset escalates. Scholars such as Enders (2010) and Pigott (2001) caution against the indiscriminate use of mean value assignment technique under any circumstances.

Listwise Deletion (LD)

List-wise deletion is a method based on deletion which involves the complete removal of all observations pertaining to an individual who has missing data within a dataset. The fundamental assumption underlying List-wise deletion is that the missing values follow the Missing Completely At Random (MCAR) pattern. When data is MCAR, the complete cases are considered to be an accurate representation of the population distribution, leading to unbiased inferences that can be calculated from them. Furthermore, this method is advantageous as it is relatively straightforward to execute, resulting in a dataset that is entirely filled with data and retains the variability initially present in the population. However, a drawback of List-wise deletion is that it can lead to a significant reduction in the sample size, subsequently diminishing the statistical power available for analysis.

Pairwise deletion (PD)

In this method, where missing values are assumed to be MCAR in PD as in LD, observed data pairs are taken into account in obtaining descriptive statistics such as mean and standard deviation and measures of association such as correlation and covariance. It is a more robust alternative to LD and produces unbiased estimates for various parameter types under MCAR. However, it poses a problem in multivariate statistical analyses when the correlation and covariance matrices are positive definite.

A.2. Principled methods

Multiple imputation

In the Multiple imputation (MI) approach, which is more sophisticated than the methods mentioned above, missing values in the dataset are replaced by two or more values, i.e. missing values are imputed m times, resulting in m complete datasets. Each of the m datasets contains different possible values for the missing observations, reflecting the uncertainty of the missing values. Statistical analyses are performed on each of the datasets separately and then the results are combined according to a set of pooling rules (Harel, 2009; Li et al., 1991; Rubin, 1987). In the imputation step, the Bayesian framework and Markov Chain Monte Carlo (MCMC) approaches are mostly used. An advantage of MI is that it yields complete datasets that are easy to analyze. A disadvantage of MI is that a misspecified imputation model can lead to overestimated variances (Little & Rubin, 2020; Raghunathan & Rubin, 1998). Another disadvantage is that distribution violations can lead to inconsistent standard errors of the resulting parameter estimates (Yuan et al., 2012).

Maximum likelihood

This methodology employs the expectation-maximization (EM) algorithm, a widely-used approach that aims to maximize the likelihood of the data for the purpose of estimating population parameters. Within the framework of the expectation-maximization algorithm, the expectation phase involves the estimation of missing values through a regression model that relies on the available data, followed by the maximization phase where the regression model is recalibrated using the entire data set, with these two steps recurring iteratively (Enders, 2010). One of the strengths of Maximum Likelihood estimation through the EM algorithm is its ability to offer consistent estimates of parameters. Nevertheless, a limitation of this technique is its provision of solely summary statistics without the capacity to impute individual values.

Random forest

The Random Forest technique is considered a novel machine learning approach utilized for the prediction of missing data points, particularly in classification tasks. Comprising multiple regression trees, this method in Random Forest (RF) enables the derivation of sample weights to assign greater importance to instances with higher probabilities of missing values. By employing a weighted average of these missing instances, a comprehensive dataset can be reconstructed (Breiman, 2003). Notably, this non-parametric strategy operates independent of any underlying assumptions. Due to the aggregation of numerous trees, RF does not yield a singular interpretable tree representation elucidating the loss estimation process.

Pattern-mixture models and selection models

Pattern mixture models (PMM) and selection models (SM) are methodologies used in situations involving non-random (MNAR) data. Given the presence of this non-negligible missing data mechanism, statistical inferences require reliance on the full likelihood, derived from the joint distribution of the observed data Y and the missing data mechanism, denoted as M. The main benefit of using PMM and SM lies in their ability to handle MNAR data. However, achieving this requires making additional untestable assumptions about the missing data process - a notable drawback of these approaches. Unfortunately, the practical application

of PMM and SM can be significantly affected by violations of these assumptions (Enders, 2011). Our empirical observations suggest that the accuracy of parameter estimates may not be optimal even under conditions of valid assumptions. This discrepancy arises because the estimated values of unobserved missing data parameters can deviate significantly from their true values in cases where a correct joint distribution is specified.

II. CONCLUSION

The main conclusions of the study should be summarized in a short Conclusions section. Missing data are frequently encountered in the realm of biological research, and if not appropriately addressed, they have the potential to diminish the statistical power of analyses and introduce a risk of producing results that are biased. The primary objective of this scholarly article was to offer a comprehensive elucidation on the operational mechanisms of imputation, aiming to enhance comprehension among researchers and foster collaboration between statisticians, ultimately paving the way for successful data analysis endeavors.

Within the scope of this investigation, various imputation techniques for addressing missing data points within datasets are meticulously examined, accompanied by a thorough analysis of their respective merits and drawbacks. It is imperative for individuals involved in research endeavors to acknowledge the potential challenges that may surface during the process of data imputation, emphasizing the critical point that utilizing an imputation model with erroneous specifications could potentially yield outcomes that are not only skewed but also lack precision.

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Performance Evolution of Support Vector Machine, Random Forest, K-Nearest Neighbors and Neuron Network Algorithms According to Happiness Score

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Abstract – The ranking of happiness levels among countries worldwide in the 2019 World Happiness Report is conducted based on a variety of criteria. Compiled by the United Nations Sustainable Development Solutions Network, this report takes into account factors such as gross domestic product (GDP) per capita, Family, Life Expectancy, Freedom, Generosity, Trust Government Corruption to assess the impact of these variables on happiness levels in each nation. Utilizing algorithms including Support Vector Machine, Random Forest, K-Nearest Neighbors, and Neuron Network, the happiness scores of countries were analyzed. K-Nearest Neighbors algorithm yielded the highest coefficient of determination (R^2=0.856) in this evaluation. This research sheds light on the potential of machine learning algorithms in happiness studies.

Keywords – Happiness score, machine learning algorithms, 2019

I. INTRODUCTION

Happiness, considered a significant indicator of the overall well-being and quality of life of both individuals and societies, has increasingly become a focal point in international comparative research. This concept of happiness is progressively emerging as a prevalent and pertinent subject within the realm of cross-national studies, being recognized as an essential metric for evaluating societal progress and a fundamental objective of public policy endeavors. The notion of happiness has garnered widespread acceptance and application in various global survey initiatives, including but not limited to the World Value Survey, the Euro-barometer, the European Welfare Survey, and ultimately, the World Happiness Report (WHR), reflecting its growing importance and relevance in contemporary discourse on human development and societal advancement.

The 2019 iteration of the World Happiness Report, an influential publication that assesses and ranks the happiness levels of 156 nations worldwide, serves as a valuable resource for policymakers and scholars alike, offering insights and data that can inform decision-making processes and academic inquiries. Through a comprehensive analysis of the determinants of happiness across diverse geographical regions and cultural settings, the report sheds light on the complex interplay of factors that contribute to subjective well-being, providing a nuanced understanding of the multifaceted nature of happiness and its variations across different societal contexts.

The World Happiness Report, a significant and noteworthy survey that delves into the current status of global happiness, has made a notable impact in the field. Initially introduced in 2012, this report provides a comprehensive analysis of happiness levels worldwide. This World Happiness 2019 pivotal report was officially unveiled at the United Nations during a special occasion commemorating the International Day of Happiness on March 20th. Over time, the report has garnered widespread acclaim and acknowledgment

from various quarters, including governments, organizations, and civil society, who are increasingly incorporating happiness indicators into their policy-making frameworks. Distinguished experts hailing from diverse fields such as economics, psychology, survey analysis, national statistics, health, and public policy, among others, expound on the utility of well-being measurements in effectively gauging a nation's progress. Through a meticulous examination, the reports not only scrutinize the current landscape of global happiness, but also shed light on how the burgeoning field of happiness science elucidates the intricate variations in happiness levels at both individual and national scales.

The primary objective of the current research endeavor is to employ a diverse array of machine learning algorithms in order to predict and approximate the happiness metrics of different nations utilizing the dataset extracted from the World Happiness Report (WHR) of the year 2019. Furthermore, the study aims to provide valuable insights and contribute to the existing body of literature focused on the multidimensional concept of happiness.

II. Materials and Method

A. Data Set

The data set utilized in this study has been sourced from the online data collection as documented on the official website of the World Happiness Report (https://worldhappiness.report) [1]. The measurements of happiness and subsequent rankings are derived from the data obtained through the Gallup World Poll, a globally recognized survey. These scores are formulated based on the responses provided to the primary life evaluation inquiry within the survey. This particular query, commonly referred to as the Cantril ladder, prompts participants to envision a metaphorical ladder where the top represents the best possible life achievable (scored as 10) and the bottom symbolizes the worst possible life (scored as 0); individuals are then required to assess and assign a rating to their present life situation on this scale. The scores themselves are tabulated from samples that are deemed nationally representative for the time frame spanning from 2013 to 2016, and statistical weights calculated by Gallup are applied to ensure that the estimations reflect the broader population accurately. Moreover, the subsequent columns accompanying the happiness scores serve to delineate the degree to which six distinct factors - namely economic productivity, social support networks, life expectancy, level of freedom, absence of corruption, and acts of generosity - contribute towards enhancing the quality-of-life assessments within each country, in comparison to a theoretical benchmark referred to as Dystopia. This hypothetical nation is characterized by possessing values equivalent to the lowest global averages across the aforementioned factors. It is imperative to note that while these factors do not directly influence the total score attributed to each country, they do elucidate the reasons behind the variations in rankings observed among different nations.

The data set contains 9 columns and 156 rows. In data set, Response variable was only one variable which named “score” was chosen and six predictor variable which were GPT per capita, social support, healthy life expectancy, freedom to make life choice, generosity and perception of corruption.

B. Methods

B.1. Support Vector Machine

The Support Vector Machine (SVM), originally developed by [2], stands as a prominent and influential machine learning algorithm utilized for the purposes of both linear and nonlinear classification, regression tasks, and even the identification of outliers. The primary objective of Support Vector Regression (SVR) is to find accurate regression function $f(x)$ that effectively captures the underlying relationship between the provided input dataset $x=\{x_1, x_2, x_3, \ldots x_n\}$ and target variable $y=\{y_1, y_2, y_3, \ldots y_n\}$ as delineated in the following mathematical expression:

$$f(x) = w\phi(x) + b \quad (1)$$

where w denotes the function weight vector, b the offset factor and ϕ is the nonlinear mapping. To avoid overfitting the calibration data samples, SVR employs an objective function (Eq. 2) and a loss function (Eq. 3) to obtain the regression parameters in Eq. (1):

$$\min \frac{1}{2}\|w\|^2 + C\sum_1^n (\xi_i + \xi_i^*) \quad (2)$$

$$\text{Subject to: } \left\{ \begin{array}{l} y_i - (w + \phi(x) + b) \le e + \xi_i \\ (w + \phi(x) + b) - y_i \le e + \xi_i^* \\ \xi_i^* \ge 0, \xi_i^* \ge 0, i = 1, ..., n \end{array} \right\} \quad (3)$$

where *e* is a positive error threshold. *C* is a penalty coefficient defined by the user. ξ_i and ξ_i^* are the positive slack variables employed to determine the calibration data deviation from *e*.

B.2. Random Forest

Random forests, also referred to as random decision forests, are a sophisticated ensemble learning approach widely employed in the realm of machine learning for the purposes of classification, regression, and a multitude of other computational tasks necessitating pattern recognition and prediction. This methodology operates by generating a multitude of decision trees throughout the iterative training process, leveraging the collective wisdom of these individual trees to enhance the overall predictive accuracy and robustness of the model under consideration.

B.3. Nearest neighbors

One non-parametric supervised learning technique known as the k-nearest neighbors algorithm (k-NN) is commonly utilized in the fields of regression and classification. This particular method involves the fundamental concept of making predictions based on the distances calculated between a given data point xi and other data points, in order to estimate the value of a target variable (yi) that is linked to the input variable (xi). While the Euclidean distance metric is a popular choice in such scenarios, it is important to note that there exist various alternative methods for computing this distance, one of which includes the Manhattan distance measurement [3].

B.4. Neuron Networks

ANN, also known as Artificial Neural Network, emerges as a potent simulation software meticulously crafted for the purpose of conducting data analysis and computations with precision and efficiency. Mirroring the intricate workings of the human brain, this innovative model stands out for its unparalleled flexibility, accelerated processing speed, and remarkable adaptability to novel environmental conditions. Comprising a structured framework, ANN is organized into three fundamental layers, namely the input layer, hidden layer, and output layer, each carrying out distinct functions to facilitate the data processing journey. The initial phase, the input layer, serves as the gateway for gathering external variables crucial for both model training and testing phases. Transitioning to the hidden layer, this intermediary component plays a pivotal role in establishing connections between the input and output layers, housing essential activation functions like hyperbolic tangent sigmoid, log-sigmoid, exponential linear units, among others. As the core of the system, the output layer takes charge of representing the final outcomes generated by the model. Within each layer, a myriad of parallel neurons, often referred to as nodes, operate as the primary information processing units, meticulously weighted and interconnected with adjacent nodes in the subsequent layer, thereby forming a complex neural network designed to optimize data processing outcomes.

B.4. Evaluation metrics

To evaluate the effectiveness of the models, metrics such as Mean Squared Error (*MSE*), Root Mean Squared Error (*RMSE*), Mean Absolute Error/Mean Absolute Deviation (*MAE/MAD*), Mean Absolute Percentage Error (*MAPE*), and R-squared (R^2) were employed.

Mean square error (*MSE*): $MSE = \frac{1}{n}\sum_{i=1}^{n}\left(y_i - y_{ip}\right)$

Root-mean-square error (*RMSE*): $RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(y_i - y_{ip}\right)^2}$

Mean absolute percentage error (*MAPE*): $MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i - y_{ip}}{y_i}\right| \cdot 100$

Mean absolute deviation (*MAD*): $MAD = \frac{1}{n}\sum_{i=1}^{n}\left|y_i - y_{ip}\right|$

Coefficent of Determination (R^2): $R^2 = \left[1 - \frac{\sum_{i=1}^{n}(y_i - y_{ip})^2}{\sum_{i=1}^{n}(y_i - \bar{Y})^2}\right]$

III. RESULTS

The data set consisted of 156 observations. The independent variables were GPT per capita, social support, healthy life expectancy, freedom to make life choice, generosity and perception of corruption. The dependent variable was score. Descriptive statistics are summarised in Table 1, 2 and 3.

Table 1. Descriptive statistics

	Mean	**Std. Error of Mean**	**Std. Deviation**	**Coefficient of variation**
GDP per capita	0.905	0.032	0.398	0.440
Social support	1.209	0.024	0.299	0.248
Healthy life expectancy	0.725	0.019	0.242	0.334
Freedom to make life choices	0.393	0.011	0.143	0.365
Generosity	0.185	0.008	0.095	0.515
Perceptions of corruption	0.111	0.008	0.095	0.855

Table 2. Regressions

Coefficients						
Model		**Unstandardized**	**Standard Error**	**Standardized**	**t**	**p**
H_0	(Intercept)	5.407	0.089		60.671	< .001
H_1	(Intercept)	1.795	0.211		8.505	< .001
	Social support	1.124	0.237	0.302	4.745	< .001
	Healthy life expectancy	1.078	0.335	0.235	3.223	0.002
	Freedom to make life choices	1.455	0.375	0.187	3.876	< .001
	Generosity	0.490	0.498	0.042	0.984	0.327
	Perceptions of corruption	0.972	0.542	0.083	1.793	0.075
	GDP per capita	0.775	0.218	0.278	3.553	< .001

Table 3. Linear Regression Model Summary - Happiness Score

Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
H_0	0.000	0.000	0.000	1.113	0.000		0	155	
H_1	0.883	0.779	0.770	0.534	0.779	87.618	6	149	< .001

In the context of linear regression analysis encompassing all independent variables, it was observed that a total of six variables collectively accounted for a substantial 78% of the variance observed in the dependent variable. This particular finding serves to indicate the high level of explanatory power possessed by the model under consideration with regards to elucidating the nuances associated with the happiness score, as denoted by the statistical significance level of $p<0.001$.

Various goodness of fit criterias including Mean Square Error (MSE), Root Mean Square Error (RMSE), Mean Absolute Error/Mean Absolute Deviation (MAE/MAD), Mean Absolute Percentage Error (MAPE), and R-square (R^2) were employed for the purpose of assessing and contrasting the efficacy of the models that were utilized within the context of this particular research endeavor. The outcomes derived from these aforementioned analyses have been meticulously and comprehensively documented, and are readily available for scrutiny and elucidation in Table 4, thereby facilitating further examination and interpretation by interested parties.

Table 4. Comparing Evaluation Metrics

Metrics	Support Vector Machine Regression	Random Forest Regression	K-Nearest Neighbors Regression	Neural Network Regression
MSE	0.343	0.229	0.232	0.259
RMSE	0.586	0.479	0.482	0.509
MAE/MAD	0.44	0.374	0.353	0.403
MAPE	106.16%	91.85%	89.04%	305.19%
R^2	0.776	0.749	0.827	0.639

The model exhibiting the utmost coefficient of determination alongside the minimal mean squared error (MSE), root mean squared error (RMSE), mean absolute error (MAE)/mean absolute deviation (MAD), and mean absolute percentage error (MAPE) values, ultimately yields a superior alignment with the dataset [6]. Based on the results derived from the analysis, it was determined that the K-Nearest Neighbors Regression model emerges as the optimal choice among the various models, demonstrating a remarkable level of congruence with the dataset. The K-Nearest Neighbors (KNN) Classification Algorithm yielded results that involved the splitting of data into three distinct segments, specifically the training set accounting for 100% of the data, a 25% portion dedicated to validation, and a 31% allocation for testing, resulting in a cumulative total of 156% as illustrated in Figure 1 below. Upon conducting the experiment, the model predictions based on the rectangular weight function were situated in the intermediary realm between the relative weight and the proportion of maximum distance, as depicted in Figure 2, whereas Figure 3 showcased a plot representing the predictive performance, highlighting a correlation value of 0.902 between the observed and predicted values (***$p<0.001$).

Fig. 1. K-Nearest Neighbor data split percentage

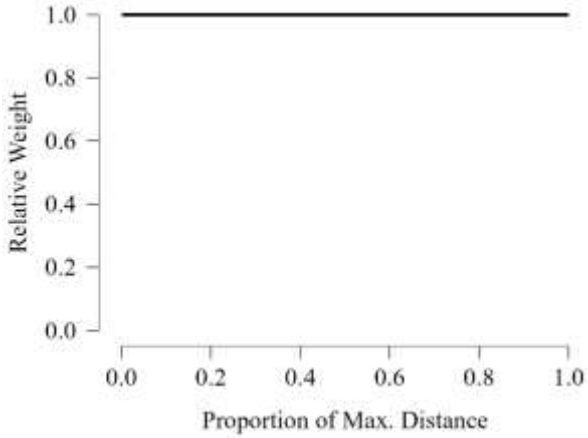

Fig. 2. Rectangular Weight Function

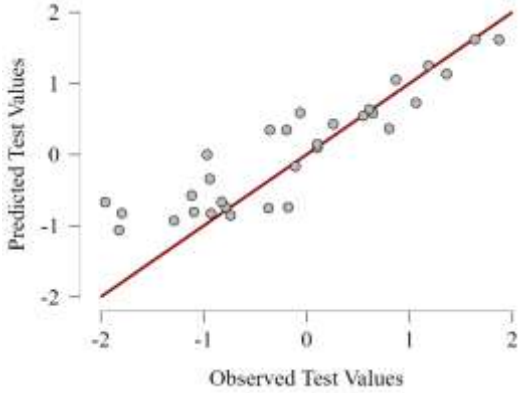

Fig. 3. Predictive performance plot

IV. CONCLUSION

The study successfully accomplished its stated aim and objective, further offering researchers a comprehensive solution to attain a more precise and dependable outcome following a thorough analysis utilizing the prediction model derived from the world happiness score dataset and intelligent analytical techniques. Through the comparison conducted, the study managed to unveil the algorithm that exhibits utmost efficiency in enhancing the accuracy of the prediction model when determining the happiness score, thus contributing significantly to the field of research. To ensure higher levels of precision in predicting data, it is recommended that researchers employ K-Nearest Neighbors (KNN) method specifically tailored for forecasting happiness scores.

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Yapay Zeka ve Bilim Dalları ile İlişkisi

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Özet – Bu derleme çalışmasında yapay zeka ile ilgili temel kavramlar ve yapay zekanın bilim dalları ile arasındaki ilişkileri kısaca araştırıp, ortaya koymaya çalıştık.

Anahtar Kelimeler – Yapay zeka, matematik, fizik, kimya, eğitim bilimleri, sağlık bilimleri

I. GİRİŞ

Yapay zekâ ya da kısaca AI, (İngilizce: Artificial intelligence ya da kısaca AI), insanlar ve hayvanlarda var olan doğal zekânın aksine makineler tarafından görüntülenen zekâ çeşidi olarak karşımıza çıkmaktadır. Yapay Zeka makineleri kullanarak insan zekasını simüle etmeye çalışan gelişen bir teknolojidir. Yapay zeka, sistemlerin eğitim verilerinden yeni yollarla öğrenmesine ve uyum sağlamasına olanak tanıyan makine öğrenimi (ML) ve derin öğrenme dahil olmak üzere çeşitli alt alanları kapsar. Sağlık, finans ve ulaşım gibi birçok sektörde geniş uygulamalara sahiptir. Yapay zeka başlıbasına bir bilim dalı değildir. Yapay zeka, birçok bilim dalının birleşiminden oluşan bir alandır. Yapay zeka, bilgisayar bilimleri, matematik, psikoloji, filozofi, mühendislik, fizik, neurobilim gibi birçok alanı içerir. Bu alanlar arasında en önemlileri makine öğrenimi, veri bilimi, nörobilim, matematik ve bilgisayar bilimidir. Yapay zekanın kullanım alanları çok çeşitlidir. Örneğin, sesli asistanlar, dil çevirileri, öneri sistemleri, navigasyon, sosyal güvenlik, sağlık hizmetleri, e-ticaret ve yardımcı robot uygulamalarıyla günlük hayatımızda yer almaktadır. Siber güvenlik ve savunma sanayi gibi sektöre özel stratejik çalışmalarda da kullanılmaktadır. Yapay zeka örnekleri arasında otomatik dil tercümesi, görüntü işleme, ses tanıma, otonom araçlar, akıllı ev sistemleri, oyunlar, chatbotlar ve daha pek çok uygulama bulunur. Ayrıca yapay zeka teknolojisinin en çok kullanıldığı yerlerden biri de askeri alandır.

II. MATERYAL VE YÖNTEM

Yapay Zeka (AI) Nasıl Çalışır? Yapay zeka genellikle robotların uygulanmasını akla getirmiştir. Teknoloji geliştikçe yapay zekayı tanımlayan önceki ölçütler geçerliliğini yitirmiştir. Yapay zekayı etkinleştiren teknolojiler şunları içerir: Bilgisayarlı görme, bilgisayarların resim ve fotoğraflardaki nesneleri ve insanları tanımlamasını sağlar, Doğal dil işleme (NLP), bilgisayarların insan dilini anlamasını sağlar, grafik işlem birimleri, bilgisayarların matematiksel hesaplamalar yoluyla grafik ve görüntü oluşturmasına yardımcı olan bilgisayar çipleridir, nesnelerin İnterneti, verileri toplayan ve paylaşan, sensörler, yazılımlar ve ağ bağlantısıyla donatılmış fiziksel cihazlar, araçlar ve diğer nesnelerden oluşan bir ağdır, uygulama programlama, iki veya daha fazla bilgisayar programının veya bileşeninin birbiriyle iletişim kurmasına olanak tanır. Algoritmalar genellikle basit uygulamalarda basit algoritmaların kullanıldığı, daha karmaşık algoritmaların ise güçlü yapay zekanın çerçevelenmesine yardımcı olduğu yapay zekanın yapısında bir rol oynar.

Yapay Zeka Türleri

Dar Yapay Zeka (Zayıf Yapay Zeka): Bu sistem, belirli bir işi gerçekleştirmek için tasarlanmıştır. Zayıf yapay zeka sistemleri, Amazon'un Alexa'sı ve Apple'ın Siri'si gibi kişisel asistanlar gibi video oyunlarını içerir. Kullanıcılar asistana bir soru sorar ve o da sizin için soruyu yanıtlar.

Genel Yapay Zeka: Bu tür, insana benzer olduğu düşünülen görevleri yerine getiren güçlü yapay zeka sistemlerini içerir. Daha karmaşık ve karmaşık olma eğilimindedirler ve sürücüsüz arabalar veya hastane ameliyathaneleri gibi uygulamalarda bulunabilirler.

Süper Yapay Zeka: Teorik bir yapay zeka türüdür ve henüz gerçekleştirilmemiştir. Süper yapay zeka, insanları aşan bilişsel yeteneklere sahip olacak, düşünecek, mantık yürütecek, öğrenecek ve sahip olacak şekilde gerçekleştirilecektir.

Yapay Zekayı Kullanmak

Yapay zeka, ilaç dozajlarını önermek, tedavileri belirlemek ve ameliyathanedeki cerrahi prosedürlere yardımcı olmak için sağlık sektörü de dahil olmak üzere birçok sektöre ve endüstriye uygulanabilir. Yapay zekaya sahip makinelerin diğer örnekleri arasında satranç oynayan bilgisayarlar ve sürücüsüz arabalar yer alıyor. Yapay zekanın finans sektöründe sahte bankacılık faaliyetlerini tespit edip işaretlediği uygulamalar var. Yapay zeka uygulamaları ticareti kolaylaştırmaya ve kolaylaştırmaya yardımcı olabilir.

2022 yılında Yapay Zeka, Üretken Eğitim Öncesi Transformatör uygulamalarıyla ana akıma girdi. En popüler uygulamalar OpenAI'nin DALL-E metinden resme aracı ve ChatGPT'dir. Deloitte'un 2024 yılında yaptığı bir ankete göre yapay zeka sektöründe lider olan katılımcıların %79'u, üretken yapay zekanın organizasyonlarını 2027 yılına kadar dönüştürmesini bekliyor.

Reaktif Yapay Zeka Nedir?

Reaktif Yapay Zeka, bir dizi girdiye göre çıktıları optimize etmek için algoritmalar kullanan bir Dar Yapay Zeka türüdür. Örneğin satranç oynayan yapay zekalar, oyunu kazanmak için en iyi stratejiyi optimize eden reaktif sistemlerdir. Reaktif yapay zeka oldukça statik olma eğilimindedir; öğrenemez veya yeni durumlara uyum sağlayamaz.

Yapay zeka ile ilgili dallar: Makine Zekâsı (Sembolik **Yapay Zekâ**), **Yapay** Sinir Ağları (Sibernetik **Yapay Zekâ**), Doğal Dil işleme (Dil ile düşünme), Görüntü İşleme, Konuşma Sentezi (**Yapay** Konuşma), Konuşma Anlama (Konuşma Analizi)**,** Tümevarımlı mantık programlama, Bilgi-tabanlı sistem gibi dallar yapay zeka ile ilgili dallardır. Şüphesiz ki bu dallar zamanla sayıca artacak ve her alanda yapay zeka karşımıza çıkacaktır.

Şimdi kısaca yapay zekanın temel bilimler ve diğer bilimlerle olan ilişkilerine bakalım.

Yapay Zeka Matematik Bilimi ile İlişkisi: Yapay zeka ve matematik, birbirine sıkı bir şekilde bağlı olan iki alan arasındaki ilişki oldukça önemlidir. Matematik, yapay zekanın temelini oluşturan teorik ve hesaplamalı prensipleri sağlar ve yapay zekanın geliştirilmesi, eğitimi ve uygulanmasında kullanılır. Yapay Zeka Matematiği ile, iyi seviye lineer cebir bilgisi, diferansiyel denklemler ve uygulamaları, olasılık ve istatistik, sayısal yöntemler ve ayrık matematik ile geometri konularının daha kolay ve iyi anlaşılması sağlanacaktır..

Yapay Zeka Eğitim Bilimleri İlişkisi: Yapay zekanın fazlaca uygulandığı yerlerden biri de Eğitim Bilimleri olarak karşımıza çıkmaktadır. Çeviri ve Simultane Tercüme **Uygulamaları**, Öğrenim Yönetim Sistemleri / Dijital Koç **Uygulamaları**, Sınav Kağıdı Notlandırma Sistemleri, Sanal Gerçeklik, Chatbot gibi uygulamarda yapay zeka karşımıza çıkmaktadır [1].

Yapay zekanın kimya bilimi ile ilişkisi: Zurich IBM Research araştırmacıları, yapay zekayı kullanarak kimyasal reaksiyonların sonuçlarının öngörülebileceğini kanıtladılar. Şimdiye kadar birçok kez kimyasal reaksiyonların sonuçlarını öngörebilen yapay zeka uygulamaları geliştirildi, geliştirilmeye çalışıldı. Bunlardan en kapsamlısı olan Bartosz Grzybowski'nin programı, yaklaşık 20 bine yakın kimyasal kuralını barındırıyor ve bunlara göre işlem yapmaktadır. IBM araştırmacıları ise kurallardan yola çıkarak bir program yazmak yerine, Google Translate gibi dilden dile tercüme yapan bir yazılımı örnek aldılar. Yapay zekaya önce reaksiyonlar verildi ve yapay zeka kendi kendine bu reaksiyonların mantığını öğrendi ve reaksiyonların sonuçlarını öngördü. Bu yapay zeka sayesinde, hem maliyetli hem de yoğun iş gücü isteyen ilaç sentezlemek, sadece tek tuşla gerçekleşebilecek. 10.000 farklı kombinasyonu saniyeler içerisinde gerçekleştirecek olan bu program sayesinde ilaç sanayi çağ atlayacak bir duruma gelecektir.

Yapay zeka ve fizik bilimi ile ilişkisi: Karmaşık problemleri çözme konusunda birbirini tamamlayan disiplinlerdir. İşte bu iki alanın karmaşık fizik problemlerini çözmedeki rolüne dair bazı önemli noktalar:
Modelleme ve Simülasyon: Yapay zeka teknikleri, fizikte karmaşık sistemlerin modellemesi ve simülasyonu için kullanılabilir. Örneğin, bilgisayarlı simülasyonlar, hava durumu tahmininde, kuantum mekaniği problemlerinde veya nükleer fizikte kullanılabilir.
Veri Analizi ve Tahmin: Yapay zeka algoritmaları, büyük veri setlerinden anlamlı bilgiler çıkarmak ve gelecekteki olayları tahmin etmek için kullanılabilir. Fizikte, bu veri analizi ve tahmin teknikleri, parçacık fiziği deneylerinden kozmolojiye kadar birçok alanda önemli bir rol oynar.
Optimizasyon Problemleri: Fizik problemleri genellikle bir optimizasyon problemi olarak formüle edilebilir. Yapay zeka, karmaşık fiziksel sistemlerin optimize edilmesi için kullanılabilir. Örneğin, belirli bir enerji fonksiyonunu minimize etmek veya belirli kısıtlar altında bir sistemin en iyi durumunu bulmak gibi problemlerde yapay zeka algoritmaları kullanılabilir.
Tasarım ve Keşif: Yapay zeka teknikleri, yeni malzemelerin, cihazların veya sistemlerin tasarımı ve keşfi için kullanılabilir. Fizikte, bu teknikler, malzeme bilimi, elektronik, enerji teknolojileri ve diğer birçok alanda kullanılabilir.
Kuantum Bilgisayarlar: Yapay zeka ve kuantum fizik arasındaki kesişim, kuantum bilgisayarlar alanında önemli bir potansiyel sunar. Yapay zeka algoritmaları, kuantum bilgisayarlar üzerinde karmaşık problemleri çözmek için geliştirilebilir, bu da önemli bilimsel ve endüstriyel uygulamalara yol açabilir.
Yeni Keşiflerin Yolunu Açma: Yapay zeka teknikleri, karmaşık fizik problemlerinin çözümünde insan yeteneklerini genişletir ve yeni keşiflerin yolunu açabilir. Özellikle, derin öğrenme gibi yapay zeka yöntemleri, karmaşık desenleri tanımlamak ve keşfetmek için güçlü bir araç olabilir. Sonuç olarak, yapay zeka ve fizik, karmaşık problemleri çözme konusunda birbirini tamamlayan ve güçlendiren alanlardır. Yapay zeka tekniklerinin fizikte kullanılması, bilimsel keşifleri hızlandırabilir, endüstriyel uygulamalara yol açabilir ve insanlığın anlayışını ve teknolojik gelişimini ileri taşıyabilir. Bu entegratif yaklaşım, özellikle karmaşık veri analizi ve modelleme süreçlerinde, fiziksel teorilerin ve deneylerin daha etkili bir şekilde sentezlenmesini sağlamaktadır [2].

Yapay Zeka Sağlık ile ilişkisi:

Sağlık hizmetlerinde yapay zeka teşhise yardımcı olmak için kullanılır. Yapay zeka, hastanın semptomlarından ve hayati değerlerinden yola çıkarak teşhisleri daha iyi üçgenlemek için taramalardaki küçük anormallikleri tespit edebilir. Yapay zeka, hastaları sınıflandırabilir, tıbbi kayıtları muhafaza edip takip edebilir ve sağlık sigortası talepleriyle ilgilenebilir.

Yapay zekanın sosyal bilimler ile ilişkisi: Yapay zekâ toplumun her alanına giderek daha fazla dâhil olmaktadır. Ses tanımadan, navigasyon sistemlerine ve yüz tanıma sistemlerine vb., toplumda yapay zekânın kapsama alanından kaçmak imkansız bir hâle gelmektedir. Yapay zekâ sistemleri, geleneksel olarak insani yargının hüküm alanı olan karar alma mekanizmalarına; örneğin, suçluların cezalandırılması, borçların dağıtılması, organ ve bağışçıların eşleştirilmesi, hastalık teşhisinin

yapılması, arabaların sürülmesi vb.ye giderek daha fazla dâhil olmaktadır. Yapay zekâya güç sağlayan algoritmalar nötr ve adımıza karar vermek için insanlardan daha çok güvenilebilir görünse de gerçek çok daha karmaşıktır. Daha şimdiden, algoritmaların insanların ırklarına dayanarak ayrımcılık yaptığı, yanlış teşhisler önerdiği vb. vakalar olmuştur. Bu yüzden, yapay zekânın sebep olabileceği olası zararlara karşı koyma ihtiyacı vardır. Bu derste yapay zekâ sistemlerinin yakın gelecekte topluma ve yönetişime nasıl nüfuz edeceği ve sosyal bilimlerin algoritmalardan gelen zararı azaltmaya nasıl yardımcı olabileceği düşünülmektedir [3].

III. TARTIŞMA

Şüphesiz ki yapay zeka hayatımızın her alanında karşımıza çıkan veya yakın gelecekte çıkacak olan bir uygulamadır. Etik kurallara uyulduğu takdirde insanlığın faydasına olduğu ve olacağı şüphesizdir. Gerek fen bilimleri ve sağlık bilimleri ve gerekse sosyal bilimlerde yapay zeka uygulamalarından faydalanmak hayatımızın kolaylaştırılması ve söz konusu bilimlerden daha fazla yararlanmak adına faydalı olacağı kanaatini taşımaktayım.

IV. SONUÇLAR

Yapay zeka günümüzün oldukça popüler çalışma alanlarından biri olarak gözümüze çarpmaktadır. Bu derleme çalışmasında yapay zekanin temel kavramlarını ve bilim dalları ile ilişkilerini araştırıp, kısaca incelemeye çalıştık.

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Zero Truncated Poisson Regression Model: A Mini Review

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Abstract – The distribution of the data obtained by counting usually does not show a normal distribution. For this reason, researchers employ transformation methods. However, transformation causes biased estimates. In this study, zero value truncated regression will be introduced for heterogeneous data with zero values in the data obtained by counting.

Keywords – Zero Truncated Regression, count data, transformations.

I. INTRODUCTION

In the field of linear regression analysis, especially in scenarios where the dependent variable exhibits non-normal distribution characteristics, various transformation techniques are applied to change the structure of the dataset in order to establish the assumption of normal distribution. However, despite the rigorous application of such transformations, normality remains difficult to achieve and there is a risk that these transformations may introduce distortions in the original structure of the dataset, as expressed by [1]. Census-derived data that lack a normal distribution typically start from zero values and contain positive values as emphasized by [2]. Where such data serve as dependent variables, results derived from linear regression analysis may lead to biased estimates of parameters. Therefore, methodologies that preserve the integrity of the original structure of the dataset should be used.

The dataset obtained by count data usually has a Poisson distribution and requires the use of Poisson regression in the modelling process as described by Ridout et al. A defining characteristic of a Poisson distribution is the equality between its variance and its mean. However, there are two scenarios where this equilibrium is not maintained. The first scenario is related to overdispersion, characterized by a situation where the variance exceeds the mean, whereas the latter scenario corresponds to underdispersion as described by [3]. Overdispersion, which can be attributed to unobserved heterogeneity or an excessive number of zeros in the dataset, are causal factors that lead to overdispersion as noted by [4,5]. Applying Poisson regression in the presence of overdispersion leads to biased parameter estimates [6]. To mitigate such problems and to obtain more precise results, they prefer to use Negative Binomial (NB) or Generalized Poisson (GP) regression models, as advocated by [7]. While NB regression addresses concerns about overdispersion, GP regression emerges as a viable alternative to Poisson regression, which is adept at accommodating both overdispersion and underdispersion scenarios.

If the dependent variable in a dataset has more zero values than expected, this situation is called Zero Inflation (ZI) [8]. In this case, it is recommended to use called Zero Inflation Regression models in modelling such dependent variables [5]. The methods that can be used in this case are Zero Inflated Poisson (ZIP), Zero Inflated Negative Binomial (ZINB) and Hurdle models [9].

Among these methods, the Hurdle model includes two stages for data analysis. The first stage is the transition stage, which shows binary responses showing positive counts (1) against zero counts (0); the second stage is the event stage, where only positive counts occur [10]. The first stage, binary responses, is modelled using the logit function. Positive counts are modelled using zero-truncated (ZT) methods [11,12].

There are several variations of zero-valued truncated regression techniques, chosen according to the characteristics of the dependent variable under study. In cases where the data distribution consists only of positive values, an appropriate approach would be to apply a zero-valued truncated Poisson regression model, denoted as ZTP. On the other hand, when the dependent variable shows an overdispersion of values, a zero-valued truncated negative binomial regression model, known as ZTNB, is more appropriate for the analysis [13].

II. METHOD

Zero Truncated Poisson Regression (ZTP)

Zero truncated Poisson (ZTP), also known as positive Poisson. In this distribution, unlike the Poisson distribution, all values are positive and do not contain a zero value (0). Zero truncated Poisson model [14]:

$$P(y_i \mid y_i > 0, \lambda) = \frac{P(y_i \mid \lambda)}{P(y_i > 0, \mid \lambda)} = \frac{\exp(-\lambda)\lambda y_i}{y_i^{!}(1-\exp(-\lambda))}$$

$$P(y_i > 0, \mid \lambda) = (1-\exp(-\lambda)), \quad y_i = 1,2,.... \quad , \; i = 1,2,...,N$$

log-likelihood for the i^{th} observation:

$$I(y_i; \mu_i \mid y_i > 0) = y_i[X^T{}_i\beta] - \exp(X^T{}_i\beta) - \ln[1-\exp\{-\exp(X^T{}_i\beta)\}]$$

Log-likelihood for the ZTP model [13]

$$I(y_i; \mu_i \mid y_i > 0) = \sum y_i[X^T{}_i\beta] - \exp(X^T{}_i\beta) - \ln(y_i!) - \ln[1-\exp\{-\exp(X^T{}_i\beta)\}]$$

III. CONCLUSION

The most well-known statistical analysis method is regression analysis. The aim of regression analysis is to predict the dependent variable(s) with two or more independent variables. However, it is not possible in some cases according to the structure of the data set. The fact that the dependent variable has a discrete and heterogeneous structure, contains too many zero values, and cannot show a normal distribution are the situations that prevent unbiased estimation with classical regression analysis. In such cases, Poisson regression can be used for analysis. However, the structure of the data obtained by counting has a structure that is frequently encountered with the aforementioned situations.

Positive counts (1) in the dependent variable with the data structure obtained by counting are modelled using zero-truncated (ZT) methods.

Zero Truncated (ZT) methods have been used in studies on health data, studies on the number of traffic accidents, and studies on regional-economic crimes. This method is preferred for biased estimation of parameters without damaging the original structure of the data structure. Since classical regression analyses cannot explain the excessive zero value density in the data structure, zero-truncated Poisson regression method should be preferred to classical models.

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Time-Dependent Killing Kinetics of Silver Nanoparticles Synthesized Using *Helichrysum italicum*

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Abstract **–** This study investigated the synthesis and time-dependent killing kinetics of silver nanoparticles (AgNPs) using the plant *Helichrysum italicum* (Roth) G. Don. The AgNPs were synthesized via a green synthesis method, which is more environmentally friendly compared to traditional chemical methods. This approach reduces reliance on toxic chemicals and is cost-effective and scalable due to lower temperature and shorter time requirements. *H. italicum* was specifically chosen for its rich polyphenolic and flavonoid compounds, which aid in reducing and stabilizing nanoparticles during synthesis. The stability of the synthesized AgNPs was confirmed by zeta potential measurements, which showed a value of -39.80 mV. This value indicates strong electrostatic repulsion between the particles, preventing aggregation and ensuring a stable suspension. Stable nanoparticles are essential for effective and long-lasting applications. The time-dependent antibacterial effects of AgNPs on *Proteus vulgaris* ATCC 13315, *Escherichia coli* NRRL B-3704, *Acinetobacter baumanii* ATCC 19606 and *Staphylococcus aureus* ATCC 6538P, *Staphylococcus haemolyticus* ATCC 43252 strains were investigated. The findings demonstrated that the AgNPs effectively inhibited bacterial growth in a dose- and time-dependent manner, proving their potential as robust antimicrobial agents. The study's results highlight the significant potential of using plant resources for nanoparticle synthesis, providing a sustainable and environmentally friendly alternative.

Overall, this research contributes to the advancement of green synthesis methods and emphasizes the importance of sustainable strategies in nanotechnology. There is also a highlighted need for future optimization studies to improve synthesis processes and explore broader applications of plant-based nanoparticles in various fields.

Keywords – Helichrysum italicum, Green synthesis, Silver nanoparticles, Nanotechnology, Time Kill, Zeta Potential

I. INTRODUCTION

Nanoparticles with superior durability, conductivity, and biocompatibility hold significant potential across biotechnology, medicine, electronics, and various industries. In response to traditional nanoparticle production methods, green synthesis approaches using plants, fungi, actinomycetes, and bacteria are being investigated as environmentally friendly alternatives. Plants such as *Helichrysum italicum* (Roth) G. Don. provide a sustainable source for nanoparticle synthesis due to their aromatic properties and

resilience to harsh Mediterranean climates. Belonging to the Asteraceae family, this plant is recognized for its small yellow flowers and potential to produce complex biological molecules (Kutluk et al., 2018; Ninčević et al., 2019; Tundis et al., 2005; Melito et al., 2013). Therefore, exploring the green synthesis of silver nanoparticles using H. italicum is crucial for developing non-toxic, eco-friendly, and economically viable production methods.

Green synthesis methods offer a more environmentally friendly and sustainable alternative compared to chemical and physical methods. Using plant extracts, green synthesis utilizes natural compounds as both reducing and stabilizing agents, eliminating the use of toxic chemicals. In this study, silver nanoparticles (AgNPs) were synthesized using extracts from H. italicum, and their antimicrobial activities against common pathogens such as *Proteus vulgaris* ATCC 13315, *Escherichia coli* NRRL B-3704, *Acinetobacter baumanii* ATCC 19606 and *Staphylococcus aureus* ATCC 6538P, *Staphylococcus haemolyticus* ATCC 43252 were investigated, along with their time-dependent killing kinetics.

Zeta potential is an indicator of the electrical charge present on the surface of nanoparticles, providing valuable information about the stability of suspensions and inter-particle interactions. Zeta potential analysis is widely used to assess the surface charge and suspension stability of nanoparticles, crucial for understanding their behavior in environmental and biological systems (Jiang, Oberdörster, & Biswas, 2009). It quantifies the electrical potential at the nanoparticle surface, closely linked to suspension stability and particle-particle interactions. Surface morphology and related studies commonly utilize this potential to determine interactions and aggregation tendencies among nanoparticles (Urnukhsaikhan et al., 2021).

Evaluation of antimicrobial agents is crucial for understanding their efficacy in clinical settings. One of the established methods used to assess bactericidal activity is the time-kill method. This technique involves exposing a microbial culture to an antimicrobial agent and monitoring the reduction in viable cell count over time, providing detailed kinetic data about the antimicrobial's effectiveness (Pankey & Sabath, 2004). The time-kill method measures the rate at which a bacterial population is killed by an antimicrobial agent, essential for understanding the potential for resistance development. The method includes sampling at specific time intervals and counting colony-forming units (CFUs) to determine the dynamics of bacterial populations in the presence of the antimicrobial agent (CLSI, 1999).

The aim of this study is to apply the time-kill method to evaluate the antimicrobial activity of AgNPs synthesized using the green synthesis approach with *H. italicum*. Given the increasing interest in alternative and sustainable antimicrobial agents, this research aims to investigate the time-dependent killing kinetics of AgNPs and their potential as potent antimicrobial agents.

II. Materials and Method

In this study, the zeta potential measurements of AgNPs synthesized from *H. italicum* (Figure 1) were conducted using a Zetasizer device, along with size analysis based on intensity. The time-kill method was employed to determine the time-dependent killing effect of AgNPs on bacterial and yeast cultures. The bacteria used in this study were adjusted to a density of 0.50 McFarland in 0.9% physiological saline. Petri dishes containing Mueller Hinton Agar (MHA) and tubes containing Mueller Hinton Broth (MHB) were marked for 20, 40, and 60 minutes according to Minimal Inhibition Concentrations1 (MIC1), MIC2, and MIC4 values. Bacteria were suspended in prepared MHB tubes according to the determined MIC values. The MHB tubes were then incubated at 37°C for 20, 40, and 60 minutes. Samples of 100 µL were taken from MIC1, MIC2, and MIC4 tubes every 20, 40, and 60 minutes and spread on plates using the streak plate method. Plates were incubated at 37°C for 24 hours. Bacterial counts were conducted after 24 hours, and the results were recorded.

Figure 1. *H. italicum* plant

III. RESULTS

In our study, the initial noticeable observation of nanoparticles is the change in colour. Silver ions reduced by the extract of *H. italicum* resulted in a transformation of the extract's inherent yellow colour to a brown hue. The AgNPs we synthesized were characterized intermittently, and the EDS peak values typically ranged from 0 to 3 KeV. The zeta potential of AgNPs was determined to be -39.80 mV. The zeta potential graph is depicted in Figure 2.

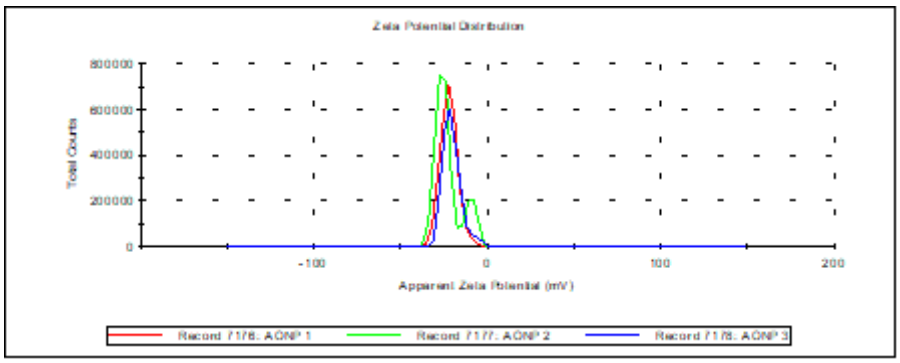


Figure 2. Zeta potential of AgNPs

The dynamic interaction between antimicrobial agents and microbial regression dependent on time and concentration is depicted in Figures 3 - 4 through time kill test results.

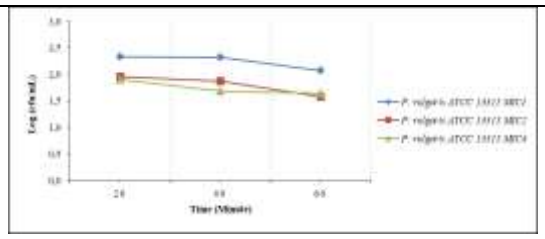


Figure 3a. *P. vulgaris* ATCC 13315

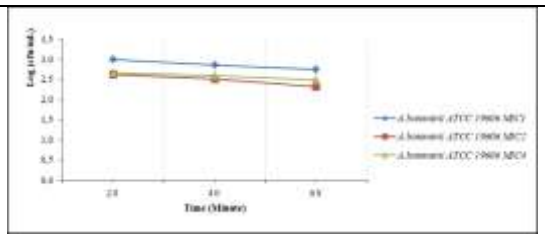
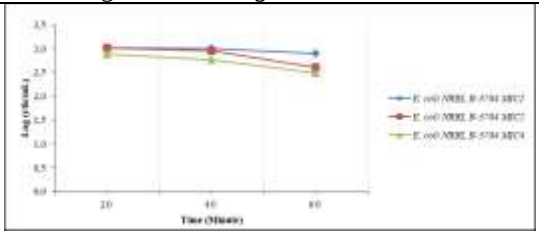


Figure 3b. *A. baumanii* ATCC 19906



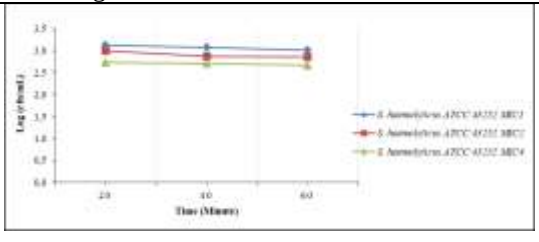


Figure 3c. *E. coli* NRRLB-3704

Figure 3d. *S. haemolyticus* ATCC 43252

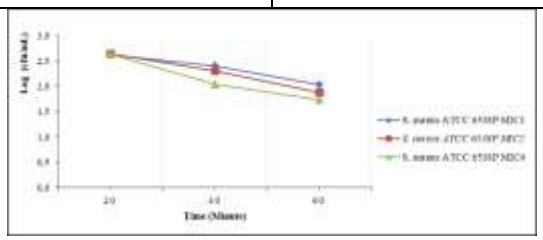


Figure 3e. *S. aureus* ATCC 6538P

Figure 3a-e. Time-kill kinetics curve of *H. italicum*

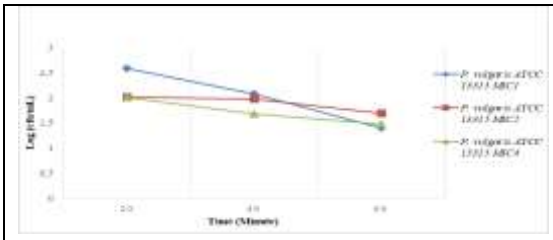


Figure 4a. *P. vulgaris* ATCC 13315

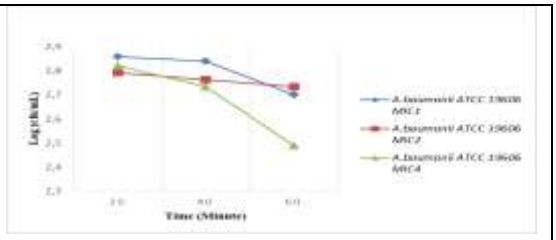


Figure 4b. *A. baumanii* ATCC 19906

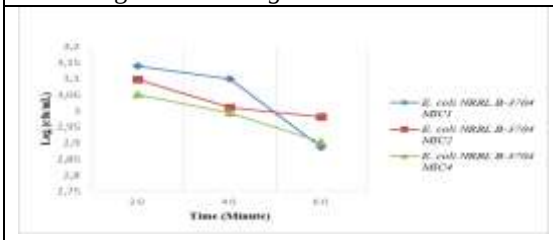


Figure 4c. *E. coli* NRRLB-3704

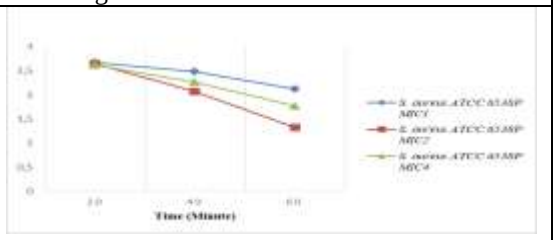


Figure 4d. *S. haemolyticus* ATCC 43252

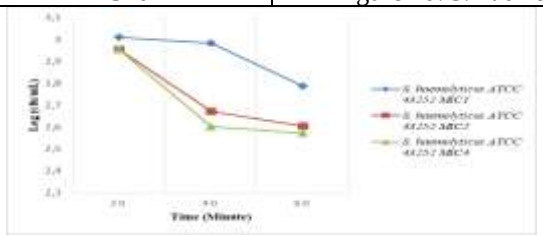


Figure 4e. *S. aureus* ATCC 6538P

Figure 4a-e. Time-kill kinetics curve of AgNPs

IV. DISCUSSION

It is presumed that the obtained AgNPs have a zeta potential value within the normal range. The negative value confirms repulsion between particles, indicating their high stability (Anandalakshmi et al., 2016). Zeta potential signifies the presence of electrical charge on the surface of NPs that have negative values (Singh et al., 2018).

The time kill method was employed to analyze bacterial viability and define the minimum time required for eradication. The effect of plant extract and AgNPs against test microorganisms was evaluated using

this time-dependent killing test. Previous studies have demonstrated the utility of the time kill method in assessing antimicrobials against various pathogens. For instance, this method has been effectively used to evaluate the bactericidal activity of antibiotics like vancomycin and linezolid against methicillin-resistant *S. aureus* (Rybak et al., 2000). Moreover, it has been applied to investigate the synergistic effects of antimicrobial combinations, providing insights into potential treatment strategies (Rybak & McGrath, 1996).

Lateef et al. (2015) investigated the time-dependent activities of AgNPs against strains of *E. coli* and *S. aureus*. The study concluded that silver nanoparticles inhibit bacterial growth in a dose- and time-dependent manner. Growth curves of bacteria exposed to nanoparticles indicated inhibition of growth and proliferation for both bacterial strains, highlighting the potential of nanoparticles to inhibit microbial growth effectively.

V. CONCLUSION

The reduction of Ag ions by *H. italicum* changed the extract's yellow color to brown. The synthesized AgNPs were typically characterized by showing EDS peak values at 0-3 keV. The zeta potential of AgNPs was determined to be -39.80 mV, indicating strong repulsion between particles and a stable structure (Anandalakshmi et al., 2016; Singh et al., 2018). The negative zeta potential values confirm the presence of electrical charge on the surface of nanoparticles (Singh et al., 2018). The dynamic interaction between time- and concentration-dependent antimicrobial agents and microbial regression was analyzed using time kill test results. A periodic decrease over time was observed for all cultures, with notable efficacy particularly noted for AgNPs derived from plant extracts compared to the plant extracts themselves.

ACKNOWLEDGMENT

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İç Anadolu Bölgesindeki Jeotermal Suların Hidrojeokimyasal Özellikleri ve Kullanım Olanakları

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Özet **–** Bu çalışma, Türkiye'nin İç Anadolu Bölgesi'ndeki jeotermal kaynakların hidrojeokimyasal özelliklerini ve kullanım potansiyellerini incelemektedir. Araştırma kapsamında Aksaray, Kırşehir, Niğde, Nevşehir ve Yozgat illerindeki toplam 16 jeotermal saha ele alınmıştır. Jeotermal suların kimyasal bileşenleri, mineral içerikleri ve sıcaklıkları analiz edilerek bölgenin jeotermal potansiyeli ortaya konulmuştur. Sonuçlar, bölgedeki jeotermal kaynakların termal sağlık ve turizm, jeotermal seracılık ve konut ısıtması gibi çeşitli alanlarda etkin bir şekilde kullanılabileceğini göstermektedir. Özellikle Kozaklı ve Sorgun gibi sahalardaki yüksek sıcaklık değerleri, bu alanların termal turizm merkezi olma potansiyelini artırmaktadır. Ayrıca, Bekdik, Boğazlıyan, Mahmutlu, Terme gibi sahalarda jeotermal seracılık uygulamaları, tarımsal üretimi artırmakta ve ekonomik katkılar sağlamaktadır. Kırşehir'deki kaynaklar ise konut ve şehir ısıtmasında kullanılmakta, enerji maliyetlerini düşürmekte ve fosil yakıtlara olan bağımlılığı azaltmaktadır. Çalışma, jeotermal kaynakların bölgesel kalkınma ve sürdürülebilir enerji kullanımı açısından büyük bir potansiyele sahip olduğunu vurgulamaktadır. Bölgedeki jeotermal suların analizleri, kaynakların mineral ve kimyasal içeriklerinin yanı sıra sıcaklıklarının da çeşitli uygulamalar için uygun olduğunu ortaya koymaktadır. Özellikle termal turizmde kullanılabilecek jeotermal sahaların varlığı, sağlık turizmi açısından da önemli fırsatlar sunmaktadır. Jeotermal seracılık faaliyetleri, bölgedeki tarımsal verimliliği artırarak, yerel ekonomiye ve istihdama olumlu katkılar sağlamaktadır. Bölgenin jeotermal potansiyeli, aynı zamanda enerji güvenliğini artırma ve çevresel sürdürülebilirliği sağlama noktasında stratejik bir önem taşımaktadır. Gelecekte yapılacak detaylı saha çalışmaları ve yatırımlar, bu potansiyelin daha verimli ve sürdürülebilir bir şekilde değerlendirilmesine olanak sağlayacaktır. Enerji maliyetlerinin düşürülmesi ve fosil yakıtlara olan bağımlılığın azaltılması, bölgesel kalkınma hedefleriyle uyumlu bir şekilde önemli ilerlemeler kaydedilmesini sağlayacaktır.

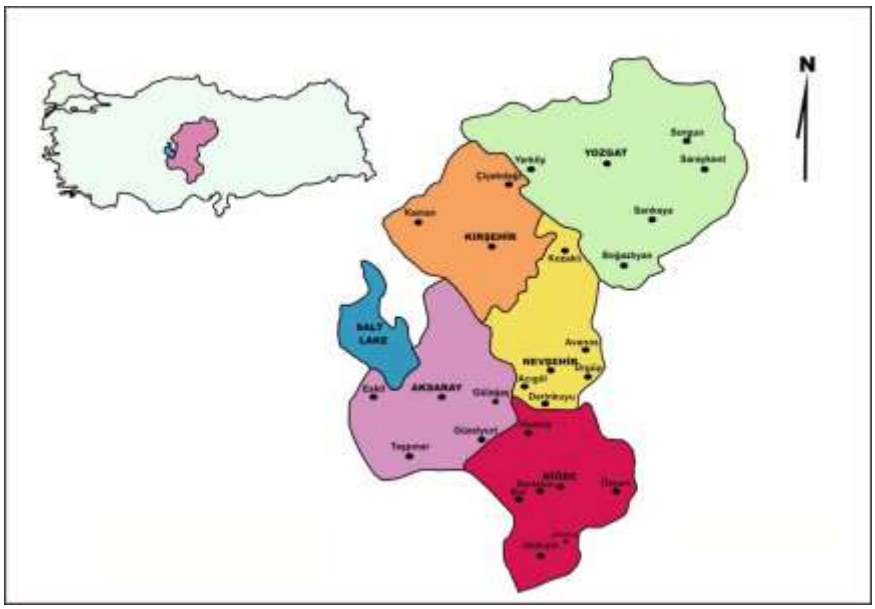
Anahtar Kelimeler – Jeotermal, İç Anadolu Bölgesi, hidrojeokimya, kullanım potansiyeli, termal turizm

I. GİRİŞ

Jeotermal enerji, sürdürülebilir ve çevre dostu bir enerji kaynağı olarak dünya genelinde artan bir öneme sahiptir. Bu enerji kaynağı, fosil yakıtlara olan bağımlılığı azaltarak karbon emisyonlarını düşürmekte ve enerji güvenliğini artırmaktadır. Türkiye, jeotermal potansiyel açısından dünyanın önde gelen ülkelerinden biridir ve özellikle İç Anadolu Bölgesi, jeotermal kaynakların zenginliği ile dikkat çekmektedir. İç Anadolu, Türkiye'nin jeotermal potansiyelinin %9'unu barındırmakta olup, bu bölgedeki jeotermal sistemler volkanik ve tektonik faaliyetlerle ilişkilidir [1]. Bölgedeki yakın zamanlı tektonik aktivitelerin varlığı, bu alanın termal gradyanının diğer bölgelere kıyasla daha yüksek olduğunu göstermektedir [2].

Bu çalışmada, İç Anadolu Bölgesi'ndeki jeotermal suların hidrojeokimyasal özellikleri incelenmiş ve bu suların mevcut ve potansiyel kullanım olanakları değerlendirilmiştir. Jeotermal suların kimyasal bileşenleri, mineral içerikleri ve sıcaklıkları detaylı bir şekilde analiz edilerek, bu verilerin bölgenin

jeotermal potansiyelini nasıl etkilediği ortaya konmuştur. Bölgedeki jeotermal sular, düşük- orta entalpili jeotermal akışkan sınıfında yer almakta olup, çeşitli uygulamalarda doğrudan kullanılabilmektedir. Bu çalışma kapsamında bölgede yer alan Aksaray, Kırşehir, Niğde, Nevşehir ve Yozgat olmak üzere 5 ildeki jeotermal sahaların kullanım amaçları ve potansiyelleri incelenmiştir (Şekil 1).



Şekil 1. Çalışmadaki jeotermal alanların yerbulduru haritası

II. MATERYAL VE YÖNTEM

Çalışma kapsamında mevcut durumda aktif olan toplam 16 adet jeotermal saha incelenmiştir. Daha önceki yıllarda, sahadan alınan termal su numunelerinin hidrojeokimyasal analiz sonuçları değerlendirilmiş olup içerdikleri anyon ve katyon değerlerine göre Piper diyagramında su tipleri belirlenmiştir. Faydalanılan 16 adet jeotermal sahanın sıcaklık değerleri, belirlenen su fasiyes tipleri ve mevcut kullanım alanları Tablo 1' de belirtilmiştir. Ayrıca her jeotermal sahanın hidrojeolojik özellikleri ve jeotermal sahaların oluşum mekanizmaları incelenerek aktif olmayan kuyuların potansiyeli değerlendirilmiştir.

III. BULGULAR

Bu çalışma için Aksaray ilinde 3 adet jeotermal alan incelenmiştir: Ziga-Yaprakhisar, Sofular , Bekdik. Aksaray ilindeki jeotermal sistemin rezervuar kayaları Bozçaldağ formasyonuna ait mermerlerdir. Üst Miyosen, Pliyosen ve Kuvaterner yaşlı gölsel-kıtasal sedimanter ve volkanik kayalar sistemin örtü kayalarını oluşturmaktadır. Hidrotermal sistemin ısı kaynağı volkanik aktivite ve jeotermal gradyandır. Bölgedeki sıcak su kaynaklarının oluşumunda tektonizmanın önemli bir yeri vardır. Bölgede tektonik doğrultular NW-SE ve NE-SW yönünde gruplanmaktadır. Bölgedeki yağmur suları, faylar, çatlaklar ve geçirgen kayalar aracılığıyla yer altına sızarak magmatik intrüzyonlarla temas etmekte ve ısınmaktadır [3]. Jeotermal sahalardaki sıcaklık değeri 51- 58 °C arasında değişmektedir ve bu sıcaklık jeotermal sularda doğrudan kullanım için uygun sıcaklıktadır. Ziga/ Yaprakhisar ve Sofular jeotermal sahalarında termal su kaplıca turizmi amaçlı kullanılırken Bekdik jeotermal sahasında sera ısıtmada kullanılmaktadır.

Kırşehir'deki jeotermal kaynaklar ağırlıklı olarak şehir merkezi (Karakut ve Terme) ve Çiçekdağı (Bulamaçlı vd Mahmutlu) bölgelerinde yoğunlaşmıştır. Çalışma alanının temeli, Paleozoyik yaşlı metamorfik, ofiyolitik ve plütonik kayaçlardan oluşmakta olup, Kırşehir Masifi olarak bilinen birkaç ayrı yapısal bloğu içermektedir. Kırşehir Masifi'ndeki metamorfik şistler genellikle geçirimsizdir, ancak mermerlerdeki çatlaklar ve kırılmalar nedeniyle geçirimlilik sağlanmaktadır. Bu nedenle, mermerler jeotermal suyun biriktiği birincil rezervuar olarak kabul edilmektedir [4]. Kırşehir jeotermal sahası, Seyfe

fay zonuna ait KD-GB ve KB-GD yönelimli faylarla kontrol edilmekte olup, tüm jeotermal sahalar genç volkanik aktivite ve blok faylanma ile ilişkilidir [5]. Karakurt ve Terme jeotermal sahalarında hakim iyon değerleri Ca^{+2} ve HCO_3 iken Bulamaçlı ve Mahmutlu jeotermal sahalarında hakim iyon değerleri Na^{+} ve Cl^{-} olarak tespit edilmiştir [6]. Kırşehir bölgesindeki jeotermal kaynaklar tarım (sera ısıtma, meyve ve sebze kurutma), kaplıca turizmi ve konut ısıtma alanlarında kullanılmaktadır. Kırşehir jeotermal sahaları, yaklaşık 1.800 konut ve 226 dekar sera ısıtma potansiyeli ile Türkiye için büyük önem taşımaktadır [7].

Nevşehir'in jeotermal kaynaklar açısından önemli bir potansiyele sahip olduğu ve özellikle Kozaklı jeotermal sahasının, bölgedeki termal sağlık ve turizm merkezi olarak öne çıktığı belirlenmiştir. Kozaklı jeotermal sahası, 1963 yılından bu yana yürütülen çalışmalarla Türkiye'nin en önemli jeotermal sahalarından biri olarak tanımlanmıştır. Jeotermal sistemin rezervuar kayası, Paleozoik yaşlı Kırşehir kristal masifine ait Bozçaldağ mermerleri olup, bu birim çatlaklı-kırıklı seviyeler ile ikincil gözenekliliğe sahiptir [8]. Sahadaki jeotermal sistem, NW-SE ve NE-SW doğrultusunda uzanan fayların kesişme noktalarından yüzeye çıkmakta olup, tektonik kontrollüdür. Kozaklı jeotermal sahasında kuyu sıcaklığı en yüksek 105,5 °C olarak ölçülmüş olup bu sıcaklık, civardaki jeotermal sahalar arasında en yüksek sıcaklık değeridir [9] . Kozaklı jeotermal akışkanı termal ve sağlık turizmi açısından hem bölge hem de Türkiye için oldukça önemlidir. Ayrıca buradaki jeotermal kaynaklar sera ve konut ısıtma amaçlı da kullanılmaktadır.

Niğde'de, başlıca Çiftehan, Narlı Göl ve Derdalan jeotermal sahaları olmak üzere üç önemli jeotermal saha bulunmaktadır. Bu sahalar, bölgedeki jeotermal potansiyelin değerlendirilmesi açısından büyük önem taşımaktadır. Narköy jeotermal sahasının temelinde yer alan Bozçaldağ Formasyonu'na ait mermerler, ikincil geçirimliliklerinden dolayı rezervuar kayaçlarıdır. Bölgede küçük alanlarda yüzeylenen travertenler, erime boşluklarına sahip olup yeraltı suyu içerebilir. Hidrotermal sistemin ısı kaynağı muhtemelen volkanik aktivitedir. Sistemin örtü kayağı, geçirimsiz Üst Miyosen-Pliyosen ve Kuaterner yaşlı ignimbirit, tüf, piroklastik ve bunlarla eş zamanlı olarak oluşan karasal göl fasiyeslerinde oluşmuş sedimanter kayaçlardır. Bu birimler içindeki geçirgen zonlarda sığ rezervuarların geliştiği düşünülmektedir [3]. Çiftehan sıcak ve mineralli suları, doğrultu atımlı ve sol yanlı Ilıca fayı ve diğer kırık sistemleri ile ilişkilidir [10]. Niğde-Derdalan jeotermal sahasında, Paleozoyik yaşlı Niğde Masifi temel kayaç birimlerini oluşturur. Bu temel kayaçlardaki mermerlerin kırıklı ve karstik boşlukları geçirimlidir ve jeotermal sistemin rezervuar kayağını oluşturur. Jeotermal sistemin ısı kaynakları, jeotermal gradyan ve Niğde masifinin granodiyorit intrüzyonlarıdır. Termal su, fay düzlemleri boyunca yükselir ve yüzeye çıkar. Jeotermal sistemin örtü kaynağı, Üst Miyosen-Pliyosen yaşlı volkanik ve sedimanter birimlerdir [11]. Niğde bölgesinde en düşük sıcaklık 29 °C en yüksek sıcaklık 60 °C olarak ölçülmüştür. Bölgedeki bütün jeotermal sular sadece kaplıca turizmi amacıyla kullanılmaktadır.

Yozgat, İç Anadolu Bölgesi'nde jeotermal kaynaklar açısından öne çıkan illerden biridir. Termal sağlık ve turizm merkezi olma potansiyelinin yanı sıra, jeotermal kaynaklar tarımsal uygulamalarda da önemli bir rol oynamaktadır. Özellikle jeotermal seracılık, Yozgat'ta yaygınlaşmakta olup, bölgenin tarımsal üretimine önemli katkılar sağlamaktadır. Bu potansiyel, hem ekonomik kalkınma hem de sürdürülebilir enerji kullanımı açısından büyük bir fırsat sunmaktadır. Sorgun jeotermal sahası Yozgat'taki en yüksek sıcaklığa sahip jeotermal alandır. Bölgeden çıkarılan jeotermal su, konut ısıtması, termal turizm, sera yetiştiriciliği ve balneolojik amaçlarla kullanılmaktadır. Suyun sıcaklığı 50 ile 85,4 °C arasında değişmektedir [12]. Saha içerisindeki jeotermal kuyular, 1.000 konutun ve 10.000 m² sera alanının termal su ihtiyacını karşılamaktadır [13]. Boğazlıyan jeotermal sahası kaplıca turizmi ve sera ısıtma amacı ile kullanılırken Saraykent, Sarıkaya ve Yerköy jeotermal sahaları kaplıca turizmi amacı ile kullanılmaktadır.

Tablo 1. Jeotermal alanların su tipleri ve kullanım olanakları

İL - İLÇE	JEOTERMAL SAHA	SU TİPİ	KULLANIM ALANI	SICAKLIK (°C)
Aksaray/ Güzelyurt	Ziga/ Yaprakhisar	Na-Ca-Cl	Kaplıca turizmi	51.0
Aksaray/ Gülağaç	Sofular	Ca-HCO_3-Cl	Kaplıca turizmi	56
Aksaray/ Sarıyahşi	Bekdik	Na-Cl	Seracılık	58
Kırşehir/ Merkez	Terme	Ca-Na-HCO_3-Cl	Kaplıca turizmi, seracılık, konut ısıtma	54- 56
Kırşehir/ Merkez	Karakurt	Ca-Na-HCO_3-SO_4	Sebze ve meyve kurutma, sera ve konut ısıtma, kaplıca turizmi	46- 57
Kırşehir/ Çiçekdağı	Bulamaçlı	Na-Cl	Kaplıca turizmi	39- 44
Kırşehir/ Çiçekdağı	Mahmutlu	Na-Ca-Cl-SO_4	Seracılık	73- 78
Nevşehir/ Kozaklı	Kozaklı	Na-Ca-Cl-SO_4 Na-Ca-SO_4-Cl	Kaplıca turizmi, seracılık, konut ısıtma	51- 105.5
Niğde/ Ulukışla	Çiftehan	Na-Ca-SO_4-Cl	Kaplıca turizmi	32- 55
Niğde/ Merkez	Narlıgöl/ Acıgöl	Ca-Na-Cl-HCO_3	Kaplıca turizmi	60
Niğde/ Merkez	Derdalan	Ca-SO_4	Kaplıca turizmi	28- 29
Yozgat/ Boğazlıyan	Bahariye	Na-Ca-Cl-HCO_3	Kaplıca turizmi ve seracılık	52
Yozgat/ Saraykent	Sarayönü	Na-Cl Na- SO_4	Kaplıca turizmi	48-73
Yozgat/ Sarıkaya	Merkez	Ca-Na-HCO_3-Cl	Kaplıca turizmi	25- 50
Yozgat/ Sorgun	Merkez/ Yenidoğan	Na-Ca-Cl-HCO_3	Seracılık, kaplıca turizm ve konut ısıtma	50- 85.4
Yozgat/ Yerköy	Merkez	Na-Ca-Cl Na- Cl	Kaplıca turizmi	40.6

IV. TARTIŞMA

İç Anadolu Bölgesi'ndeki jeotermal kaynaklar, sahip oldukları çeşitli kullanım potansiyelleri ve bölgesel ekonomik katkıları ile dikkat çekmektedir. Yapılan hidrojeokimyasal analizler ve saha incelemeleri, bölgedeki jeotermal suların kimyasal bileşimlerini ve sıcaklıklarını ortaya koyarak, bu kaynakların hangi alanlarda en verimli şekilde değerlendirilebileceğini göstermektedir.

Jeotermal kaynakların en yaygın kullanım alanlarından biri termal sağlık ve turizm sektörüdür. Özellikle Kozaklı ve Sorgun gibi bölgelerdeki yüksek sıcaklık değerleri, bu alanların termal turizm merkezi olma potansiyelini artırmaktadır. Kozaklı jeotermal sahasında ölçülen 105,5 °C'lik sıcaklık, bölgedeki en yüksek değer olup, termal sağlık tesislerinin yanı sıra sera ısıtma ve konut ısıtma gibi çeşitli uygulamalara da olanak tanımaktadır. Bu durum, bölgeye hem yerli hem de yabancı turist çekerek ekonomik canlılık sağlamaktadır.

Tarımsal uygulamalar, jeotermal kaynakların bir diğer önemli kullanım alanıdır. Özellikle jeotermal seracılık, düşük-orta entalpili jeotermal akışkanların verimli bir şekilde kullanıldığı bir sektördür. Bu çalışma kapsamında incelenen jeotermal sahalar arasında, Aksaray'daki Bekdik ve Kırşehir'deki çeşitli sahalarda jeotermal suların sera ısıtma amaçlı kullanımı öne çıkmaktadır. Jeotermal seracılık, yıl boyunca kesintisiz üretim imkanı sunarak tarımsal verimliliği artırmakta ve bölge ekonomisine önemli katkılar sağlamaktadır.

Jeotermal enerjinin bir diğer kullanım alanı ise konut ve şehir ısıtmasıdır. Özellikle Kırşehir'deki jeotermal kaynaklar, yaklaşık 1.800 konutun ısıtılmasında kullanılmakta olup, bu durum enerji maliyetlerini

düşürmekte ve fosil yakıtlara olan bağımlılığı azaltmaktadır. Aynı zamanda, jeotermal enerji kullanımı karbon emisyonlarını düşürerek çevresel sürdürülebilirliğe de katkıda bulunmaktadır.

Yozgat, Niğde, Nevşehir ve Aksaray gibi illerdeki jeotermal sahalar, bölgesel kalkınma ve sürdürülebilir enerji kullanımı açısından büyük potansiyele sahiptir. Bu sahaların etkin bir şekilde değerlendirilmesi, bölgedeki enerji güvenliğini artırmakta ve ekonomik kalkınmayı desteklemektedir. Ayrıca, jeotermal kaynakların çok yönlü kullanımı, enerji kaynaklarının çeşitlendirilmesine ve yenilenebilir enerji hedeflerine ulaşılmasına katkıda bulunmaktadır.

V. SONUÇLAR

Bu çalışma, İç Anadolu Bölgesi'ndeki jeotermal kaynakların hidrojeokimyasal özelliklerini ve kullanım potansiyellerini detaylı bir şekilde ele almıştır. Elde edilen bulgular, bölgedeki jeotermal kaynakların çeşitli alanlarda verimli bir şekilde kullanılabileceğini göstermektedir:

1. **Termal Sağlık ve Turizm**: Kozaklı ve Sorgun gibi yüksek sıcaklığa sahip jeotermal sahalar, termal sağlık ve turizm açısından büyük bir potansiyele sahiptir. Bu bölgelerdeki termal tesisler, bölge ekonomisine önemli katkılar sağlamakta ve turizmi canlandırmaktadır.
2. **Jeotermal Seracılık**: Bekdik, Kırşehir ve Yozgat gibi bölgelerde jeotermal kaynakların sera ısıtma amaçlı kullanımı, tarımsal üretimi artırmakta ve yıl boyu kesintisiz üretim imkanı sunmaktadır. Bu durum, tarımsal verimliliği artırarak bölgesel kalkınmaya katkı sağlamaktadır.
3. **Konut ve Şehir Isıtması**: Kırşehir'deki jeotermal kaynaklar, yaklaşık 1.800 konutun ısıtılmasında kullanılmakta olup, enerji maliyetlerini düşürmekte ve fosil yakıtlara olan bağımlılığı azaltmaktadır. Bu, sürdürülebilir enerji kullanımı açısından önemli bir katkıdır.
4. **Çevresel Sürdürülebilirlik**: Jeotermal enerji kullanımı, karbon emisyonlarını düşürerek çevresel sürdürülebilirliğe katkıda bulunmaktadır. Fosil yakıtların yerine jeotermal kaynakların kullanılması, enerji kaynaklarının çeşitlendirilmesine ve çevresel hedeflere ulaşılmasına yardımcı olmaktadır.

Sonuç olarak, İç Anadolu Bölgesi'ndeki jeotermal kaynaklar, bölgenin ekonomik ve sosyal kalkınmasına önemli katkılar sağlamakta olup, bu potansiyelin etkin bir şekilde değerlendirilmesi büyük önem taşımaktadır. Gelecekte yapılacak detaylı saha çalışmaları ve yatırımlar, jeotermal kaynakların daha verimli ve sürdürülebilir bir şekilde kullanılmasına olanak tanıyacaktır.

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Deep Learning Approaches for Sugarcane Disease Diagnosis:A Comparative Study of DenseNet121 and MobileNetV3

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Abstract – Sugarcane is a strategic agricultural product worldwide, playing a critical role, especially in sugar and bioenergy production. However, sugarcane's productivity and product quality are negatively affected by various diseases. Traditional disease diagnosis methods are usually time-consuming, laboratory-oriented, and costly. In recent years, deep learning techniques, especially convolutional neural networks, offer significant potential in the automatic diagnosis of agricultural diseases. This study used DenseNet121 and MobileNetV3 deep learning models to classify diseases in sugarcane leaves. A dataset containing a total of 2521 images was used in the study. The dataset contains five different classes: healthy leaves, yellow disease, mosaic disease, red rot disease, and rust disease. The obtained results showed that both models were successful in diagnosing sugarcane diseases, and the DenseNet121 model performed better than the MobileNetV3 model with a 93% accuracy rate and a 90% accuracy rate. In addition, the classification reports of both models are detailed with metrics such as recall, precision, and F1 score. This study highlights the role of deep learning techniques in disease diagnosis and management in the agricultural sector, and the findings provide an important reference point for future research.

Keywords – Deep Learning, DenseNet121, MobileNetV3, Sugarcane, Convolutional Neural Network.

I. INTRODUCTION

The human greatly value agriculture in terms of its economic significance as well as food production. Many countries' economies still depend primarily on agricultural activities, just as they did ages ago. When diseases affect agricultural crops, people find it hard to access and distribute food leading to the danger for all mankind [1].

Sugarcane (Saccharum officinarum) is a perennial plant that grows in warm climates. It is a vital global crop due to its role in sugar and bioenergy production. Sugar is one of the most important nutrients produced and consumed in millions of tons every year. Approximately 80% of the world's sugar production is derived from sugar cane [2]. Brazil and India lead the global production, together producing 61% of the world's sugarcane in 2021, and the crop is grown in more than 80 countries [3].

Sugarcane cultivation is of great importance for the agricultural sector and the world economy. One of the most important factors affecting the sugarcane economy is the diseases that occur in sugarcane. These diseases seriously affect the productivity and product quality of the plant [4].

Sugarcane is an essential crop for the agricultural sector and the world economy. Diseases occurring in sugar cane are the most important factor affecting the sugar cane economy. These diseases badly hamper the productivity and quality of plants [4].

The diseases responsible for massive loss in sugarcane cultivation are induced mainly by various fungal, bacterial, and viral pathogens such as mosaic disease, yellow disease red rot, and rust. Yellow disease is a viral infection characterized by yellowing of leaves, plant growth retardation, and yield reduction and is usually carried by insects such as aphids [5]. The mosaic disease, as the name suggests manifests in a random pattern of yellow and green spots all over leaves to curtail plant growth. Viral disease can be spread by insects. Red rot is characterized by reddish brown spots on the stems, softening, and rotting of the inner tissue. It is a fungal infection that spreads especially in hot and humid conditions. Rust disease forms rust-colored spots and spore clusters on the leaves, inhibiting photosynthesis and slowing plant growth. This disease, which is usually a fungal infection, is spread by wind-borne spores and can cause major economic losses in sugarcane cultivation. Therefore, early diagnosis and appropriate treatment are important [1], [6].

Effective diagnosis and control of sugarcane diseases is vital to increase agricultural productivity and support sustainable agriculture. Classical approaches to disease recognition require standardized inspection of crops by experts. However, these methods can be time-consuming and costly [7].

It has been an important innovation in the last years in the diagnosis of agricultural diseases. Symptoms of plant diseases can be automatically analyzed using deep-learning algorithms in image processing [8]. In particular, Convolutional Neural Networks have been effectively used for agricultural disease detection. They can analyze images from large datasets to identify plant diseases much faster and more accurately than the human eye [9]. It is also helpful in predicting the trend of disease spread; hence, farmers would minimize yield loss through preventive measures. Therefore, the application of deep learning techniques to diagnose sugarcane diseases has been seen as having great potential in increasing agricultural productivity and sustainable agricultural practice. In this context, some studies use deep learning methods in the literature for the diagnosis of sugarcane diseases. Daphal et al. applied their dataset of sugarcane leaves with 1470 images to deep learning algorithms VGG16 and ResNet to achieve 83% and 91% accuracy for classification, respectively [10]. Renugambal et al. used Support Vector Machines (SVM) and Artificial Neural Networks (ANN) models to automatically classify sugarcane leaf diseases. They used 100 images of five sugarcane leaf diseases as training and test sets. While linear and non-linear SVMs achieved 91% and 94% accuracy, respectively, ANN performed lower than SVM with 85% accuracy [11].]. Banerjee et al. developed a hybrid CNN-SVM model to predict the severity of Grass Shoot Disease in sugarcane crops with high accuracy. Using a dataset of 2925 sugarcane plant images, preprocessing, feature extraction with three-layer CNN, and classification with SVM were performed. With the developed model, 81.53% accuracy was obtained [12]. Maurya et al. developed a specially designed VGG16 model to diagnose sugarcane leaf diseases. This model achieved a significant classification accuracy of 94.47% [13].

In this study, we aim to diagnose sugarcane diseases using CNN-based DenseNet121 and MobileNet V3 models. DenseNet121 provides more effective feature transfer in the deep learning process thanks to the dense connections between layers. This architecture facilitates the training of deeper networks, helping to achieve more accurate results in complex data. On the other hand, MobileNet V3 stands out with its lightweight structure and can be used effectively in mobile and embedded systems by offering fast prediction capabilities. This model shows high performance even on devices with limited resources. Our research aims to contribute to the determination of the most effective method in this field by separately evaluating the effectiveness of both models in the diagnosis of sugarcane diseases. Furthermore, this comparison aims to improve agricultural productivity by providing practical solutions for early detection of diseases in agricultural applications.

II. Materials and Method

A. Dataset

In the study, a dataset containing images of sugarcane leaf diseases was used [14]. The dataset consists of five disease classes: Healthy, Mosaic, Red Rot, Rust, and Yellow. The images in the dataset were taken with smartphones with different configurations to maintain diversity. The dataset, the number of images belonging to each disease class given in Table 1, consists of a total of 2521 images. The dataset, which

has a balanced distribution, offers a good variety. The image sizes are not fixed due to the use of various shooting devices. All images are in RGB format.

Table 1. Dataset image counts

Classes	Image Counts
Healthy	522
Mosaic	462
Red Rot	518
Rust	514
Yellow	505

The dataset is divided into two groups training and testing according to k-fold 5 value. Figure 1 shows sample images in 5 different disease classes in the dataset.

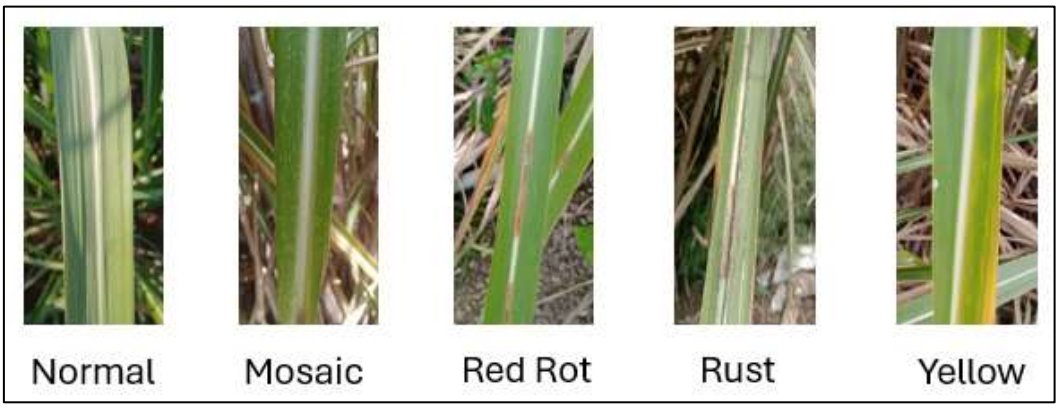

Fig. 1 Examples of sugarcane datasets

B. MobileNetV3

MobileNet is a deep learning architecture used in computer vision developed by Google. This architecture is designed specifically for use in resource-limited environments such as mobile devices. MobileNet offers an approach that minimizes computational and memory requirements to achieve high accuracy. However, classification tasks on mobile devices not only require high accuracy but also require low memory costs and high computational efficiency more practically [15]. MobileNet has 3 different versions, V1, V2 and V3.

MobileNetV3 is optimized to provide higher accuracy and use less memory than previous MobileNet series. Unlike traditional deep neural network structures, it uses a special architecture called "expand-translate-reduce" blocks. These blocks reduce the overfitting problems of the network and provide faster training processes for real-time applications on mobile devices. There are two models for MobileNetV3. The model described as large uses a lot of resources, while the model described as small uses fewer resources [16].

C. DenseNet121

DenseNet is a network structure that densifies the connections between layers, making them deeper, more accurate, and more efficient in training. While traditional convolutional networks have only a single connection between successive layers, DenseNet connects each layer to all previous layers. This approach encourages the reuse of feature maps, alleviates the vanishing gradient problem, strengthens feature propagation, and improves parameter efficiency. The advantages of DenseNet include more efficient backflow of gradients, richer feature learning, and high performance with fewer parameters [17].

DenseNet121 is a model consisting of 121 layers in total and includes four dense blocks. After the first convolution and pooling layer, each dense block consists of a certain number of convolutional layers and there are transition layers between the blocks. The last layer is the global average pooling and softmax

classification layer. This structure increases the learning capacity and efficiency of the model and provides superior performance in tasks such as object recognition [18], [19].

D. Evaluation Metrics

In order to objectively evaluate the performance of the study, accuracy, recall, precision, and F1-Score evaluation metrics, which are most preferred in classification problems, were used. The equations of the evaluation metrics used are presented in Table 2 [20], [21].

Table 2. Evaluation Metrics Equations

Classes	**Image Counts**
Accuracy = $(TP + TN)/(TP + TN + FP + FN)$	(1)
Recall= $TP/(TP + FN)$	(2)
Precision= $TP/(TP + FP)$	(3)
F1–Score= $2 * \frac{Recall * Precision}{Recall + Precision}$	(4)

III. RESULT AND DISCUSSION

The following part of the research showcases the outputs obtained with MobileNetV3 and DenseNet121 models for diagnosing sugarcane diseases. The models were trained and tested on a Windows 10 Pro 64-bit operating system with an Intel Core i7 processor and 16GB RAM. For coding, Python 3.11 programming language and TensorFlow library were used. The dataset was split into 80% for training and 20% for testing using the k-fold 5 method. For both models, the study was completed with 500 epochs in total. The complexity matrices obtained are given in Table 3 and Table 4, and the accuracy, precision, sensitivity, and F1 score metrics are given in detail in Table 5. In addition, the accuracy and loss graphs for the MobileNetV3 model are shown in Figure 3 and Figure 4, and the graphs for the DenseNet121 model are shown in Figure 5 and Figure 6.

Table 3. MobileNetV3confusion matrix

		Predict Label				
		Healthy	Mosaic	Red Rot	Rust	Yellow
True Label	Healthy	90	8	1	0	6
	Mosaic	0	87	0	2	3
	Red Rot	3	0	86	3	12
	Rust	2	0	3	98	0
	Yellow	1	3	2	1	94

Table 4. DenseNet121 confusion matrix

		Predict Label				
		Healthy	Mosaic	Red Rot	Rust	Yellow
True Label	Healthy	98	3	1	0	3
	Mosaic	2	89	0	0	1
	Red Rot	0	0	102	1	1
	Rust	0	2	2	98	1
	Yellow	8	5	6	0	82

Table 5. Performance results

Model	Accuracy	Classes	Precision	Recall	F1-Score
MobileNetV3	0,90	Healthy	0,94	0,86	0,90
		Mosaic	0,89	0,95	0,92
		Red Rot	0,93	0,83	0,88
		Rust	0,94	0,95	0,95
		Yellow	0,82	0,93	0,87
DenseNet121	0,93	Healthy	0,91	0,93	0,92
		Mosaic	0,90	0,97	0,93
		Red Rot	0,92	0,98	0,95
		Rust	0,99	0,95	0,97
		Yellow	0,93	0,81	0,87

When the performances of MobilNetV3 and DenseNet121 models, whose performance results are shown in Table 5, are compared, 93% accuracy is achieved with DenseNet121, and 90% accuracy is achieved with MobilNetV3. With this result, it is determined that DenseNet121 performs better. While MobilNetV3 works with 0.94% precision and 0.86% recall rate in the healthy class, DenseNet121 has 0.91% precision and 0.93% recall rate in the same class. In addition, it is seen that DenseNet121 shows superior performance with 0.99% precision and 0.95% recall in the Rust disease class. Both models generally have high precision and recall rates between classes, and it is noteworthy that DenseNet121 reaches higher F1 scores, especially in some classes (e.g. Red Rot). In summary, while DenseNet121 provides better results in general performance and some specific classes, MobilNetV3 also provides successful accuracy and consistency.

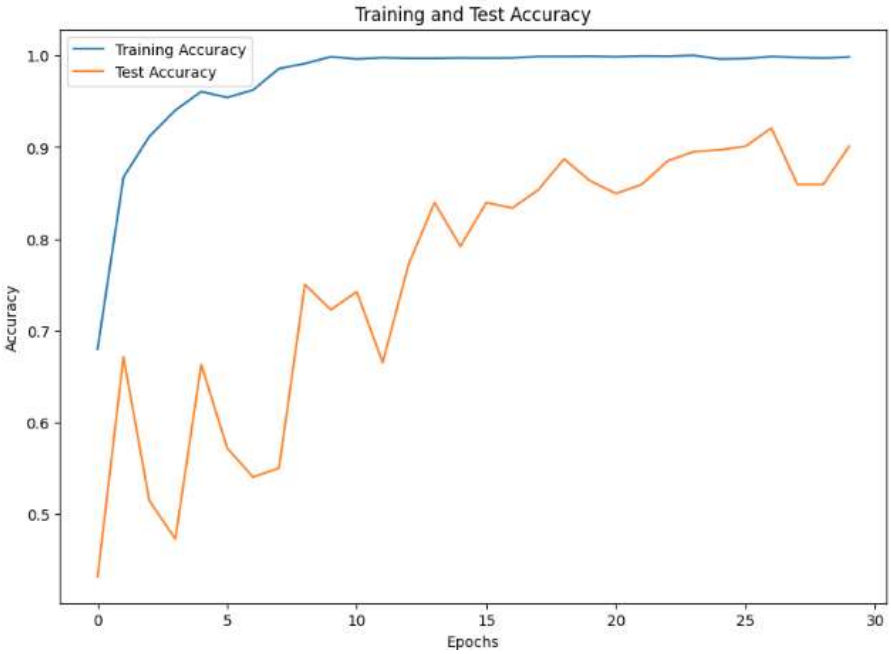

Fig. 3 Accuracy graph of the MobileNetV3 model

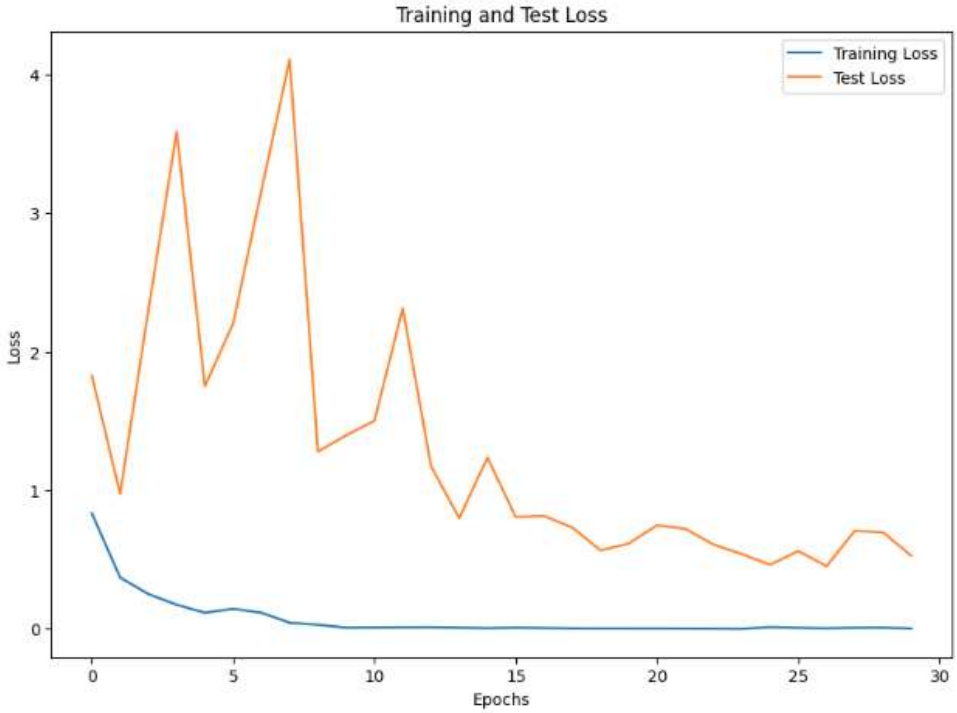

Fig. 4 Loss graph of the MobileNetV3 model

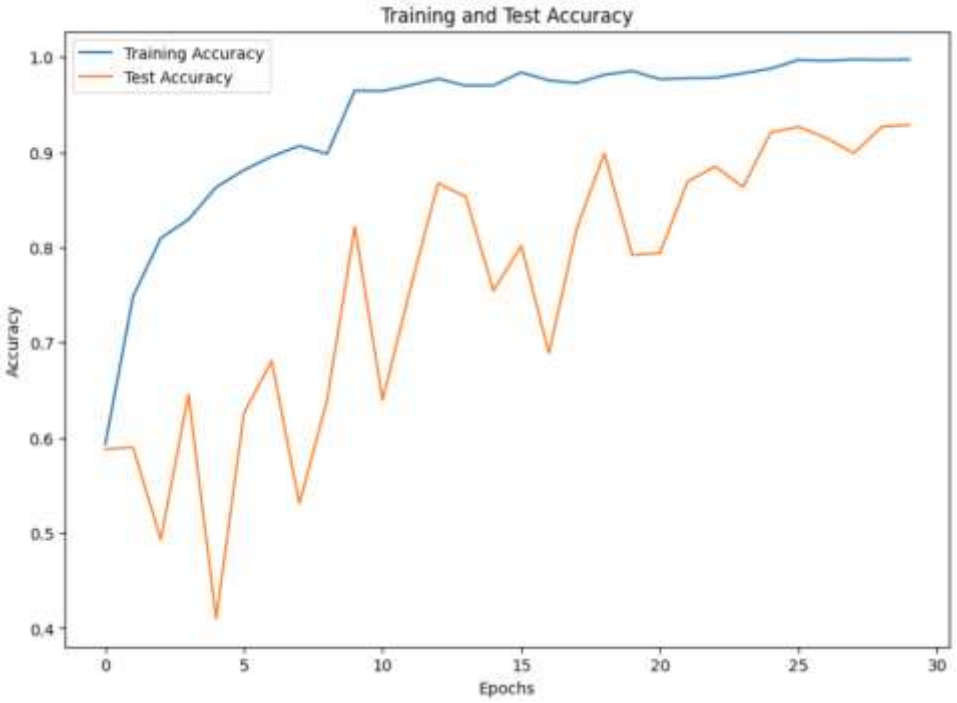

Fig. 5 Accuracy graph of the DenseNET121model

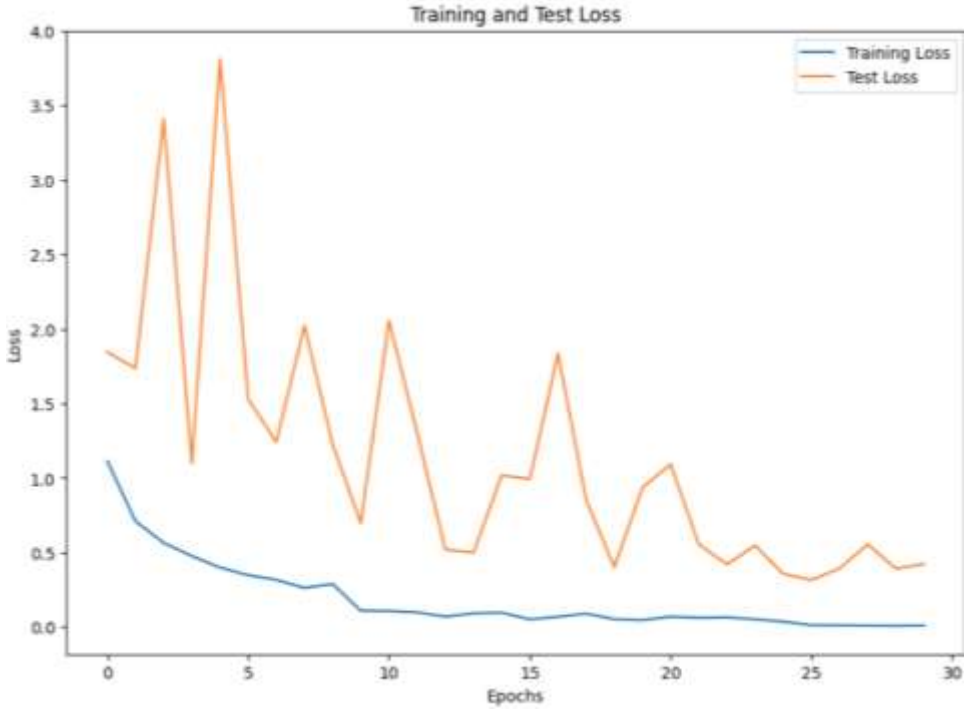

Fig. 6 Loss graph of the DenseNET121model

IV. CONCLUSION

Early diagnosis of sugarcane diseases is important for the agricultural sector and the world economy. Such early detection is therefore vital in raising the bar of agricultural productivity geared towards ensuring sustainable agriculture. The present project involves the use of deep learning models, such as DenseNet121 and MobileNetV3, to diagnose of sugarcane diseases. The results show that the DenseNet121 model outperforms MobileNetV3 with 93% accuracy compared to 90% accuracy of MobileNetV3.

This study establishes that deep learning techniques have the potential to make an effective diagnosis of agricultural diseases and demonstrates the wider applicability of such technologies in agriculture. Early detection of diseases, especially economically important crops like sugarcane, greatly contributes to reducing crop loss and increasing productivity in agriculture. The methodologies of deep learning should help, not only in the diagnosis of diseases but also in predicting trends in the spread of the disease, which will help farmers minimize yield losses and take preventive measures. Improved technologies in the future, with larger datasets and more advanced models, could make the control of diseases related to agriculture even more effective. With the highlighted importance of DenseNet121, high accuracy levels, and improved performance for some diseases, on the other hand, MobileNetV3 is also a lightweight and fast model, so its advantages are obvious in practical applications. This study verifies, once again, the necessity of utilizing deep learning techniques in the diagnosis of agricultural diseases and hence opens the way for fruitful future research.

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Deep Learning in Medical Imaging: EfficientNetB0 vs. Inception v4 for Knee Osteoarthritis Detection

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Abstract – Arthritis is a common health problem that causes inflammatory conditions in the joints and affects millions of people worldwide. Osteoarthritis (OA) is a type of arthritis characterized by the deterioration of cartilage tissue and is common in the knee, hip, hand, and spine joints. The Kellgren and Lawrence classification system for diagnosing OA assesses the severity of the disease on five levels. Modern medical imaging and deep learning algorithms play a critical role in the early diagnosis of OA. Deep learning methods such as Convolutional Neural Networks (CNNs) offer significant contributions to healthcare professionals by providing automatic disease diagnosis from image data. In this study, we compare the performance of CNN-based EfficientNetB0 and Inception v4 models in Knee Osteoarthritis (KOA) diagnosis. Training and test data were separated by k-fold 5 and analyzed. The EfficientNetB0 model achieved 85% accuracy and the Inception v4 model achieved 81% accuracy. While both models showed high success in KOA detection, EfficientNetB0 achieved a significant superiority in the "Moderate" and "Severe" classes. The main contribution of this study to the literature and the field is to provide experts with the ability to make fast and accurate diagnoses, leading to significant improvements in disease management. Furthermore, image-based automated analysis plays a critical role in the early diagnosis of KOA, saving time and resources in clinical practice. In conclusion, both models were found to be effective, but EfficientNetB0 may be a more prioritized option in clinical applications.

Keywords – Deep Learning, EfficientNetB0, Inception v4, Knee Osteoarthritis, Convolutional Neural Network.

I. INTRODUCTION

Arthritis is an inflammatory condition that develops in the joints against body tissue or is caused by external factors (microorganisms, trauma, etc.). Arthritis is a common health problem affecting millions of people worldwide. Arthritis can cause symptoms such as joint pain, swelling, stiffness, and limitation of movement. There are many types of arthritis, but the two most common types are known as Osteoarthritis (OA) and Rheumatoid Arthritis (RA) [1].

OA is a type of arthritis, also called degenerative joint disease, that affects millions of people worldwide. OA is characterized by the gradual deterioration of cartilage in joints. Cartilage is a protective tissue that covers the joint surfaces and prevents bones from rubbing against each other. When the cartilage deteriorates, the bones rub against each other, and this causes pain, stiffness, and swelling [2].

OA is a state where the cells are stressed, and their structure gets deteriorated because of not getting appropriate repair response against minor and major traumas. It causes pain and limits the motion of the joints. The damage done to the cartilage disables the joint's function and leads to a decline in joint function over time. It results in difficulties in activities of daily living and a poor quality of life [3]. OA

can affect any joint in the body but more commonly involves the knee, hip, hand, and spine joints. KOA is a type of OA that affects only the knee joint. OA is becoming more and more common, especially with the aging population and the epidemic of obesity [4]. Various parameters are examined to analyze the width of the patient's joint space in radiographic images examined in the detection of KOA disease. Although there is no strictly defined grading system for the diagnosis of KOA. The classification system created by KL [5] is a method widely used by medical professionals to determine the degree of KOA. This system, called KL, was developed to assess the severity of KOA based on visual analysis of X-ray or MRI images.

The KL system categorizes the severity of KOA into five different levels ranging from 0 (normal) to 4 (severe) [6].

- Level 0: (Normal): Healthy and without any signs of arthritis.
- Level 1 (Suspected): At this stage, the symptoms of arthritis are quite mild and usually not radiologically evident. The patient may experience mild discomfort, but this does not significantly affect the quality of life.
- Level 2 (Minimal): Mild knee pain and stiffness may be present. On radiological images, cartilage loss or minimal changes in the joint can be detected. Mild discomfort is felt during daily activities.
- Level 3 (Moderate): Moderate pain and stiffness are present. These symptoms may increase, especially during movement or later in the day. Radiological examinations show marked narrowing of the joint space and loss of cartilage. Some daily activities may become difficult, and the patient may experience limitation of movement.
- Level 4 (Severe): Severe pain and stiffness are felt both at rest and during movement. Radiological images show extensive cartilage loss, deformities, and bone spurs (osteophytes) in the joint. Daily activities are severely restricted, and the patient may experience significant loss of movement.

Nowadays, medical imaging is of vital importance for the early diagnosis of diseases and the development of effective treatment plans. Especially in the diagnosis of degenerative joint diseases such as OA, the use of methods that require high accuracy and precision is of great importance. In this context, deep learning techniques have made significant advances in the field of medical imaging. The increasing use of deep learning-based methods allows healthcare professionals to make more informed and efficient clinical decisions by partially or fully automating diagnostic processes.

Deep learning algorithms make significant contributions to the early diagnosis of diseases and the improvement of treatment processes by extracting meaningful patterns from complex image data [7]. Especially CNN is successfully used in the field of medical imaging and attracts attention with its ability to automatically diagnose diseases from image data.

In the literature, studies are using deep learning methods for the diagnosis of KOA. Rehman et al. proposed a new hybrid model combining CNN and VGG16 architectures to perform KOA detection [8]. They achieved an accuracy of 93% with the proposed hybrid model. Patil et al. modified the ResNET152 model and achieved an overall accuracy of 81% in predicting the KL score [4]. Touahema et al. developed a new deep learning software called "MedKnee" to support physicians in the diagnosis of knee osteoarthritis based on KL score. This software achieved a 95.36% accuracy rate on the Medical Expert-I dataset and a 94.94% accuracy rate on the Medical Expert-II dataset [9].

In this study, we aimed to detect morphological changes in joints and disease symptoms more precisely by using CNN-based EfficientNet and Inception v4 models in the diagnosis of KOA. While the scalable structure of EfficientNet increases efficiency, the complex features of Inception v4 attract attention with its learning ability. Our research aims to highlight the role of image-based automated analysis in clinical practice by separately evaluating the effectiveness of both models in diagnosing osteoarthritis according to the KL score. The results obtained will contribute to the determination of the most effective method in this field by evaluating the diagnostic accuracy and clinical usability of each model.

II. MATERIALS AND METHOD

A. *Dataset*

X-ray images of the knee used in the study were obtained from the Mendeley Repository [28]. The dataset contains radiographic images of the knees of patients with and without KOA. In total, it consists of 1650 images ranging from 0 to 4 CL ratings. Table 1 details the number of images in the dataset.

Table 1. Dataset image counts

KL Level	Image Counts
Level 0 (Normal)	514
Level 1 (Doubtful)	477
Level 2 (Mild)	232
Level 3 (Moderate)	221
Level 4 (Severe)	206

The dataset is divided into two groups as training and testing according to the k-fold 5 value. Figure 1 shows sample images at 5 different degrees in the dataset.

Fig. 1 Examples of KOA datasets

B. *Inception v4*

Inception v4 is a deep learning architecture developed by Google and offers a deeper and more efficient structure using various cross-connections. This model is an improvement of the previous versions of Inception (GoogLeNet) and Inception v3; it has more parameters and higher accuracy performance [10].

Inception v4 is specifically designed for visual processing tasks such as image classification and object recognition. The model includes a classic CNN architecture with convolution, pooling, and fully connected layers, as well as extended versions of the Inception modules. These modules allow filters of different sizes to be used in parallel, which increases computational efficiency and improves the learning ability of the model.

The Inception v4 model, shown in Figure 2, consists of 48 layers, which contain various building blocks for feature extraction and classification of data. The architecture of Inception v4 allows deeper and more complex features to be learned, making it an effective tool in modern deep learning applications.

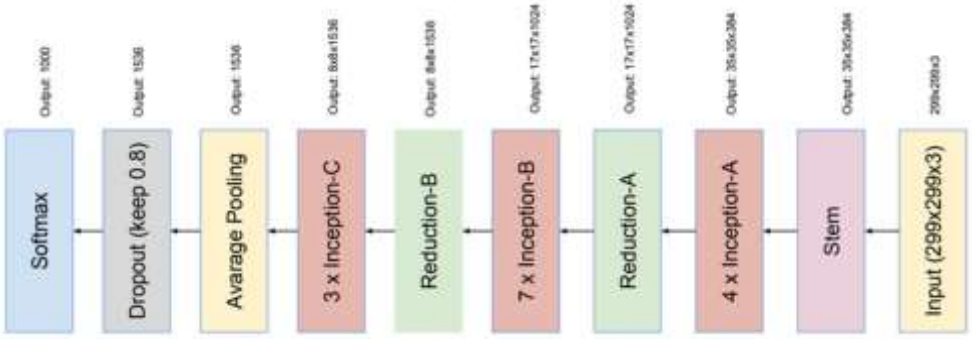

Fig. 2 Inception v4 architecture [11]

C. *EfficientNetB0*

The EfficientNet algorithm is designed to efficiently scale neural network models by increasing depth, width, and resolution [12]. This method uses a composite coefficient to scale all these dimensions equally. Instead of random adjustments, EfficientNet consistently increases the width, depth, and resolution of the network with a given set of scaling parameters. In this architecture, a mobile inversion bottleneck convolution called Mobile Inverted Bottleneck Convolution (MBConv) is used [13].

The basic model in the EfficientNets family is EfficientNet-B0. The structure of this model is based on the MBConv module, which includes the Squeeze-and-Excitation (SE) module. The architecture of the model is shown in Table 2. All layers, except the last fully connected layer, are followed by a batch normalization and a ReLU activation. Downsampling is performed by performing in-depth convolutions in the first block at each stage. Before the last fully connected layer, a global average pooling is performed to reduce the spatial resolution to 1. The classification result is the result of the softmax layer applied to the output of the last fully connected layer [14].

Table 2. EfficientNetB0 architecture [14]

Stage i	Operator $\hat{\mathcal{F}}_i$	Resolution $\hat{H}_i \times \hat{W}_i$	#Channels $\hat{C}_i$	#Layers $\hat{L}_i$
1	Conv3x3	224×224	32	1
2	MBConv1, k3x3	112×112	16	1
3	MBConv6, k3x3	112×112	24	2
4	MBConv6, k5x5	56×56	40	2
5	MBConv6, k3x3	28×28	80	3
6	MBConv6, k5x5	14×14	112	3
7	MBConv6, k5x5	14×14	192	4
8	MBConv6, k3x3	7×7	320	1
9	Conv1x1 & Pooling & FC	7×7	1280	1

EfficientB0 has 230 layers and 7 MB Conv blocks. Each layer in this structure uses the output feature maps of the previous levels as input feature maps. The dense block concept consists of convolution layers of the same size as the input feature maps in EfficientNet. The dense block utilizes the output feature maps of the previous convolution layers to produce more feature maps with fewer convolution kernels [15].

D. *Evaluation Metrics*

In this study, metrics such as accuracy, recall, precision, and F1-score ratios, which are commonly used to evaluate performance in classification or recognition problems, are used. These metrics are used to objectively measure the performance of the model. The equations of the evaluation metrics used are presented below [16], [17].

$$\text{Accuracy} = (TP + TN)/(TP + TN + FP + FN) \quad (1)$$

$$\text{Recall} = TP/(TP + FN) \quad (2)$$

$$\text{Precision} = TP/(TP + FP) \quad (3)$$

$$\text{F1–Score} = 2 * \frac{Recall * Precision}{Recall + Precision} \quad (4)$$

III. RESULT AND DISCUSSION

In this section, the values obtained using EfficientB0 and Inception v4 for the diagnosis of KOA disease are presented. The training and testing processes of the models were performed on Windows 11 Pro 64-

bit operating system, on hardware running with Intel Core i7 processor and 64 GB RAM. Python 3.12 programming language and TensorFlow library were used for coding. The data in the data set was divided into two groups as 80% training data and 20% test data according to the cross-validation (k-fold) value of 5. The study was completed with 1000 epochs for both models. The complexity matrices obtained as a result of the study are presented in Tables 3 and 4, and the accuracy, precision, recall, and F1-Score are presented in detail in Table 5. The accuracy and loss graphs of the Inception v4 model are presented in Figures 3 and 4, and the accuracy and loss graphs of the EfficientNetB0 model are presented in Figures 5 and 6.

Table 3. EffcientNetB0 confusion matrix

		Predict Label				
		Normal	Doubtful	Mild	Moderate	Severe
True Label	Normal	97	6	0	0	0
	Doubtful	24	68	2	2	0
	Mild	0	0	37	2	1
	Moderate	0	1	3	40	0
	Severe	0	1	1	1	38

Table 4. Inception v4 confusion matrix

		Predict Label				
		Normal	Doubtful	Mild	Moderate	Severe
True Label	Normal	84	18	1	0	0
	Doubtful	12	76	6	0	2
	Mild	1	7	31	5	2
	Moderate	0	1	2	40	1
	Severe	0	1	0	3	37

Table 5. Performance results

Model	**Accuracy**	**Classes**	**Precision**	**Recall**	**F1-Score**
EfficientNetB0	0,85	Normal	0,80	0,94	0,87
		Doubtful	0,83	0,71	0,76
		Mild	0,86	0,80	0,83
		Moderate	0,89	0,91	0,90
		Severe	0,97	0,93	0,95
Inception v4	0,81	Normal	0,87	0,82	0,84
		Doubtful	0,74	0,79	0,76
		Mild	0,78	0,67	0,72
		Moderate	0,83	0,91	0,87
		Severe	0,88	0,90	0,89

When the performances of the EfficientNetB0 and Inception v4 models, whose performance results are shown in Table 5, are compared, the EfficientNetB0 model performed better than the Inception v4 model with 85% overall accuracy. The EfficientNetB0 model showed very high performance, especially in the "Moderate" and "Severe" classes, and also achieved satisfactory results in the "Normal" and "Doubtful" classes. In contrast, the Inception v4 model performed lower than EfficientNetB0 in the "Doubtful" and "Mild" classes but offered competitive results by reaching similar accuracies in the "Normal" and "Severe" classes. In general, the EfficientNetB0 model showed superior performance with higher accuracy and F1-Score and therefore stood out as a more effective model in KOA detection.

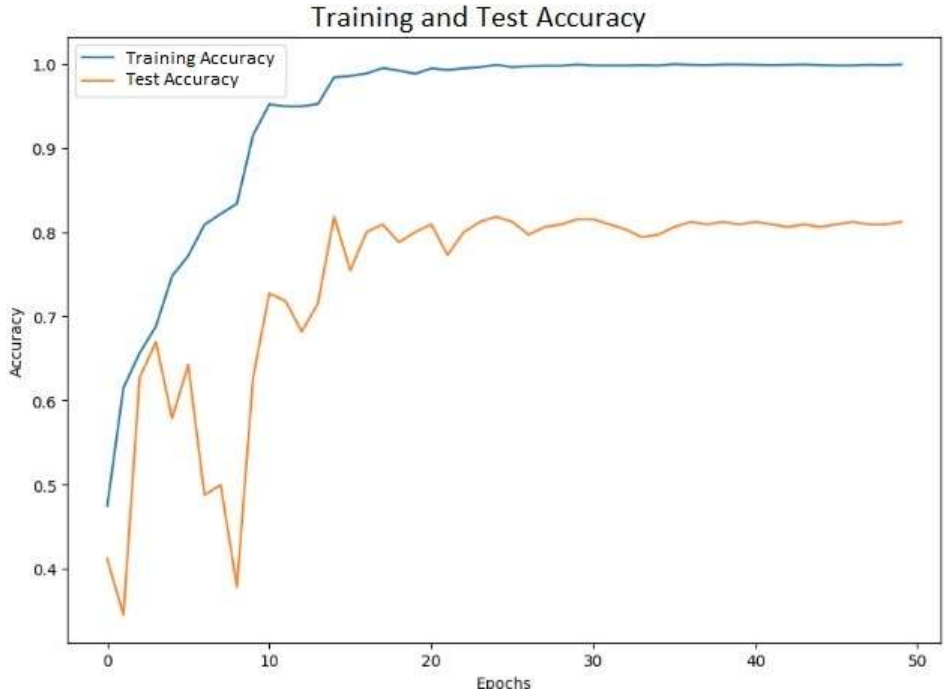

Fig. 3 Accuracy graph of the InceptionV4 model

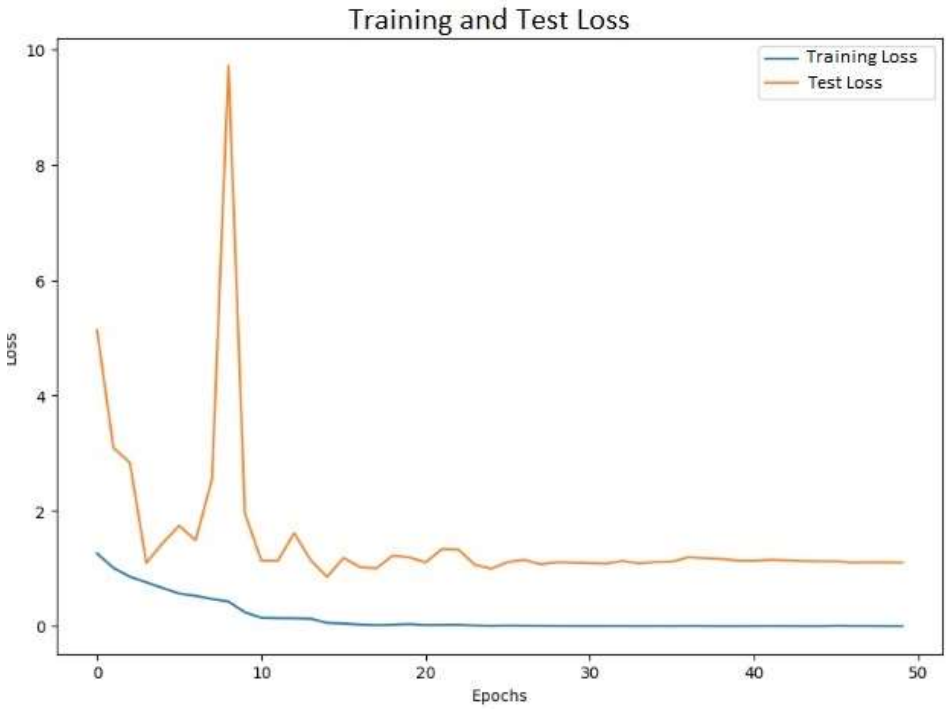

Fig. 4 Loss graph of the InceptionV4 model

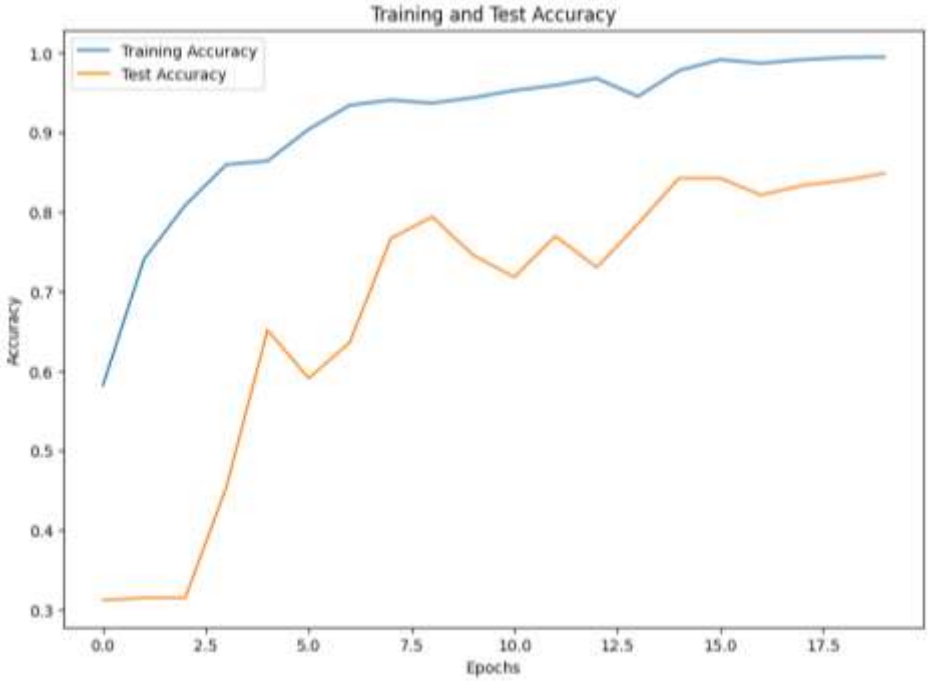

Fig. 5 Accuracy graph of the EfficientNetB0 model

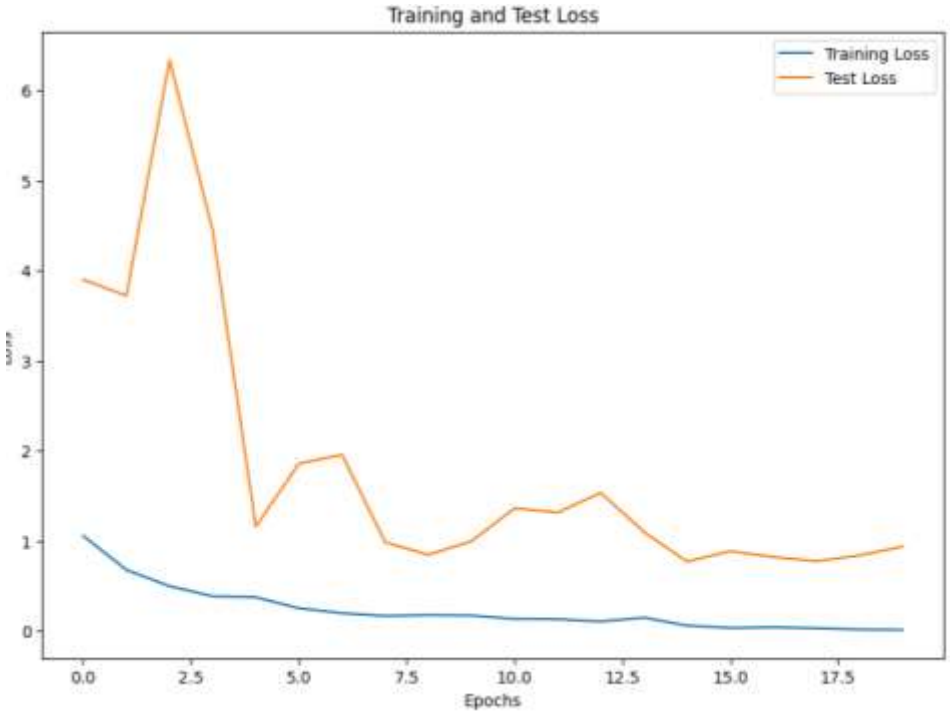

Fig. 6 Loss graph of the EfficientNetB0 model

IV. CONCLUSION

Osteoarthritis (OA) is a degenerative joint disease characterized by the deterioration of cartilage tissue in the joints and affects millions of people worldwide. It is especially seen in the knee, hip, hand, and spine joints and becomes more widespread due to factors such as aging and obesity. The KL classification system used in the diagnosis of OA supports clinical diagnosis processes by evaluating the severity of the disease at five different levels (0-4). Modern medical imaging techniques and deep learning algorithms play an important role in the early diagnosis of OA and the development of effective treatment plans.

Deep learning methods, especially Convolutional Neural Networks (CNNs), provide valuable contributions to healthcare professionals by automating disease diagnosis from image data. In this study, the performances of CNN-based EfficientNetB0 and Inception v4 models were evaluated in the diagnosis of KOA.

In this study, where the data was separated into 80% training and 20% test ratios, the EfficientNetB0 model achieved 85% overall accuracy, while the Inception v4 model achieved 81% accuracy. EfficientNetB0 has shown superior performance, especially in the "Moderate" and "Severe" classes and has given satisfactory results in the "Normal" and "Doubtful" classes. The inception v4 model has shown lower performance in the "Doubtful" and "Mild" classes but has provided competitive results in the "Normal" and "Severe" classes. In general, the EfficientNetB0 model has shown superior performance in KOA detection with higher accuracy and F1-scores and has emerged as a more effective model in this field.

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AISI 1040 Çeliğinin Kuru Tornalanmasında Yüzey Pürüzlülüğü, Kesme Kuvveti ve Kesme Sıcaklığı İncelemeleri

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Özet **–** Bu çalışmada AISI 1040 çeliğinin kuru koşullarda tornalama yöntemi ile işlenmesi esnasında işlenebilirlik parametrelerindeki değişimlerin yüzey pürüzlülüğü, kesme kuvveti ve kesme sıcaklığı üzerindeki etkisi incelenmiştir. Deneyler De Lorenzo S547-8899 torna tezgahında, CCMT 09T308-304 kesici takımı ile gerçekleştirilmiştir. Tam faktöriyel deney tasarımına göre hazırlanan ve her biri iki farklı seviyeden oluşan işlenebilirlik parametreleri, kesme hızı, ilerleme ve talaş derinliğidir. AISI 1040 çeliğinin işlenebilirliğini incelemek için yapılan deneyler sonucunda, belirlenen çıkış parametrelerinin değerlendirmesini yapmak önemli bir yaklaşımdır. Yapılan çalışmada kesme kuvveti değerleri bir dinamometre vasıtasıyla ölçülmüştür. Deney sonucunda yüzey pürüzlülük değerleri için bir profilometre kullanılmıştır. İmalat çeliği olarak da anılan, otomotiv imalat sektöründe sıklıkla tercih edilen malzemelerden birisi olan AISI 1040 çeliğinin işlenebilirliğinin daha iyi anlaşılması amacıyla grafiksel değerlendirme yöntemi kullanılmıştır. Yüzey pürüzlülüğü için ele alınan değerlerden kesme hızı (45 m/dk) ve ilerlemenin (0,2 mm/dev) en etkili parametreler olduğu belirlenmiştir. AISI 1040 çeliğinin işlenebilirliğinde yapılan deneyler sonucunda, kesme kuvveti grafiksel analizine göre ilerlemenin artmasıyla kesme kuvvetinin de arttığı görülmüştür. Böylece ilerleme hızı değerinin kesme kuvveti için belirleyici parametre olduğu sonucuna ulaşılmıştır. AISI 1040 çeliğinin işlenebilirliği konusunda bir diğer unsur olan kesme sıcaklığı değerleri için sıcaklık ölçüm sensörü kullanılmıştır. Yapılan incelemede sıcaklığın talaş derinliğine bağlı olarak değiştiği sonucuna varılmıştır. Kesme sıcaklığı için en yüksek değer, 1 mm talaş derinliği, 0,4 mm/dev ilerleme hızı ve 45 m/dk kesme hızı seviyelerinde ortaya çıkmıştır.

Anahtar Kelimeler – AISI 1040, Kuru Tornalama, Yüzey Pürüzlülüğü, Kesme Kuvveti, Sıcaklık

I. GİRİŞ

İmalat sanayisinde, en önemli üretim şekillerinden biri talaş kaldırılarak yapılan üretimdir. Talaşlı imalat, yeni takımların geliştirilmesi ve teknolojik gelişmelerle birlikte bilim dünyası tarafından gördüğü ilgiyi devam ettirmektedir [1, 2]. Talaşlı imalat türlerinden biri olan tornalama yöntemi, yüksek hassasiyetle işleme, geniş uygulama alanı, hızlı işleme ve teknolojik gelişmelere entegrasyonu gibi özellikleri nedeniyle en çok kullanılan üretim yöntemlerinden biridir [3, 4]. AISI 1040 çelikleri dayanım ve kaynaklanabilme gibi özellikleri nedeniyle otomotiv, havacılık ve uzay sanayisi, kalıp, mil, motor, yatak ve dişli endüstrisinde sıklıkla kullanılmaktadır. İlaveten orta sertlik derecesine sahip olan AISI 1040 çeliklerinin mukavemeti ısıl işlemle arttırılabilir. Talaşlı imalatta ana amaç iyi bir iş parçası kalitesi elde etmek ve malzemeyi istenilen boyutlara getirmektir. Talaş kaldırma işlemi sırasında kesici takım ile iş parçası arayüzeyinde oluşan yüksek sürtünmeden kaynaklı yüksek sıcaklıklar meydana gelmektedir [5-7]. Takım-iş parçası arayüzeyinde meydana gelen aşırı sıcaklıklara önlem alınmaması durumunda kesici takımın çalışma performansı olumsuz olarak etkilenmektedir. Takım ömründe azalma, malzeme özelliklerinin zarar görmesi ve takım aşınmasının artması, yüksek sıcaklıkların negatif etkilerindendir. Bu tür olaylara dikkat edilmemesi durumunda takımın kesme kabiliyeti de kötü etkilenir [8-10]. Buna bağlı olarak kesme

kuvvetleri artar ve istenmeyen yüzey pürüzlülüğüne neden olur [11, 12]. Yukarıda da bahsi geçtiği üzere birçok kullanım alanına sahip olması AISI 1040 çeliğinin işlenebilirliği üzerine araştırmalar yapılmasını gerekli kılmaktadır. Aşağıda AISI 1040 çeliğinin işlenebilirliği üzerine yapılan işleme çalışmalarının bir özeti sunulmuştur.

Kavak ve Üstel, tornalama işlenmesi sırasında işleme parametrelerinin yüzey pürüzlülüğüne olan etkisini incelemişlerdir. Çalışmada AISI 1040 çeliği için işleme sonrası en uygun yüzey kalitesinin eldesi için doğru parametre kombinasyonu belirlenmiştir [13]. Salur ve arkadaşları, yaptıkları çalışmada frezelemede kuru ve minimum miktarda yağlama (MMY) ortamlarında, takım aşınması, kesme sıcaklığı ve güç tüketimi değişimlerini karşılaştırmalı olarak incelemişlerdir. Yaptıkları çalışmada en etkili işleme ortamının MMY olduğunu belirtmişlerdir [14]. Özay ve Küçük, ortogonal ve teğetsel tornalama-frezeleme yöntemleri ile işleme sonrasında yüzey pürüzlülüğünün değişimini incelemişlerdir [15]. Yaka, tornalamada en düşük yüzey pürüzlülüğüne ulaşmak için en uygun işlenebilirlik kesme parametrelerinin belirlenmesini amaçladıkları bir çalışma gerçekleştirmişlerdir. AISI 1040 malzemesinin işlenmesinde ortalama yüzey pürüzlülüğü için en önemli etkiyi ilerlemenin yaptığını belirtmiştir [16]. Kartal ve Gökkaya, malzemenin aşındırıcı su jeti ile tornalanması üzerine bir çalışma gerçekleştirmişlerdir [17]. Uğur ve Öztürk, çalışmalarında AISI 1040 çeliğinin tornalama işlemini gerçekleştirmişlerdir. Hız, talaş derinliği ve ilerleme değerlerinin Taguchi L_9 deney tasarımına göre değerlendirildiği çalışmada yüzey pürüzlülük değerlerindeki değişimler incelenmiştir. Yaptıkları çalışma sonucunda en düşük yüzey pürüzlülük değeri için uygun işleme şartlarının 150 m/dk kesme hızı ve 2 mm talaş derinliği miktarı olduğunu belirtmişlerdir [18].

Literatür araştırmasında da gözlemlendiği üzere AISI 1040 çeliği işlenebilirlik çalışmaları mevcuttur ve bu çalışmanın da hem literatüre hem imalat sektörüne ilave katkı sağlaması amaçlanmıştır. Bu maksatla AISI 1040 çeliğinin kuru koşullarda tornalanmasında işleme parametrelerinin çeşitli işlenebilirlik kriterleri üzerindeki etkisi incelenmiştir.

II. MATERYAL VE YÖNTEM

Deneysel çalışma esnasında De Lorenzo S547-8899 torna tezgâhı ve CCMT 09T308-304 kesici takımı kullanılmıştır. Deneyde kullanılan silindirik formdaki AISI 1040 çeliği, 35 mm çapında, 300 mm boyundadır ve yapılan her bir deney 100 mm işleme boyunda gerçekleştirilmiştir. Tablo 1'de AISI 1040 çeliğinin kimyasal özellikleri gösterilmiştir. Çalışmada kullanılan işlenebilirlik parametreleri, her biri iki seviyeye sahip olan ilerleme, kesme hızı ve talaş derinliğidir. Deney parametreleri ve seviyeleri Tablo 2'de ayrıntılandırılmıştır.

Tablo 1. AISI 1040 kimyasal özellikler (ağırlık %)

P	C	Mn	S	Fe
0,04	0,44	0,9	0,05	Kalan

Tablo 2. Deney parametreleri

Deney Numarası	İlerleme (f:mm/dev)	Talaş Derinliği (d:mm)	Kesme Hızı (Vc: m/dak)
1	0.2	0,5	45
2	0.2	0,5	70
3	0.2	1	45
4	0.2	1	70
5	0.4	0,5	45
6	0.4	0,5	70
7	0.4	1	45
8	0.4	1	70

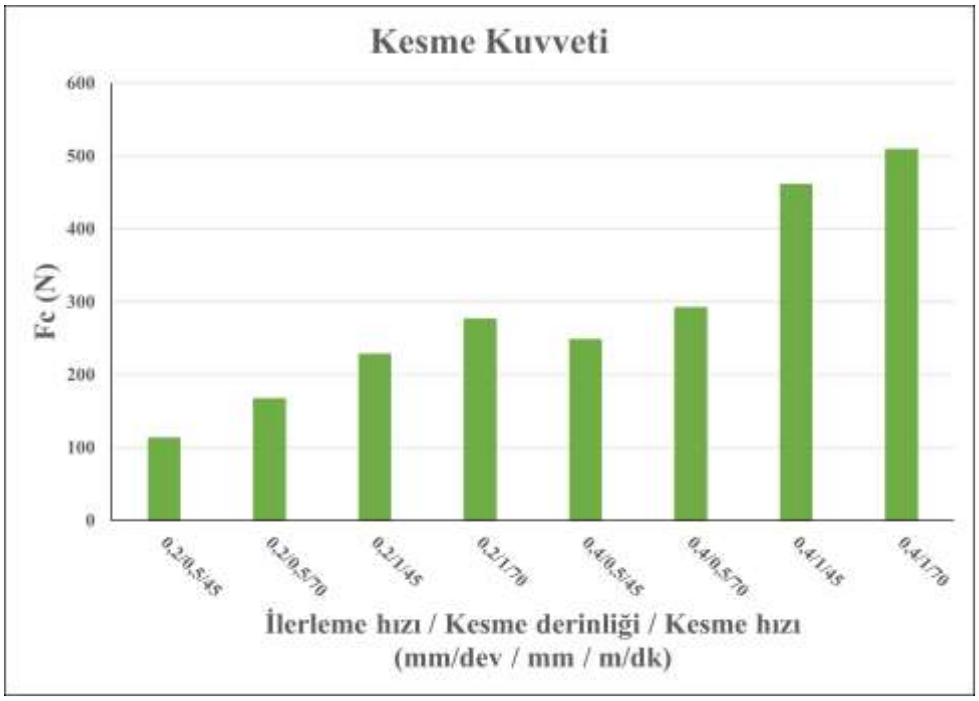
Talaş kaldırma sırasında oluşan kesme kuvveti değerleri bir TelC DKM2000 marka dinamometre yardımıyla ölçülmüştür. Parça işleme sonrasında yüzey pürüzlülüğü bir profilometre ile ölçülmüştür. Markası Mahr Co. Ltd., Goettingen, Almanya olan bu pürüzlülük cihazı ile üç farklı noktadan pürüzlülük değerleri ölçülüp ortalamaları alınarak değerlendirme yapılmıştır. Deneylerin işlem sırasındaki kesme sıcaklıkları, sıcaklık ölçüm sensörü (Telc, Frankfurt, Almanya) ile ölçülmüştür. Şekil 1'de çalışmada deney tezgâhına ek olarak iş parçası bağlantısı ile kesici takım kurulumu gösterilmiştir.

Şekil 1. Deney düzeneği

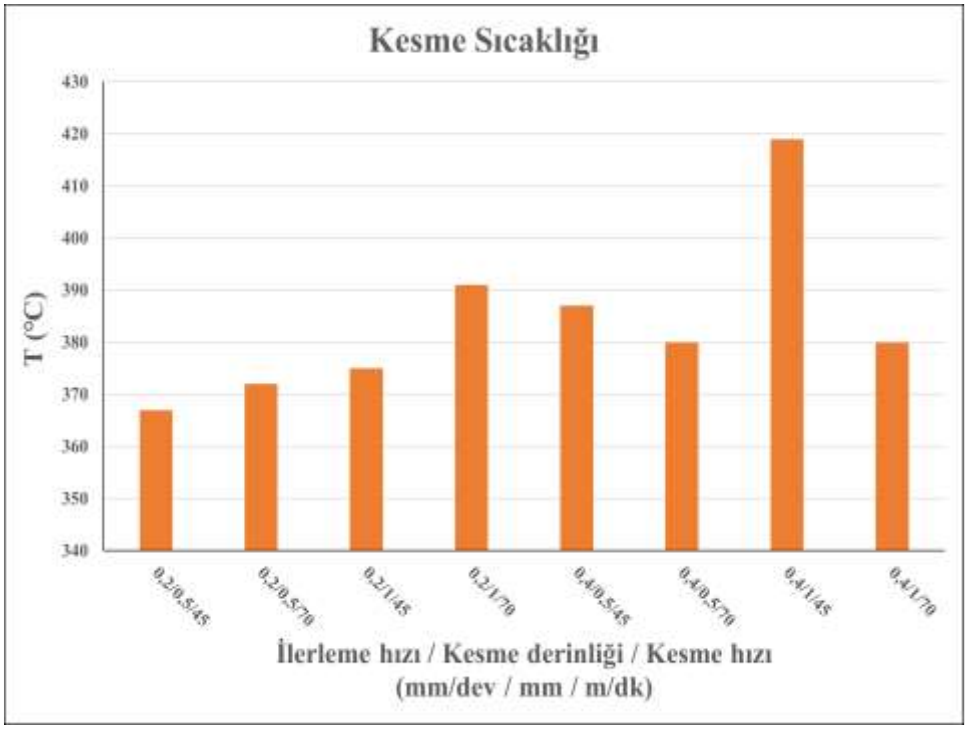
III. BULGULAR

Deney sonuçlarının değerlendirilmesi, grafik oluşturma yöntemi ile gerçekleştirilmiştir. Bunun nedeni, grafik oluşturma yönteminde seçilen parametrelerin etkilerinin, elde edilen verilerle görsel olarak kıyaslanabilmesi ve daha iyi anlaşılabilmesidir. Deneyler iki farklı kesme hızı (45, 70 m/dk), iki farklı talaş derinliği (0,5, 1 mm) ve iki farklı ilerleme (0,2, 0,4 mm/dev) değerleri/seviyeleri belirlenerek gerçekleştirilmiştir. Şekil 2'de yüzey pürüzlülüğünün kesme hızı, talaş derinliği ve ilerleme seviyelerine göre grafiksel değerlendirilmesi verilmiştir. Grafik değerlendirilmesi yapıldığında elde edilen değerlerin 1,5 ve 2 µm arasında değiştiği gözlemlenmektedir. Birbirine yakın değerlerde olan bir ve üç numaralı çalışmalarda düşük yüzey pürüzlülüğü değerleri elde edildiği görülmüştür. Bununla birlikte ilerleme sabit tutulurken kesme hızının artırılmasının yüzey pürüzlülük değerinin olumsuz etkilenmesine yol açtığı, dört numaralı deneyde gözlemlenmiştir. Kesme hızı, talaş derinliği ve ilerleme değerlerindeki değişimlere göre kesme kuvvetinin nasıl etkilendiğine dair grafik Şekil 3'te verilmiştir. Kesme kuvveti grafiği incelendiğinde elde edilen en yüksek değerin sekiz numaralı çalışmada ortaya çıktığı görülmüştür. Bununla birlikte genel olarak kesme hızındaki ve ilerlemedeki artışların, kesme kuvvetinin artmasına neden olduğu gözlemlenmiştir. Deney parametreleri/seviyelerine göre kesme sıcaklığı değişimini sunan grafik Şekil 4'te verilmiştir. Kesme sıcaklığı değişiminin aralığının 300°C ve 400°C civarlarında olduğu grafikte görülmektedir. Ancak en yüksek sıcaklık değerinin yedi numaralı deney sonucunda elde edildiği görülmektedir.

Şekil 2. İşleme parametrelerine göre yüzey pürüzlülüğü değişimi



Şekil 3. İşleme parametrelerine göre kesme kuvveti değişimi



Şekil 4. İşleme parametrelerine göre kesme sıcaklığı değişimi

IV. SONUÇLAR

Çalışmada elde edilen sonuçlar aşağıda belirtilmiştir.

- Yüzey pürüzlülük değerleri için en iyi sonuçlar ilerleme ve kesme hızları değerleridir. Kesme derinliğindeki değişimlerin, yüzey pürüzlülüğü açısından olumlu bir etkisi olduğu görülmüştür.
- Kesme kuvveti sonuçlarına göre tüm işleme parametrelerinin yüksek seviyelerinin kullanılması ile talaş kaldırma oranının artması neticesinde daha büyük kesme kuvvetlerinin ortaya çıktığı görülmüştür.
- Düşük ilerleme değerlerinde kesme hızı artışı ile sıcaklığın önemli ölçüde arttığı görülürken, yüksek ilerlemelerde ise tam tersi durum göze çarpmıştır.

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Frezeleme İşleminde Hava Soğutmalı Ortamın Takım Aşınmasına Etkisi

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Özet – Sürdürülebilir üretimin günümüzde önem kazanmasının en önemli sebepleri daha az maliyetli ve çevre dostu bir üretimin gerçekleştirilme düşüncesidir. Takım aşınması sürdürülebilir üretim açısından oldukça dikkat çeken konulardandır. Bundan dolayı da literatürde takım durumu izleme konusunda birçok çalışma gerçekleştirilmektedir. Bu çalışma kapsamında kaplamalı karbür takımların iki farklı kesme hızı ve ilerleme hızı parametre değerleri ile frezeleme yönteminde davranışı incelenmiştir. Çalışma kapsamında kullanılan St52 diğer çelik türlerine göre daha kolay işlenebilir olduğundan dolayı imalat sektöründe oldukça fazla tercih edilmektedir. Bu sebeple iş malzemesi olarak St52 çeliği seçilmiştir. Deneylerin sonucunda kesme hızının artışıyla takım aşınması değerleri artarken, ilerleme hızının artışıyla takım aşınması değerlerinin azaldığı gözlemlenmiştir. Bununla beraber düşük kesme hızının ve ilerleme miktarlarının BUE oluşumunda etkili olduğu sonucuna varılmıştır.

Anahtar Kelimeler – Takım aşınması, St52, BUE, Kaplamalı Karbür Takım, Frezeleme

I. GİRİŞ

Takım aşınması mekanik ve termal kaynaklı olarak meydana gelebilmektedir. Mekanik aşınma, takım-iş parçası arasında işlem sırasında oluşan sürtünme, titreşim ve darbelerden kaynaklı olarak ortaya çıkarken termal aşınma ise kesici takım ve iş parçası yüzeyi arasında oluşan sürtünme sonucu yüksek sıcaklıkların etkisiyle iş parçasından ayrılan malzemenin takıma yapışması veya yüksek sıcaklıkların kesici takım malzemesini deforme etmesi sonucu meydana gelmektedir [1]. Takım aşınmasını etkileyen ve talaşlı imalatta işlenebilirlik için en önemli parametreler kesme hızı, ilerleme miktarı ve kesme derinliğidir. [2, 3]. Bu parametrelerin düşük veya yüksek seviyeleri takım aşınmasını direkt olarak etkilemektedir. Bahsedilen üç işleme parametreleri için de yüksek seviyelerde işlemin gerçekleştirilmesi iş parçası ve kesici takım arasında yüksek sürtünmenin meydana gelmesine sebebiyet verirken bu durum yüksek kesme sıcaklıklarına da neden olmaktadır. Bununla beraber de takım aşınması değerleri artış göstermektedir. İşleme parametrelerinin yanı sıra iş parçasının veya kesici takımın malzemesi de takım aşınmasını etkilemektedir [18]. Bu sebeple işlem gerçekleştirilmeden önce iş malzemesinin mekanik ve kimyasal özelliklerine uygun kesici takım seçimi yapılması gerekmektedir [2, 4]. Bilindiği üzere çelikler talaşlı imalatta oldukça yaygın olarak kullanılmaktadır. Endüstride bulunan çelik türlerinden daha düşük karbon miktarına sahip olan St 52 çeliği işlenebilirlik açısından oldukça elverişlidir ve az karbon içeriği sebebiyle düşük karbonlu çelik sınıflandırmasına tabii tutulmaktadır. St52 malzemesinin işlenebilirliğinin kolay gerçekleştirilmesinin sebebi yüksek karbon miktarının malzeme mukavemetini arttırması sonucu yüksek olan mukavemetin de işlenebilirliği zorlaştırmasına bağlanabilmektedir [5]. Düşük karbonlu çelikler diğer çelik türlerine göre nispeten daha yumuşaktır fakat olağanüstü tokluk ve sünekliğe sahip olduğundan dolayı otomobil ve inşaat sektörleri gibi oldukça geniş kullanım alanına sahiptir [6]. Malzemenin işlenebilirliğini etkileyen bir diğer parametre de kesme ortamıdır. Kesici takım ve iş parçası arasında oluşan sürtünmenin yarattığı ısı kesme ortamından etkin bir şekilde uzaklaştırılamazsa eğer takımda termal aşınma meydana gelme olasılığı artmaktadır. Bu sebeple talaşlı imalat yöntemlerinde iş parçasında aşırı ısının oluşmasını engellemek, kesici takım ömrünü uzatmak, iş parçası yüzey kalitesini

iyileştirmek ve talaşların kesme ortamından tahliyesini sağlamak için kesme sıvıları kullanılmaktadır [7]. Fakat kesme sıvılarının avantajlarının yanı sıra gelişen dünyanın getirileri ile ISO 14000 standartlarının zorunlu kılınması kesme sıvısı konusunda birçok dezavantaj ortaya çıkarmıştır. Bu sebeple talaşlı imalat sektöründe işlenebilirlik parametrelerinin yanı sıra ekolojik parametreler de göz önüne alınarak geleneksel yağlama yöntemlerine alternatifler aranmaktadır [8]. Alternatif bulma arayışı ilk olarak araştırmacıları kuru işleme yöntemine yönlendirmiştir. Fakat kuru işlemenin takım aşınmasında artışa sebebiyet vermesi bununla beraber de takım ömrünü azaltması, kesme ortamında yüksek sıcaklıkların meydana gelmesi ve düşük performansa sebebiyet vermesi ekolojik koşulların iyileşmesine yardımcı olurken işlenebilirlik parametrelerinde dezavantaj yaratmıştır [9]. Bir diğer alternatif MMY yöntemidir. Bu yöntem kesme ortamına basınçlı hava ile çok az miktarda kesme sıvısının uygulanması esasına dayanmaktadır. Hem kesme sıvısının az kullanılması hem de kesme sıvısının işlem bölgesindeki yüksek sıcaklıkla beraber buharlaşması sonucu herhangi bir atığın oluşmaması gibi sebepler MMY yöntemini oldukça avantajlı kılmaktadır [10]. Ancak MMY yönteminde buğu oluşumu sebebiyle yüksek aerosol konsantrasyonları meydana gelerek operatör tarafından kesme sıvılarının sürekli solunması sağlık açısından bir tehdit oluşturmaktadır [11]. MMY yönteminin araştırmacılara çıkardığı bir başka sorunda süper alaşımların işlenmesi esnasında bu yöntemin ısı transferinin yetersiz kalmasından kaynaklanmaktadır [12, 13]. Bahsedilen dezavantajların önüne geçebilmek için bir diğer alternatif hava soğutmalı ortamda kesme işleminin gerçekleştirilmesidir [14]. Bu yöntemde sürtünme sonucu oluşan ısının kesme alanından uzaklaştırılması için hava, kesme ortamına basınçlı bir şekilde gönderilir. Kesme işlemi sırasında hava soğutmalı ortam kesici takım korozyonunu ve kesme sıvısının sebep olduğu kimyasal reaksiyonu önlenmektedir [15, 16]. Hava tahliyesi ile kesme bölgesinden uzaklaştırılan ısı kesici takım aşınması konusunda pozitif sonuçların elde edilmesini sağlamaktadır. Literatürde halihazırda soğutma gazı olarak hava, nitrojen ve karbondioksit gibi gazlar aktif olarak kullanılmaktadır fakat havanın temin edilmesinin diğerlerine göre daha az maliyetli olması ve operatör sağlığı ile çevre üzerinde olumsuz etkisinin olmaması soğutma gazı olarak havanın tercih edilme sebebinin en başında gelmektedir [17]. Açık literatürde farklı kesme ortamlarında veya farklı işleme parametreleri için takım aşınmasının incelendiği birçok çalışma bulunmaktadır.

Maruda vd. [18] AISI 1045 karbon çeliğinin tornalanması sırasında soğutma koşullarının kesici takım aşınması ve talaş oluşum mekanizması üzerindeki etkisini araştırmışlardır. Çalışma kapsamında kuru işleme, MMY ve fosfat ester bazlı katkılı ve ilave basınçlı MMY yöntemi kullanmışlardır. Sonuç olarak fosfat ester bazlı katkılı ve ilave aşırı basınçlı MMY yönteminde elde edilen takım aşınmasının kuru işleme ile kıyaslandığında %40, MMY yöntemine göre ise %25 azaldığı sonucuna varmışlardır. Takım aşınmasında meydana gelen bu iyileşmenin fosfat ester bazlı tribofilm oluşumu sonucu meydana geldiğini de eklemişlerdir. Şap [19] çalışmasında St52 çeliğinin kuru ve MMY yöntemlerinde yüzey pürüzlülüğü, yanak aşınması ve kesme sıcaklığı parametrelerini frezeleme yöntemi kullanarak değerlendirmiştir. Çalışma sonucunda MMY yöntemi ile gerçekleştirilen deneylerin kuru ortamda yapılan deneylere göre yüzey pürüzlülüğünde %62,37, yanak aşınmasında %9,95 ve kesme sıcaklığında %13,82 oranlarında iyileşme gözlemlemiştir. Dhar ve vd. [20] AISI 4037 çeliğinin kriyojenik kesme koşulunda tornalanmasında kesme sıcaklığı, takım aşınması, yüzey pürüzlülüğü konularında çalışmışlardır. Kriyojenik deneylerde elde ettikleri sonuçları kuru kesme ortamı ve çözünebilir yağ ile soğutma ortamlarında elde ettikleri sonuçlarla karşılaştırmışlardır. Deneylerin sonuçlarında kriyojenik işlemenin kesme performansının çözünebilir yağ ile yaptıkları deneyden daha iyi olduğu, kriyojenik ortamın kesme sıcaklığını önemli miktarda azalttığını, kuru işlemenin maksimum yüzey pürüzlülüğü ve takım aşınmasına neden olduğunu en son olarak da kriyojenik işlemenin diğer yöntemlere göre daha az takım aşınması, daha iyi yüzey kalitesi sağladığı sonucunu raporlamışlardır. Verilmekte olan literatür araştırmalarının kesme ortamıyla ilgili olduğu görülmektedir bununla beraber literatürde işleme parametrelerinin kesici takıma etkisini gösteren çalışmalar da yer almaktadır. Altin vd. [21] Inconel 718'in seramik kesici uçlarla tornalanması sırasında kesme hızının takım yan aşınması ve takım ömrü

üzerindeki etkilerini incelemişlerdir. Çalışma sonucunda optimum kesme hızının 250 m/dak olduğu ve bu hızın üzerinde takım ömrünün negatif etkilendiği, kullanılan iki farklı tip kesici uçtan olan kare tipin, düşük kesme hızlarında yuvarlak tipe göre daha iyi performans gösterdiği bunun sonucu olarak da Inconel 718 malzemesinin işlenmesinde düşük hızlarda kare tip, yüksek hızlarda yuvarlak tip takım kullanılmasını önermişlerdir. Ek olarak yuvarlak tip kesici uçlarda baskın olarak yan yüzey ve çentik aşınması görünürken, kare tiplerde yan yüzey ve krater aşınma çeşitleri görüldüğünü belirtmişlerdir. Wagner vd. [22] Ti-5553 malzemesinin kuru işlenmesi esnasında kesme hızı, takım aşınması ve talaş oluşumu arasındaki ilişkiyi incelemişlerdir. Bu incelemenin sonucunda en uzun takım ömrünün kesme hızının 35 m/dak, en kısa takım ömrünün ise 65 m/dak'da ile elde edileceğini, kesme hızı artışının işleme süresini %20 oranında azaltması ile takım ömrünün da aynı oranda azalacağını buradan da artan kesme hızının takım aşınmasını arttırdığı sonucuna varmışlardır. Benzer bir sonucu Hou vd. [23] de çalışmalarında elde etmişlerdir. Çalışmada Ti-6Al-4V alaşımının parmak frezelemesinde kesme hızının kesme kuvveti, takım aşınması ve kesme sıcaklığı üzerindeki etkisini araştırmaları sonucu, kesme hızının artışının takım aşınmasını arttırmasıyla takım ömrünü azalttığı, kesme hızının belirli bir değere kadar artışının kesme kuvvetini etkilemediğini fakat o değerden sonra arttırdığını bildirmişlerdir. Übeyli vd. [24] Al-4%Cu/B4 Cp kompozitinin frezelemesi esnasında ilerleme hızının takış aşınmasına olan etkisini incelemişlerdir. Sonuçta ise yüksek ilerleme hızlarının ele alınan tüm takım türlerinde takım aşınmasını pozitif etkilediği ve daha düşük takım aşınmasına yol açtığını bununla beraber de kaplamalı takımlarda yan yüzey aşınması konusunda kaplamasız takımlara göre daha iyi sonuçlar elde edildiğini raporlamışlardır. Karakaş vd. [25] B_4C_p takviyeli alüminyum metal matrisli kompozitlerin frezeleme yönteminde kesme hızının takım aşınmasına etkisini araştırmışlardır. Araştırmalarının sonucunda kesme hızının artışı ile takım aşınmasının arttığını ve tüm kesme hızlarında da BUE oluşumunun gözlenmesine rağmen artan kesme hızının BUE boyutunda azalmaya neden olduğunu aktarmışlardır. Jawaid vd [26] Ti-6246 titanyum alaşımının tornalanmasında farklı kesme hızları ve ilerleme hızları için takım aşınmasını değerlendirmişlerdir. Değerlendirmenin sonucunda ilerleme hızının artışı takım aşınmasını arttırırken takım ömrünü azalmıştır. Bu durumu sıcaklıktaki artışın sonucu oluşan plastik deformasyona bağlamışlardır. Aynı sonuç kesme hızındaki artışta da elde edilmiştir. Kesme hızındaki artışla artan sıcaklık takımların mukavemetini kaybetmesine ve bunula beraber de plastik deformasyonuna neden olmasına atfetmişlerdir. Kılıçkap vd. [27] SiC-p takviyeli alüminyum metal matrisli kompozitin tornalanmasında takım aşınması ve yüzey pürüzlülüğünü araştırmışlardır. Sonuç olarak kesme hızının takım aşınmasında en etkili parametre olduğunu bu sıralamayı ilerleme hızının takip ettiğini ve en az etkinin de kesme derinliğinin sağladığını, üç parametrenin de değerlerindeki artışın takım aşınmasını arttırdığını raporladılar. Yüzey pürüzlülüğünün en çok kemse hızından etkilendiğini ve kesme hızının artışıyla yüzey pürüzlülüğünün azaldığını, ilerleme hızının artışının ise yüzey pürüzlülüğünü arttırdığını eklemişlerdir. Debnath vd. [28] yumuşak çeliğin tornalanması esnasında kesme hızı, ilerleme hızı ve kesme derinliği parametrelerini üç farklı seviyede aynı zamanda üç farklı kesme koşulunda deneylerini gerçekleştirmişlerdir. Yanıt parametresinde takım aşınması ve yüzey pürüzlülüğünü irdelemişlerdir. Sonuçta ise yüzey pürüzlülüğünü ilerleme hızı en çok etkilerken takım aşınması için bu parametre kesme hızıdır. Aynı zamanda kesme sıvısı yüzey pürüzlülüğüne %33,1 takım aşınmasına ise %13,7 oranlarında katkı sağlamıştır. Ekinović vd. [29] çalışmalarında St52-3 ve kesilmesi zor malzemeler kategorisine ait nikel bazlı süper alaşım Nimonic 263'ün MMY ortamında tornalama işleminde iki farklı değerlerde kesme hızı, ilerleme hızı ve talaş derinliği parametrelerinde kesme sıcaklığı, kesme kuvveti ve takım aşınmasını incelemişlerdir. Çalışmanın sonucunda MMY yönteminin %25 daha az kesme kuvvetine ve bununla beraber de daha az güç gereksinimine, yüzey pürüzlülüğü açısından daha iyi bir sonucun alınmasına ve MMY yöntemi ile kesme alanında elde edilen daha az kesme sıcaklığı değerlerinin takım aşınmasını azaltmasına bununla beraber de kesme işleminin daha stabil bir şekilde gerçekleşmesi sonuçlarını ortaya çıkarmıştır.

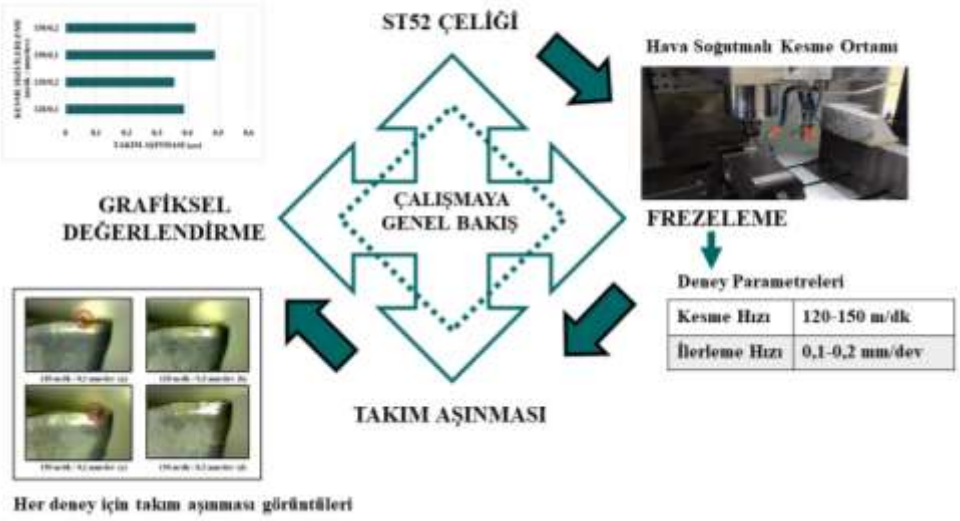
Literatür araştırmasından da görüleceği üzere farklı kesme koşullarında ve farklı parametre seviyelerinde takım aşınması değerlendirmeleri yapılmıştır. Fakat hali hazırda bulunan çalışmaların çoğunluğu takım aşınmasının yanında diğer yanıt parametrelerinin de irdelendiği çalışmalardır. Tek takım aşınmasının incelendiği çalışma sayısı oldukça azdır. Bu yüzden bu çalışmada St52 malzemesinin hava soğutmalı frezeleme işleminde farklı kesme parametrelerinin takım aşınmasına etkisi incelenmiştir. Çalışma sonucunun açık literatüre takım aşınması konusunda katkı sağlaması amaçlanmaktadır.

II. MATERYAL VE YÖNTEM

Gerçekleştirilen işlemde iş parçası olarak St52 malzemesi kullanılmıştır. Tablo 1' de St52 malzemesinin kimyasal bileşimi verilmektedir. İş parçasında frezeleme işlemi 40 mm kesme uzunluğunda gerçekleştirilmiştir. Yapılan deneylerin hepsi 0,5 mm talaş derinliğinde yapılmıştır. Deneylerde kullanılan kesici takım kaplamalı karbürdür ve her deneyin sonunda net bir sonuç alabilmek için kesici takım değiştirilmiştir. Kesme hızının iki farklı (120, 150 m/dk) değeri ile gerçekleştirilen deneylerde ilerleme hızı için de (0,1, 0,2 mm/dev) iki farklı değer kullanılmıştır. Bu veriler ışığında deney sonuçları irdelenmiştir. Çalışma kapsamında irdelenen takım aşınması takım mikroskobu kullanılarak ölçülmüştür. Deneyler Selçuk Üniversitesi Teknoloji Fakültesi Makine Mühendisliği Merkez Laboratuvarında gerçekleştirilmiştir. Şekil 1'de çalışma metodolojisine genel bir bakış oluşturacak ve işlem sürecini anlatan şema verilmektedir.

Tablo 1. St52 çeliğinin kimyasal bileşimi (ağ %) [30].

Malzeme	C	Si	Mn	CR	Ni	Ay	P	S	Ti	Cu
St52	0.16	0.13	0,44	0,04	0,03	0,01	0,01	0,01	0,002	0,04



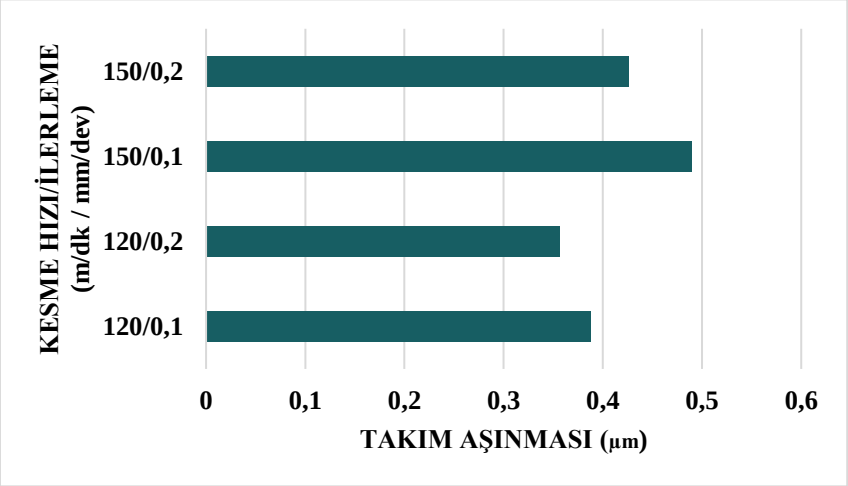
Şekil 1. Çalışma Metodolojisi ve İşlem Süreci

III. BULGULAR

Talaşlı imalat yöntemlerinin günümüzde green manufacturing başlığı altında irdelenmesiyle işlenebilirlikte de bu başlık altında değerlendirilmektedir. İşlenebilirliğin çevre dostu bir yaklaşımla değerlendirilmesinin önemi özünde bu konuyu ilgilendiren birçok noktanın bulunmasıdır. Bu sebeple işlenebilirlik yanıt parametrelerinden birisi olan takım aşınması konusunda deneysel çalışmalar grafiksel ve görseller kullanılarak değerlendirilmektedir.

A. *Grafiksel Değerlendirme*

İmalat sektöründe oldukça fazla kullanım alanına sahip çelik malzemelerin işlenmesi sırasında işleme verimliliğinin arttırılması için takım aşınması faktörü göz önüne alınmak zorundadır. Kesici takımın minimum miktarda aşınmış olması en iyi yüzey kalitesi sonuçları sağlarken maksimum takım aşınmalarında işlem sonunda istenilmeyen negatif sonuçlar elde etmemize sebebiyet verir. Şekil 2'de kesme hızı ve ilerleme hızına göre takım aşınmasının değişiminin grafiği görülmektedir. Grafik incelendiğinde kesme hızının 120 m/dk'dan 150 m/dk'ya çıkarılmasıyla takım aşınması artmıştır. Kesme hızının artışı kesme bölgesinde artan sürtünme ile yüksek kesme sıcaklıklarına sebebiyet verir. Bununla beraber de iş parçası ve kesici takımda plastik deformasyona neden olarak takımın daha kolay aşınmasına neden olur [20]. Grafikten gözlemlenen kesme hızındaki artışla artan takım aşınması durumu buna atfedilebilmektedir. Burada dikkat çekilmek istenen husus ilerleme hızının 0,1 mm/dev olduğu deneylerde kesme hızının 120 m/dk'dan 150 m/dk'ya çıkarılmasıyla elde edilen takım aşınması miktarı %26,03'ken ilerleme hızının 0,2 mm/dev olduğu deneylerde bu artış %19,66'dır. Bu durum ilerleme hızının artmasıyla kesici takımın iş parçasına temasının azalması ve işlem süresinin kısalmasıyla daha az sürtünme ve daha az ısı oluşumuna bağlanabilmektedir. En düşük takım aşınmasının elde edildiği deneyden en yüksek takım aşınmasının elde edildiği deneye göre %37,35'lik bir artış gerçekleşmiştir. En yüksek takım aşınma 150 m/dk kesme hızı ve 0,1 mm/dev ilerleme hızında elde edilirken en düşük takım aşınması kesme hızının 120 m/dk ilerleme hızının 0,2 mm/dev ile gerçekleştirilen deneyde ölçülmüştür.

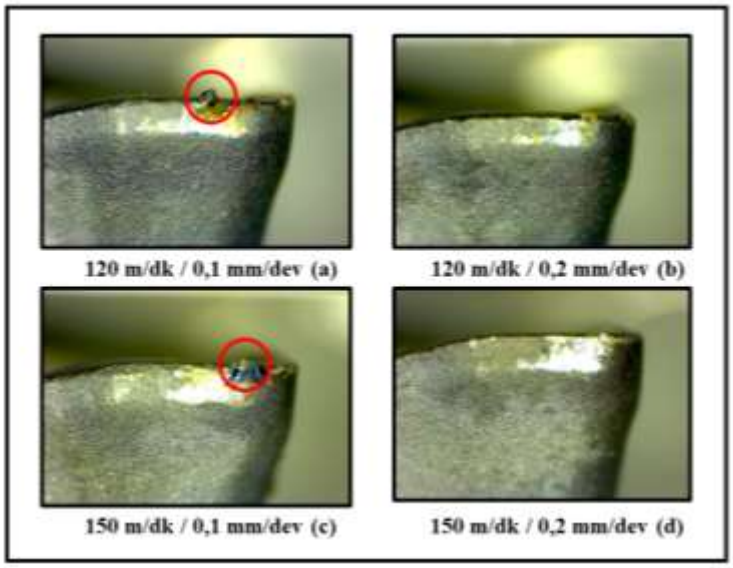


Şekil 2. Kesme Hızı ve İlerleme Parametrelerine Göre Takım Aşınması Değişimi

B. *Görsel Değerlendirme*

Grafiksel değerlendirmede deney sonuçlarının sayısal olarak yorumlanması gerçekleştirildikten sonra bu bölümde deneylerin sonucunda elde edilen görüntüler yorumlanacaktır. Şekil 3'de çalışmanın sonucunda elde edilen kesici takım aşınmalarının görüntüleri görülmektedir. Takım aşınması sertlik, tokluk, ısıl işlemler ve üretim metodları gibi malzeme özellikleri; yarıçap, yaklaşma açısı, kaplama türleri gibi kesici takım özellikleri ve kesme işleminin aralıklı veya sürekli olarak gerçekleştirilmesine bağlıdır [31, 32] Kesici takımda kesme işlemi tamamladıktan sonra farklı çeşitte aşınma mekanizmaları gözlemlenmektedir. Literatürde takım aşınmaları dış köşe aşınması, flank (yan kesici kenar aşınması), hudut aşınması, kavitasyon ve kesici uç aşınması gibi sınıflandırılmaktadır [33]. Şekil 3 incelendiğinde her deneyin sonucunda kesici takımda burun aşınması gerçekleştiği görülmektedir. Burada dikkat çekilmek istenen nokta şekil 3 (a) ve (c)'de kırmızı daire ile gösterilen built up edge (BUE) oluşumudur. Genellikle düşük kesme hızında ve negatif talaş açısı ile kesme kenarının yakınında meydana gelen yığma kenar iş parçasında daha yüksek yüzey pürüzlülüğüne, boyut toleransı üzerinde daha düşük kontrol kabiliyetine ve kesici takımlardaki aşınmanın artış göstermesine sebebiyet verir [34-36]. 120 m/dk kesme

hızında ve 0,1 mm/dev ilerleme hızında built up edge (BUE) oluşumunun sebebi ise düşük kesme hızlarında sıcaklığın düşük seviyerlerde olması ve St52 malzemesinin yumuşak bir çelik türü olmasıyla iş parçasından kesici takıma malzemenin yapışmasıdır. Yüksek kesme hızlarında bu durum artan sıcaklıkla beraber ve kesme ortamıyla rahatlıkla kesici takımdan uzaklaştırılmasıyla BUE oluşumunun az görülmesine sebebiyet verir [37, 38]. Şekil 3 (a) ve (b) incelendiğinde ilerleme hızının artışıyla beraber BUE oluşumunun gerçekleşmediği görülmektedir. Bu durum ilerleme hızının artışıyla kesici takımın iş parçası üzerinde hızlı hareket etmesi sonucu malzeme birikiminin azalması durumuna atıf edilebilmektedir.



Şekil 3. Farklı İşleme Parametrelerine Göre Kesici Takım Aşınmaları

IV. SONUÇLAR

Bu makalenin temel amacı işleme parametrelerinin yumuşak çelik olan St52 malzemesi işlenirken takım aşınmasının nasıl bir değişim gerçekleştirdiğini irdelemektir. Bu amaçla frezeleme deneyleri iki farklı kesme hızı ve ilerleme hızında hava soğutmalı ortamda gerçekleştirilmiştir. Yapılan değerlendirme yöntemi ve literatür taraması ile takım aşınması hakkında detaylı bir analiz sunulmuştur. Çalışmanın bitiminde elde edilen sonuçlar aşağıda özetlenmiştir:

- Kesme hızı değerinin artış göstermesi takım aşınmasını negatif etkileyerek artışa sebebiyet verir. Bunun sonucunda aşınan takımın hem ömrü azalır hem de iyi yüzey kalitesi elde edilemez.
- İlerleme hızının artışı kesme hızının aksine takım aşınması konusunda olumlu sonuç alınmasını sağlamıştır. Artan ilerleme hızı ile daha uzun takım ömrü ve iyi yüzey kaliteli bir sonuç alınır.
- İlerleme hızının ve kesme hızının artış göstermesi BUE oluşumunu azaltır.
- Takım aşınmasının minimum seviyede gerçekleşmesi için düşük kesme hızı değerleri ve yüksek ilerleme hızı değerleri seçilmelidir.
- Optimum sonuçlar kesme hızının 120 m/dk ve ilerleme hızının 0,2 mm/dev ile gerçekleştirilen deneyde elde edilirken takım aşınması için en yüksek değerler 150 m/dk kesme hızı ve 0,1 mm/dev ilerleme hızının kullanıldığı deneyde elde edilmiştir.
- Takım aşınması ile alakalı daha geniş kapsamlı bir analiz için işleme parametrelerinin sayısının arttırılması ve kesme ortamlarının çeşitlendirilmesine başvurulabilir.

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The Effect of Global Warming on Animal Welfare in Sudan

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Abstract – Global warming is a serious problem that has an impact on ecosystems all across the world and has ramifications for animal welfare, particularly in weaker places like Sudan. This article examines how Sudan, a nation known for its varied climate zones and abundant biodiversity, is being affected by global warming in a number of ways. Sudan is dealing with a number of environmental issues, such as protracted droughts, intense heat waves, and desertification, as a result of dramatic climatic changes, including rising temperatures and more unpredictable rainfall patterns. Livestock is a major source of income for many people in Sudan, but it is beset by low production and health problems. Through the investigation, it became clear that there are direct and indirect effects of climate change on animal welfare in Sudan. These factors represent the most important determinants facing the livestock sector in Sudan. Therefore, employing sustainable agriculture methods and enhancing animal resistance to climatic fluctuation are necessary to solve these issues. This will be accomplished by putting into practice thorough mitigation and adaptation plans for these environmental shifts. Additionally, coordinated efforts by governments and researchers are required to guarantee food security in a sustainable manner and lessen the detrimental consequences of climate change on animal welfare.

Keywords – Global warming, Animal welfare, Sudan

I. INTRODUCTION

The Sudanese economy and the general well-being of the populace are heavily dependent on the cattle industry. In addition to providing a steady supply of vital food, it generates a sizable quantity of foreign money through export revenue, serves as a primary mode of transportation, generates draft power to assist agricultural cultivation and processing, supplies dung for fuel and fertilizer, and creates jobs. Just under 50% of all agricultural exports and slightly less than 30% of non-oil exports are the value of exports from the animal industry, on average. Resources allocated to livestock and animal health services do not match the profits made by the industry, despite this sector's importance to the national economy [1]. (Behnke, 2012). In Sudan, the national livestock policy, export and domestic trade regulations, and disease management of cattle fall under the purview of the Ministry of Livestock, Fisheries, and Rangelands. The Ministry, the Pastoralists Union, individual National Assembly members, and other federal and state ministries provide input to the Committee on Agriculture and Animal Resources of the National Assembly, which is the last stop in the creation of livestock policy [2].

In developing countries in Africa, the livestock subsector contributes one-third and more than half of the value of agricultural output worldwide. The growing human population in emerging nations is driving up demand for cattle products. Nonetheless, the subsector of livestock is extremely vulnerable to abrupt changes in the environment. It is predicted that the effects of climate change would increase cattle production systems' vulnerability to newly developing and reemerging diseases. Perhaps the most significant environmental challenge presently affecting the cattle industry is climate change, which also affects natural systems, human livelihoods, and the survival of species [3]. Rising sea levels, longer summer seasons, more warmer days and nights annually, altered rainfall patterns and volumes, and an increase in the frequency and severity of heat waves, droughts, and floods are only a few of the consequences of climate change that have been documented [4]. In order to lessen reliance on imports, a number of African governments and regional organizations are attempting to solve the mismatch between the rising demand for animal products in Africa and the development in local livestock production [5].

Unfavorable climatic changes negatively affect agricultural productivity and food security, especially in low-income nations. Elevations in the frequency and intensity of extreme weather events have the potential to disrupt food production and distribution networks and drive up food costs [6]. The production of livestock is regrettably given less importance in international climate debates than the effects of climate change on crops. It is a reality that indigenous livestock have helped disadvantaged communities survive even in the face of severe crop failure, indicating the urgent need for a paradigm shift. But there are other elements that also pose a danger to the resilience of native cattle, such as excessive climatic fluctuation combined with careless cross-breeding. The capacity of indigenous cattle to adapt to harsh circumstances makes them valuable, especially in light of the current focus on climate change [2].

Animal welfare is an important variable yet in the discussion of climate change, neither it nor the extensive effects animal husbandry has on human health have gotten much attention [7]. For instance, the Intergovernmental Panel on Climate Change's Sixth Assessment Report emphasizes the significance of lowering emissions from animal agriculture, but it makes no mention of One Health or takes into account how mitigation measures may affect animal wellbeing [8]. This absence raises the possibility that certain climate initiatives may unintentionally negatively impact animal welfare and health, undermining public support for those efforts [9]. Livestock production is one of the crucial topics that has to be analyzed and examined since it directly affects people, given the hazards connected with it in light of climate change and its relationship to food security in Africa. Therefore, the aim of this article is to review the impact of climate change on livestock production and animal welfare in Sudan.

II. Global Warming in Sudan

Countries such as Sudan are likely to experience further declines in agricultural yields, leading to negative impacts on rural income and food security [10]. A decrease in precipitation will change the production of hydropower, and an increase in the frequency and scale of floods and droughts will significantly increase the need for public investment in physical infrastructure [11]. Overall, the impacts of climate change on agriculture, the food system, and macroeconomics are expected to be immediate, negative, and stronger than the global average in poor countries in sub-Saharan Africa, the Middle East, and North Africa. This is due to prevailing environmental conditions, less diversified and poor rural economies, and a low level of agricultural development, despite the importance of the sector in generating export revenues and income [10].

Sudan, a country already beset by environmental, social, and economic difficulties, is particularly vulnerable to the effects of global warming [12]. Due to its mostly dry and semi-arid environment, Sudan is especially susceptible to the consequences of global warming. Severe droughts, more frequent heat waves, and greater desertification are the results of rising temperatures and shifting rainfall patterns exacerbating already-existing environmental stressors. The consequences of climate change in Sudan are probably going to vary in how much of an impact farmers have. This is a result of the many effects of climate change on crop yield and price, as well as variations in production mix at the regional and farm levels [10]. The livestock, agriculture, and economy are all predicted to suffer as a result of climate change, particularly in developing countries, including Sudan.

In addition to expected increases in precipitation (expected to rise by 4% each decade) and mean temperature (expected to rise by up to 3°C by 2050), Sudan is expected to have greater rainfall variability and a rise in the frequency of both droughts and floods [13]. While droughts mostly impact the country's northern regions and sections in the middle and middle west, floods, flash floods, and perhaps landslides afflict the country's southern, southeast, and mountainous northeast regions. Pastoralists, low-income farmers, and often impoverished households with elderly members, children, and women are the communities most susceptible to droughts and floods [14]. According to Pereira [15], Sudan's agricultural yield was negatively impacted by high temperatures and variations in rainfall. The impact of these factors was exacerbated by the fact that most Sudanese depend on agriculture and livestock.

As a result of climate fluctuations and human activity, desertification—a phenomen that refers to land degradation in arid, semi-arid, and dry sub-humid regions—is regarded as one of the most serious environmental and socioeconomic issues of our day in Sudan. Deep plowing and surface soil leveling in Sudan's rain-fed agricultural zones increased the soil's vulnerability to wind erosion, which in turn severely reduced the soil's fertility and, in certain areas, resulted in the creation of sand dunes. The ramifications of these patterns on the foundation of natural resources encompass deterioration of the environment, food insecurity, and intensification of disparities among the producers in Sudan [16]. The supply of food in Sudan is under threat from climate change and deteriorating environmental conditions. As a result, in order to overcome these obstacles and develop adaptive skills, sustainable practices must be implemented, and policies that lessen the adverse consequences of climate change must be promoted.

III. The Effect of Global Warming on Animal Welfare in Sudan

Global livestock systems are currently facing significant challenges due to climate change. Feed and water supplies, as well as animal health and productivity, are impacted by global warming and its concomitant changes in mean climatic variables and climate variability. Livestock product production, storage, transportation, retailing, and consumption are all impacted by climate change. It is therefore concerned that the existing livestock systems would not be able to sustain livelihoods and supply the growing demand for animal products [17]. Currently, the livestock industry is crucial to both food security and supply. With regional variations, livestock products (meat, milk, and eggs) account for 15%, 31%, and 4% of the world per capita supply of calories and protein, respectively [18]. In fact, the production of cattle now contributes to climate change and its detrimental cross-sectoral effects globally, accounting for 16–22% of total greenhouse gas emissions. The expansion of livestock farms to meet the rising need for food has resulted in an increased demand for water, mainly for the cultivation of crops used as animal feed [19]. This reflects the importance of the livestock sector as an important source of global food security.

Many studies point to the effects of climate change on the livestock sector, and these effects include all processing, storage, and even access to the consumer in the form of a final product. With the steady acceleration of environmental changes, adaptation options must also be accelerated to avoid the potential damage of climate change to animal welfare [17]. The interplay between climate-related hazards (such as dangerous occurrences and trends), livestock supply chain exposure to these hazards, and the susceptibility of the socioeconomic systems in which they are integrated, results in the risks of climate-related consequences. According to a variety of socioeconomic vulnerability measures at the local and national levels, rangeland communities that are expected to experience the greatest adverse effects of climate change on vegetation are also among the most vulnerable populations globally [20]. Godber and Wall [21] discovered that South Asia was the area most at danger for livestock-based food production. They discovered that LMICs were often more vulnerable than higher income areas, with Sub-Saharan Africa—seven of which were in Eastern Africa—hosting the top decile of vulnerable countries.

Less feed availability and quality, heat stress, infections (from outbreaks and compromised animal immune systems), and animal mortality from extreme weather events such storms, floods, heat waves, and cold snaps are likely to have a detrimental influence on animal productivity and welfare. The impacts are probably going to be bad on a global scale, but in certain areas with harsh winters, higher temperatures could lessen animal cold stress, the amount of energy needed for upkeep, and inside heating [17]. Global climate change puts livestock, which is crucial to Sudanese livelihoods, in particular danger. Thermal stress, which lowers productivity and raises animal death rates, is brought on by high temperatures. Drought and hunger are brought on by a lack of water, which intensifies these issues [22]. Furthermore, as a result of altered climatic patterns, illnesses and parasites spread more widely, endangering the animal's health even more.

While several countries have made it official that they have a duty to safeguard animal welfare, several other nations have implemented laws to that effect. It is important to remember that occasionally, public concern for animal welfare might prevail over environmental considerations. Customers in high-income nations, for instance, are more likely to accept price increases for meat because they care about animal welfare than because they are concerned about sustainability [23]. Agricultural and food policy in general, however, still fail to acknowledge the complex interrelationships that exist between people, animals, and the environment [7]. The regional distributions of infectious livestock illnesses, yearly and seasonal cycles, disease incidence and severity, and vulnerability of cattle to sickness are all potential effects of climate change on infectious livestock diseases [24]. Numerous infectious pathogens that cause illness in cattle are zoonotic, meaning they are susceptible to variations in temperature, moisture, precipitation, and particle matter. Climate also has an impact on some disease transmission pathways more than others. Climate change is most likely to effect diseases that are vector-borne, food-borne, water-borne, and soil-borne, but it is least likely to affect infections that are directly or indirectly transferred by fomite [25]. Many countries including Sudan, have enacted laws protecting animal welfare or have explicitly acknowledged that doing so is their duty.

Through thousands of years, Sudan's livestock breeds have evolved to fit both the challenging physical terrain they live in and the regional agricultural techniques. Given the adaptable genetic traits of Sudan's native livestock breeds, there is therefore a great deal of opportunity for breed improvement, especially in the production of sheep and cattle. Enhancing the cattle industry would require more focus on reducing some of the production barriers. Reduced disease impacts would come from factors like herd health as a

whole, not simply vaccination. Improving the effects of illness would also help animals produce more by allowing them to utilize the few feed supplies more effectively [2]. According to Sinclair et al. [9]., 83% of Sudanese respondents in a study on animal welfare stated that animal welfare laws are important, and almost 99% of them knew what animal welfare meant to some extent. Sudan has a law in place to provide some protection for animals, although there is no significant animal welfare movement or previous literature on the subject. Cruelty is defined in the Animal (Tolerance and Welfare) Act (2015), which also enumerates such operations as transportation, animal production, slaughter, management of stray dog populations, killing for disease prevention, and use of animals for research and teaching [26]. Decades of development programs and policies have supported the horizontal expansion of grain production at the expense of livestock and pastoralism, despite the fact that livestock is essential to Sudan's rural and urban communities. Huge tracts of rangelands and grazing land have been taken over by successive administrations in an effort to advance mechanized and irrigated rain-fed agriculture, which has disrupted social, political, and economic life almost everywhere in the country [2]. Animal welfare is important, especially for those engaged in subsistence agriculture, such as in Sudan.

IV. Conclusion

All food production systems, including livestock production, are seriously threatened by climate change. The majority of producers in developing countries, including Sudan, rely on livestock as a source of income, while it also helps ensure the world's food security by offering customers a variety of vital nutrients. However, due to global climate change, a variety of extreme climatic conditions have a significant impact on the livestock industry. Climate change has an unfavorable impact on animal productivity, development, and well-being, as well as on animal reproduction, the composition of animal products, and access to feed and water. This will negatively affect both the systems used for animal production and the sustainability of this important sector. Consequently, a more thorough study of the numerous environmental pressures and how they affect animal welfare is required. Furthermore, more potent plans for countering and adjusting to these constant changes that jeopardize sustainability ought to be devised.

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Economic Developments in Agricultural Production of Pakistan

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Abstract – Agriculture is important for economic growth of any country because it provides jobs, decrease poverty and gives food security. In Pakistan, agriculture includes growing crops, using water and arable land as resources, and rearing animals for food and other uses. Pakistan's agriculture sector is also essential to the country's growth, food security, and fight against poverty. The nation's abundant natural resources, diligent farmers, and rural communities have all contributed significantly to the growth and development of the economy since the country's independence in 1947. Agriculture also contributes significantly to foreign exchange profits: in 2013/2014, export earnings from Pakistan were around 11% made up of cotton, rice, and leather, another 27% came from ready-made clothing and cotton textiles. Pakistan is primarily an agricultural nation with abundant natural resources, an ideal climate, deep soils, and water supplies; as a result, the nation has enormous potential to produce crops and cattle. Pakistan's economy greatly benefits from the agriculture sector, which generates roughly 21% of the country's GDP, employs 45% of the labor force, and provides livelihoods for 60% of the country's rural population. Despite its immense significance, Pakistan's agricultural sector is growing relatively slow. The main causes of Pakistan's poor yield and stagnant output are a lack of information tailored to the region's needs and a lack of technical expertise at the farm level. Pakistan's economy is based on agriculture, which makes it susceptible to natural disasters. Natural catastrophs have a greater impact on agriculture sector, damaged almost a million crops, had an impact on both the overall agricultural yield and the country's revenue.

Keywords – Agriculture yield, Economic growth, Natural resource, Natural catastroph

I. INTRODUCTION

Agriculture is essential to a nation's growth because it produces jobs, boosts the economy, and guarantees food security. It improves economic stability by supplying raw materials and sustaining foreign exchange gains. Growing agribusiness also promotes rural development, lowers poverty rates, and increases consumer demand for a range of products and services. Moreover, sustainable agriculture strongly contributes to general economic well-being by fostering innovation and environmental stability. In Pakistan, agriculture includes growing crops, using water and arable land as resources, and rearing animals for food and other uses. Punjab is the main agricultural province, producing 18.9% of the country's GDP and employing 42.3% of its labor force. It focuses on wheat and cotton, and both Sindh and Punjab are among the world's top producers of mangoes.

The general public's fuel costs have increased due to Pakistan's dependency on imported petroleum products and currency devaluation, which exacerbates the problems associated with rising diesel prices for farmers.

Pakistan's rural economy and agriculture sector are essential to the country's growth, food security, and fight against poverty. The nation's abundant natural resources, diligent farmers, and rural communities have all contributed significantly to the growth and development of the economy since the country's independence in 1947. For the first forty years of the nation, Pakistan's economic growth was centered on agriculture, which was aided by state investments in roads, irrigation, agricultural technology, and market development. The core of Pakistan's economy has always been the agricultural sector, which includes the subsectors of forestry, fishery, livestock, poultry, and crops. About 40% of Pakistan's GDP was produced by agriculture up to the early 1960s. Since then, the agriculture sector has had positive, although sometimes only modest, expansion at the expense of the industrial and service sectors. Consequently, since 2010, the industrial and services sectors' combined GDP share has increased over 80%, driven mostly by development in the services sector, while agriculture's part of the GDP has decreased by almost 20%. This indicates that while agriculture is still a key tool for reducing poverty in rural areas and across society, it is no longer a primary way of fostering economic growth and development. The agricultural industry continues to be a vital part of Pakistan's economy, despite the country's economy undergoing a gradual but continuous structural shift since the 1960s. First agriculture continues to play a major role in the lives of over half of the nation's people and is crucial to the future of rural communities. Second, agriculture supplies Pakistan's fast expanding population with sources of micronutrients and essential dietary staples. Third, agriculture plays a vital role in many areas of the industrial and services sectors by serving as a vital supply of inputs as well as a significant market for industrial goods like agricultural machinery and inorganic fertilizer. For instance, the manufacture of textiles, which contributed almost 30% of the industrial GDP in 2013–2014, is heavily reliant on the production of cotton grown domestically.

Agriculture also contributes significantly to foreign exchange profits: in 2013/2014, export earnings from Pakistan were around 11 percent made up of cotton, rice, and leather, and another 27 percent came from ready-made clothing and cotton textiles [10]. The rural economy is significantly broader than just agriculture output, even after accounting for these direct contributions. Through a broad and diverse range of businesses, Pakistan's rural nonfarm economy contributes significantly to the nation's output and employment. Between 40 and 57 percent of all rural household income was estimated to come from nonfarm sources in the early to mid-2000s; even households that were exclusively farmers received between 36 and 51 percent of their income from nonfarm rural sources [4, 17, 3]. Pakistan's experience has been in line with the abundance of theoretical and empirical data supporting the centrality of agriculture in economic growth through rural nonfarm activities [11] and intersectoral connections that support industrialization [18].

The agricultural sector and the rural nonfarm economy undoubtedly have a critical role to play in fostering growth and lowering poverty in Pakistan given their connections to the larger economy and the significant portion of the population that is directly supported by agriculture [3]. Therefore, it is especially concerning that agriculture has grown slowly in recent years. Over the course of the four years, the average annual growth rate in agriculture has been just 2.8%. This is almost a full percentage point less than the 3.7 percent growth rate per year that was averaged during the previous decade, 2000–2010, and roughly 2 percentage points less than the 4.6 percent growth rate per year that was averaged between 1990 and 2000. From 2000 to 2010, the agricultural GDP expanded at a pace of 1.3 percent per year per capita, which was much lower than the 2.5 percent growth rate achieved in the 1990s. Furthermore, the agricultural sector's growth rates have lagged those of the rest of the economy. From 2000 to 2010, the services sector grew at a rate of 5.0 percent and 4.3 percent annually, respectively, while the agricultural sector's growth rate was 3.7 percent.

II. Importance of Agriculture

Pakistan is primarily an agricultural nation with abundant natural resources, an ideal climate, deep soils, a good terrain, and water supplies; as a result, the nation has enormous potential to produce crops and cattle [12, 14]. Pakistan's economy greatly benefits from the agriculture sector, which generates roughly 21.00% of the country's GDP, employs 45.00% of the labor force, and provides livelihoods for 60.00% of the country's rural population. By supplying raw materials to agro-based sectors like textile, food processing, sugar, ghee, dairy, paper, leather, etc., agriculture also aids in growth [6]. Despite its immense significance, Pakistan's agricultural sector is growing relatively slowly. Rehman [15] and FAO [5] both revealed how less agricultural productivity we had in comparison to many other nations. According to Abbas et al. [1], the main causes of Pakistan's poor yield and stagnant output are a lack of information tailored to the region's needs and a lack of technical expertise at the farm level. According to Ali et al. [2], Pakistan's economy is based on agriculture, which makes it susceptible to natural disasters. As a result, changes in weather patterns, rising temperatures, and droughts have a greater impact on land and water resources.

Pakistan and other least developing countries (LDCs) rely heavily on agriculture for their economy. An essential component of Pakistan's economy is agriculture, with an annual growth rate of 2.7%, Pakistan's agriculture sector contributes 21% of the country's GDP [7]. 44% of the work force finds work in agriculture, while 62% of those living in rural areas rely on this industry for their livelihood. A significant industry where our ways of living and commercial innovation come together is agriculture. It plays a variety of functions in any country's economy, including those related to food security, the fight against poverty, the industrial revolution, and economic growth particularly in emerging nations [16].
The intersection of economic and fundamental reproduction occurs in agriculture. Three factors contribute to agriculture's economic significance: 1) it supplies the nation with food and fuel for domestic industry; 2) it generates foreign exchange revenues; and 3) it supplies commodities and services for both home and foreign markets. There are approximately 22 million cultivated and 8.3 million uncultivated km^2 in Pakistan's total area of 796,095 km2. Pakistan is endowed with an abundance of natural resources, spanning several biological and climatic zones. Water and arable land are Pakistan's two main natural resources [8]. The Federal Bureau of Statistics for 2015–2016 reports that this industry employs 42.3% of the labor force (36.2% male and 74.5% female), sustains three quarters of the nation's population, and generates a sizable portion of its foreign exchange profits.

Agriculture has a significant role in improving the nation's economy and reducing poverty. Water and land are vital resources for agriculture, and food production is largely dependent on both. Pakistan's population is growing daily, and the country's food needs are rising annually. Important economic resources include food, fiber, and housing, all of which have grown annually along with the population. Asia produces and consumes around 43% of the world's wheat and 90% of its rice. Global population increase, climate change, natural catastrophes, conflict, and civil instability all affect the availability of food. It is difficult for the impoverished to get food when food prices rise because of scarcity. The research states that Pakistan's agricultural industry accounts for 70% of its foreign exchange reserves and employs 47% of the country's overall population. Agriculture plays a major role in Pakistan's economy, food security, and revenue, however these aspects are particularly vulnerable to the impact of unfavorable weather, such as natural catastrophes. Major crops including wheat, rice, sugarcane, cotton, and maize are the foundation of Pakistani agriculture and account for 4.67% of the country's GDP and about 24% of the value added in all of agriculture. Bajra, Jowar, mash, gram, and other minor crops make up 11.36% of the value contributed in all of agriculture and 2.25% of the GDP. Livestock makes for 11.61% of GDP and 58.55% of the value added in agriculture. The value addition of agriculture is 2.06% and the GDP is 0.41%, respectively, from forestry. Agriculture gains 2.17% and the GDP gains 0.43% from fishing.

Climate change will cause Pakistan's wheat output to fall by almost 50% by 2050, with 40% of the food going to the country's home area, where it would be greeted with unconscionable consequences. Pakistan is currently losing millions of dollars because of climate change's detrimental effects on its mango harvests. Pakistan must protect its agricultural sectors as they have an impact on food production [13]. Due to outdated technology, poor management, a lack of production investment, problems with pests and animal illnesses, and financial difficulties, Pakistan's agricultural industry is not performing well, which results in low agricultural growth. Pakistan has an unstable food system, extreme poverty, and little access to food. One-third of the population is thought to be impoverished. Food poverty is around 35% greater in rural regions and 26% higher in urban areas. The lack of food in both rural and urban regions is Pakistan's main concern, which must be solve by government.

III. Agriculture and Economic Loss

Floods mostly affect the agriculture sector, causing harm to the main crops rice, cotton, wheat, and sugarcane, when they occur. Natural catastrophes damaged almost a million crops, had an impact on both the overall agricultural yield and the revenue of the farmers. Droughts in 2014 caused damage to 250,000 bales of cotton output, a 726,000-ton reduction in sugarcane production, and a 217,000-ton decline in rice production. According to the Government of Pakistan [9], livestock is a poor source of revenue for meeting domestic food demands and is a part of the agriculture industry. The economic research states that future crop and farm sector damage would increase inflation, demolish markets and businesses, cause trade imbalances, and ultimately cause Pakistan's economy to decline in comparison to other nations. Flooding caused Pakistan's economy to decline through lost manufacturing, fewer jobs, and a reduction in natural resources. In summary, Pakistan's economic development slowdown was brought on by floods. Pakistan's most significant crop, wheat, was harmed by the 2010 floods. The loss of wheat was 44,896 tons in Punjab, 80,823 in KPK, 5, 41,696 in Sindh, and 321,651 acres in Baluchistan, according to the ministry of food. The largest flood to hit Pakistan in recorded history struck in 2010, destroying over a million acres of crops and causing 2.9 billion dollars' worth of agricultural losses. 200,000 acres of rice, 700,000 acres of cotton, and sugarcane were destroyed by flooding in 2010.

Climate change has also caused havoc in the agriculture sector; for example, intense rains have wrecked 300,000 acres of animal feed, killed 100,000 animals, and damaged around 500,000 metric tons of wheat. Thousands of hectares of wheat that were ready for harvesting were devastated by flooding in 2014. The economic assessment states that the annual loss to Pakistan's over 715,000 affected individuals due to flooding is projected to be US$ 2.7 billion. The economic analysis projects that floods would likely affect 2.7 million people in the future, resulting in a reduction in GDP. To lessen flooding, Pakistan should build dams, create new legislation, and preserve its forests and ecosystem. The government of Pakistan intends to reduce the flooding. The agricultural industry in Pakistan is evolving in terms of composition and structure. Although Pakistan's economy still primarily depends on agriculture, this sector's ability to spur growth and development is declining as a percentage of overall production. While a common trend of economic development is a diminishing percentage of agriculture in GDP and employment, historically the fastest developing countries also have sustained a rise in their agricultural GDP at the same time.

In these nations, even though agricultural earnings increased, the percentage of agriculture in GDP decreased because nonagricultural development happened more quickly than agricultural expansion. Furthermore, Pakistan would find it very challenging to attain strong overall development in the absence of significant agricultural expansion and the ensuing favorable growth linkage effects on nonagricultural sectors, given the significant contribution of agriculture to the country's GDP. A sluggish rate of agricultural expansion may also result in other issues. For example, excessively quick movement of rural people to cities may cause widespread urban unemployment, traffic jams, and political instability if agricultural and rural nonfarm earnings do not continue to expand.

If policies and regulations governing markets for seed, fertilizer, land, and commodities like wheat are strengthened and provide more appropriate signals, markets can play a critical role in giving farmers access to the land, inputs, science, and price incentives required to accelerate productivity to growth. Increased governmental attention to land tenure concerns and rural enterprise development that stimulates growth in the rural economy can lead to even greater possibilities for balanced growth and development. Growing agricultural production and a rise in rural economic activity won't be enough to end rural poverty in Pakistan on their own. Pakistan's chronically high rates of malnutrition, particularly in youngsters. The delivery of public services in rural areas requires more focus, particularly in the areas of community development, healthcare, and education.

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Effect of Different Ratio of Boric Acid Addition on Some Physical and Mechanical Properties of Particle Boards

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Abstract **–**Wood-based composites are widely used in many areas today due to their advantages. In addition to these advantages, wood composites' tendency to burn stands out as a significant disadvantage. Particleboard, as a wood-based board, has widespread use with high production quantities. Especially in social living spaces, wood composites are required to be resistant to burning. Different fire retardant chemicals are used to increase fire resistance. The type and usage ratio of these chemicals affect the physical and mechanical properties of the boards differently. In this study, the effect of BA usage rate on some physical and mechanical properties of particleboards produced by adding melamine urea formaldehyde (MUF) glue and different amounts of boric acid (BA) was examined. In this context, MUF glue is used at 12% in the surface layers, 9% in the middle layer, and BA is used in 4 different rates as 10/20, 10/25, 15/25 and 20/25 in the middle and surface layers (percentage compared to the weight of the fully dry chip), respectively. Particleboard was produced by adding When the results obtained were evaluated, it was determined that the properties of BA-added particleboards were negatively affected compared to the control sample (without BA addition). It was determined that with the use of BA, thickness swelling values increased and mechanical properties MOR, MOE and IB values decreased.

Keywords – Particleboard, boric acid, melamine urea formaldehyde, fire retardant, mechanical properties

I. INTRODUCTION

Wood-based composite materials are widely used in construction, furniture and various industrial applications today, thanks to their advantages. These materials generally offer more economical and sustainable solutions while preserving the aesthetic and mechanical properties of natural wood. While wood composites attract attention with their homogeneous structure and dimensional stability, they also offer additional advantages such as processability and design flexibility [1]. However, one of the disadvantages of these materials is their tendency towards fire. Fire safety is of critical importance, especially in building materials, and therefore the fire resistance of wood composites needs to be increased [2].

Particleboard is one of the most widely used wood composite materials. High production quantity and wide application area increase the popularity of particle boards. Particleboards are produced by pressing wood chips using various binders [3]. Factors such as the size of wood chips used in the production process, the type and amount of binder, pressing temperature and time determine the properties of the final product [4]. Therefore, optimizing the materials used in particle board production is of great importance to increase the performance and durability of the product.

Boric acid is a compound known for its fire retardant properties, and when used on wood-based materials, it can reduce their tendency to burn. At high temperatures during fire, boric acid creates a protective barrier on the surface of wood chips, which delays the burning of the material [5]. However, the effect of boric acid on other physical and mechanical properties of particleboards should also be taken into account.

The amount of glue has a significant effect on the water resistance, mechanical strength and dimensional stability of particle boards [6]. Binders used in particle board production hold the wood chips together and provide the overall structure of the board. The use of different types and amounts of glue significantly affects the performance of particleboards. Melamine urea formaldehyde (MUF) glue is a binder widely used in particle board production, especially for special purposes, with its high adhesion strength and water resistance [7].

In this study, the effect of boric acid used in particleboard production at different glue ratios was examined. In the production of 3-layer particle board, 9% MUF glue was used in the middle layer and 12% in the surface layers. Boric acid was added to the middle and surface layers (percentage relative to the completely dry chip weight) in 4 different ratios: 10/20, 10/25, 15/25 and 20/25. The effect of the amount of boric acid on the physical and mechanical properties of the produced chipboards was analyzed. In this context, the results of the study emphasize the importance of optimizing the quantities and ratios of materials used in particle board production.

II. Materials and Method

A. Materials

In this study, a mixture of 60% coniferous (Larch) and 40% deciduous (Poplar) wood was used as wood raw material. In the study, melamine urea formaldehyde (MUF) glue, which is the most preferred glue in the fire retardant particleboard process in the market, was used. The glue was supplied from a company. The solids content of the glue is 50% and its density is 1.24 g/cm^3. 20% ammonium chloride solution was used as a catalyst in the glue. Boric acid chemical was purchased ready-made from a company. The density of boric acid is 2.71 g/cm^3 and its molecular weight (g/mol) is 1.30 ±0.02.

B. Method

The chips to be used in production were pre-dried to a moisture content of 1-3%. For gluing, a melamine-urea-formaldehyde (MUF) resin with a solid content of 50% was preferred. The melamine content in the MUF glue is 13%. A 20% solid content ammonium chloride solution was mixed into the glue at a rate of 1% as a hardener. In the production of three-layer particleboard, 9% glue was used for the middle layer and 12% for the surface layers. Boric acid was added to the core and surface layers (by the percentage of dry chip weight): 10/20, 10/25, 15/25, and 20/25 at four different ratios.The chips was glued in two stages. In the first stage, the chips were moistened by applying a certain amount of glue. Then, the specified amount of powdered boric acid was applied to the chips. In the second stage, the final gluing process was carried out. A mold with dimensions of 52x52 cm was used in the formation of the mat. The chip spreading process was done manually. The mat was formed by spreading 60% of the chips for the core layer and 40% for the surface layers. The mat was pressed at 30±3 kg/cm² pressure and 180±5°C temperature for 5 minutes to form the particleboard. After cooling, the boards were placed in a conditioning chamber at 20±2°C temperature and 65±5% relative humidity. The samples were climatized in the chamber for one week. The production workflow is given in Fig. 1.

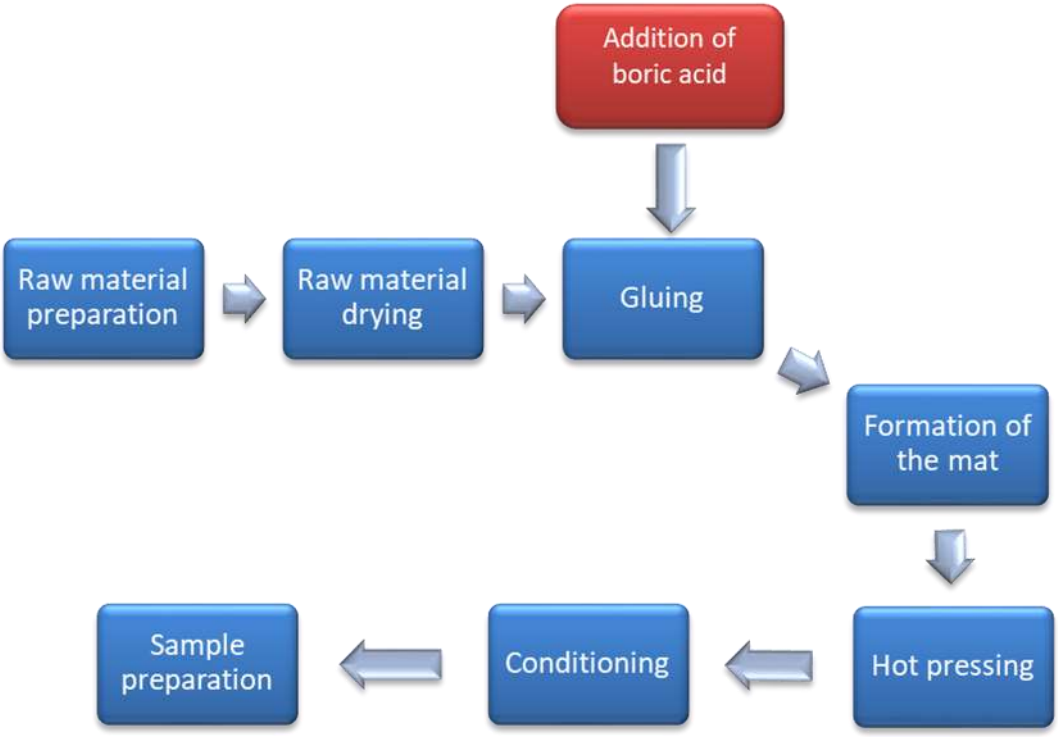

Fig. 1 The production workflow of particleboard

C. *Characterization of particleboard*

The density determination was conducted according to the TS EN 323 standard. Samples were prepared in dimensions of 50x50x18 mm. The 24-hour thickness swelling (TS) tests were conducted in accordance with the TS EN 317 test standard. For presenting the numerical results of the bending strength and modulus of elasticity in bending, the TS EN 310 standard was followed. The samples were rectangular with a width of 50 mm. The length of the samples was adjusted to be 20 times the nominal thickness of the board ±50 mm. In the test device, the length, width, thickness, density, and bending strength results were automatically calculated. The tensile strength perpendicular to the surface was conducted according to the TS EN 319 standards. The sample dimensions were 50x50 mm, and the samples were treated at 65±5% relative humidity and 20±2°C temperature until their weights stabilized. The climatized samples were then glued to metal apparatus blocks of 50x50 mm dimensions using hot silicone. The samples with the apparatus attached were placed back in the conditioning test chamber. Subsequently, the samples were removed for testing and attached to the test device.

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III. RESULTS AND DISCUSSION

In this study, the effects of different boric acid ratios on the physical and mechanical properties of particleboards were examined. The results showed significant differences in parameters such as density, moisture content (MC), thickness swelling (TS), internal bond strength (IB), bending strength (MOR), and modulus of elasticity in bending (MOE) of the particleboards. The density, moisture content, and 24-hour thickness swelling results of the produced particleboards are presented in Table 1.

Table 1. The physical properties of particleboards

Codes	Density (g/cm^3)	MC (%)	TS (%) (24h)
Control	0.66±0.03	6.4±0.62	2.8±0.42
B.A 10/20	0.65±0.02	7.67±0.70	5.63±0.48
B.A 10/25	0.66±0.02	7.22±0.72	5.79±0.56
B.A 15/25	0.66±0.02	7.46±1.10	9.29±1.20
B.A 20/25	0.66±0.02	8.30±1.08	12.11±2.05

The density of all samples was 0.66 g/cm^3, except for the B.A 10/20, but the moisture content increased as the boric acid ratio increased. Notably, the moisture content of the samples with a 20/25 boric acid ratio was measured at 8.30%, showing a significant increase compared to the control group. This result was similar to Ishihara's (1981) findings that boric acid, when used with lithium compounds, slightly increases the equilibrium moisture content [8]. The water absorption rate and thickness swelling values significantly increased with the rise in the boric acid ratio. In the control group, the TS (24h) value was 2.8%, while in the samples with a 20/25 boric acid ratio, this value rose to 121.1%. This indicates that boric acid negatively affects the water resistance of particleboards. These results were consistent with the previous research by Hashim et al. (1994), which found that fire retardants like boric acid do not positive effect water absorption or thickness swelling [9].

The IB, MOR, and MOE results of the produced particleboards are presented in Table 2.

Table 2. The mechanical properties of particleboards

Codes	IB (N/mm^2)	MOR (N/mm^2)	MOE (N/mm^2)
Control	0.75±0.08	17.7±1.6	3020±221.23
B.A 10/20	0.36±0.04	13.42±0.99	1777±117.77
B.A 10/25	0.37±0.11	9.19±0.85	1420±34.64
B.A 15/25	0.26±0.03	9.75±0.79	1574±95.25
B.A 20/25	0.26±0.03	10.30±0.68	1482±133.27

According to mechanical properties, a decrease in both the bending strength (MOR) and the modulus of elasticity in bending (MOE) was observed with the increase in boric acid content. In the control group, the MOR was 17.7 N/mm^2, whereas this value reduced to 13.42 N/mm^2 in samples with a 10/20 boric acid ratio and to 10.30 N/mm^2 in samples with a 20/25 boric acid ratio. Similarly, the MOE values decreased from 3020 N/mm^2 in the control group to 1482 N/mm^2 in the samples with a 20/25 boric acid ratio. These results indicate that boric acid negatively affects mechanical strength. Terzi (2018) stated that common boron-based fire retardants, including boric acid, lead to lower mechanical performance in treated particleboards [10].

The internal bond strength (IB) values also decreased as the boric acid ratio increased. In the control group, the IB value was 0.75 N/mm^2, which dropped to 0.26 N/mm^2 in the samples with a 20/25 boric acid ratio. These results show that the mechanical performance of particleboards is adversely affected by the use of boric acid, especially at higher ratios. Yildirim and Candan (2021) also observed that increasing boric acid content reduced the internal bond strength of particleboards, which is consistent with present study [11].

This study demonstrates that boric acid can negatively impact mechanical properties and water resistance. Therefore, optimizing boric acid ratios in particleboard production is of great importance. Lower boric acid ratios (10/20 and 10/25) may increase fire resistance while maintaining acceptable levels of mechanical properties. However, higher boric acid ratios (15/25 and 20/25) may negatively affect mechanical performance, creating limitations in practical applications. Consequently, the use of boric acid to enhance the fire resistance of particleboards should be carefully optimized considering its effects on the boards' mechanical and physical properties.

IV. CONCLUSION

This study aimed to optimize the physical, mechanical, and fire resistance properties of particleboards produced using different ratios of boric acid. Among the particleboards, the lowest boric acid ratio was 10/20, while the highest was 20/25. The percentage of boric acid in the core layer was kept lower than in the surface layers. The results showed that the addition of boric acid increased the moisture content and water absorption capacity. Specifically, in the samples with 20/25 boric acid, the moisture content rose to 8.3%. Similarly, thickness swelling also increased significantly with the addition of boric acid.

Mechanical test results indicated that properties such as bending strength (MOR), modulus of elasticity in bending (MOE), and internal bond strength (IB) decreased with higher boric acid ratios. Consequently, the optimum boric acid ratio for this study was found to be 10/20. At this ratio, water absorption and mechanical properties remained within acceptable limits. Higher boric acid ratios adversely affected performance, leading to limitations in product standards. This optimized formulation enhances the fire safety of particleboards while maintaining a balanced improvement in other properties.

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Yaşam Döngüsü Analizinin Üniversitelerin Çevresel Etkilerini Hesaplama Metodolojisi Olarak Kullanımı: Literatür Analizi

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Özet – Sanayi devrimi ile teknolojinin gelişmesi, hızlı nüfus artışı ve küreselleşme doğal kaynakların hızla tüketilmesine ve çevresel düzenin bozulmasına neden olmuştur. Sürdürülebilir Kalkınma Hedefleri (SKH) 2030'a küresel düzeyde ulaşmak için sürdürülebilirliği teşvik etmek amacıyla uygulanan çeşitli girişimlere rağmen, üniversitelerin uygulamalarına, söylemlerine ve yönetimine ilişkin anlayış sınırlı kalmaktadır. Üniversitelerin çevresel etkileri çeşitli araçlarla denetlenebilmektedir. Bu araçlardan bazıları; yaşam döngüsü değerlendirmesi, yeşil bina sertifika sistemleri, karbon ayak izi gibi yöntemler ve çok amaçlı doğrusal programlama (MOLP)'dır. Bu çalışmada üniversitelerin çevresel etkilerini ölçmek için yaşam döngüsü değerlendirmesi (LCA) metodolojisi uygulanmaktadır. Üniversite kampüslerinde yapılan LCA çalışmalarını inceleyerek, mevcut uygulamaları, bulguları ve iyileştirme önerilerini sunmayı amaçlamaktadır. Bu çalışmada, 2015-2023 yılları arasında yayınlanan yerli ve ulusalarası akademik makaleler taranmıştır. Google Scholar ve scince direct veri tabanları kullanılarak "üniversite kampüsü", "Yaşam Döngüsü Değerlendirmesi (LCA)" ve "sürdürülebilirlik" anahtar kelimeleri ile arama yapılmıştır. Elde edilen makaleler, LCA uygulamaları, bulguları ve önerileri açısından değerlendirilmiştir.
Araştırmalar sonucunda, incelenen makalelerin çoğu sürdürebilirlik ve karbon ayak izi hesaplamasını ele almıştır. Ancak, LCA yönteminin üniversitelerin çevresel etki hesaplamasında diğer yöntemlere göre daha yeni kullanılmaya başlandığı görülmüştür. Üniversitelerde sadece karbon ayak izine değil, LCA gibi yöntemlerle farklı etki kategorilerini de araştırmak, yük kaymalarını engellemek ve sürdürülebilir politikalar geliştirebilmek adına önem arz etmektedir. Üniversiteler için LCA bilgilerinin kullanılabilirliğini artırmak amacıyla, mevcut LCA standartlarına dayalı olarak amaç ve kapsam tanımı, yaşam döngüsü envanteri ve yaşam döngüsü etki değerlendirmesine ilişkin bu makalede detaylıca açıklanmıştır.

Anahtar Kelimeler – eğitim; kurum; metot; Sürdürülebilirlik; Üniversite; yaşam döngüsü analizi

I. GİRİŞ

2015 yılında tüm Birleşmiş Milletler (BM) üye ülkeleri tarafından kabul edilen 2030 Sürdürülebilir Kalkınma, küresel ve ulusal kalkınma politikalarına rehberlik edecek 17 Sürdürülebilir Kalkınma Hedefi (SKH) içermektedir. Sürdürülebilir tüketim ve üretim, doğal kaynakların sürdürülebilir yönetimi ve iklim değişikliği konusunda harekete geçilerek gezegenin bozulmadan korunması temel hedeflerden biridir [1]. Üniversiteler büyüklükleri nedeniyle "küçük şehirler" olarak değerlendirilebilir ve çevresel etkileri yüksek olabilir [2]. Bunu dikkate aldığımızda bu kurumlarda sürdürülebilir önlemlerin kullanılması son derece önemlidir [3]. Ayrıca, Birleşmiş Milletler'in eğitim yoluyla sürdürülebilir kalkınmanın ilerlemesini teşvik etmek için belirlediği hedeflere daha fazla vurgu yapmış olması da bu durumun bir göstergesidir [4].
Geçtiğimiz on yılda giderek artan sayıda üniversite sürdürülebilirliği kampüslerine dahil etmeye kararlıdır [5]. Literatür incelendiğinde Konu üzerinde çalışan ilk yazarlardan birinin Shriberg [6] olduğu görülmektedir. Okullar ve üniversiteler, çevre üzerindeki potansiyel etkileri konusunda bilgili ve eğitimli

vatandaşların yetiştirilmesinde ve toplumun farkındalığının arttırılmasında önemli bir etkiye sahiptir. Küçük şehirler olarak tanımlanabilen ve sürdürülebilirlik etkilerine önem verilen üniversitelerin sürdürülebilirlik faaliyetlerini değerlendirmek için çeşitli yöntemler de geliştirilmiştir. Sıklıkla kullanılan yöntemlerden biri Endonezya Üniversitesi tarafından geliştirilmiş olan GreenMetric (UI GreenMetric) puanlamasıdır [7]. Ayrıca, QS Dünya Üniversite Sıralaması, üniversitelerin resmi olarak tanınan bir iklim eylemi veya sürdürülebilirlik grubunun üyesi olup olmadığı veya üniversite müfredatının iklim bilimi veya sürdürülebilirlik konularını içerip içermediği gibi çevresel ve sosyal etkileri değerlendirmek için 8 gösterge kullanarak üniversiteleri sıralamak için bir metodoloji geliştirmiştir [8].

Yaşam Döngüsü Analizi (LCA), sürdürülebilirlik kavramıyla yakından ilgilidir. LCA çerçevesinde, dünya çapında bugün ve gelecekte etkileri olan, İklim Değişikliğini azaltan düşük karbon emisyonu stratejilerini teşvik etmek amacıyla karbon emisyonları sürdürülebilir kalkınmanın bir göstergesi olarak kullanılmaktadır. LCA, bir ürün, hizmet veya faaliyetle ilgili potansiyel çevresel yükleri değerlendirmek için kullanılan standartlaştırılmış niceliksel ve niteliksel bir yöntemdir [9].

LCA, bireylere ve kurumlara günlük faaliyetler ile potansiyel çevresel etkiler arasındaki ilişki hakkında bilgi sağlamak, en büyük potansiyel çevresel etkilerin kaynaklarını belirlemek, daha sürdürülebilir uygulamalara yönelmek ve daha etkili azaltım önlemlerini benimsemek için uygulanabilir [10]. LCA'yı diğer karbon ayak izi hesaplama yöntemlerinden ayıran en önemli özelliklerinden biri de, farklı etki kategorilerinde çevresel etkilerin tespit edilmesine imkan vermesidir. Bir ürün ya da hizmetin, potansiyel çevresel etkisi sadece karbon salınımlarını kaynaklı karbon ayak izi ya da buna bağlı iklim değişikliği potansiyeli değildir. Bir ürün ya da hizmetin, asidifikasyon, ötrofikasyon, su tüketimi ve abiotik kaynakların tüketilmesi gibi farklı kategorilerde etkileri olabilir. Çevresel faaliyetleri tespit ederken ya da emisyon azaltım hedeflerini belirlerken, sadece karbon ayak izine odaklanmak, yük kaymalarına ve farklı kategorilerdeki potansiyel etkilerin artmasına neden olabilir. LCA, geniş perspektifi ile bu riskin önüne geçmeye imkan verir. Ayrıca LCA, yaşam döngüsü düşüncesini sürekli iyileştirmeye koymak amacıyla sistemi değiştiren yönleri değerlendirmek için bir metodoloji sağlar. Literatürde LCA yaklaşımını kampüs öğrenme deneyimleriyle birleştiren birçok örnek halihazırda mevcuttur. Üniversite kampüslerinin sera gazı emisyonlarının azaltılmasında, atıkların yönetilmesinde ve farkındalığın arttırılmasında aktif rol oynadığı belirtilmektedir [11].

Üniversitelerin geleceğin akademik çalışanlarını ve profesyonellerini yetiştirmedeki çarpan rolü nedeniyle sürdürülebilir kalkınmada önemli bir rolü vardır. Ayrıca üniversitelerin büyüklükleri, çalışan sayıları, inovasyon ve geleceğin teknolojileri üzerindeki etkileri nedeniyle başlı başına sürdürülebilirlikle ilgili bir sektördür. Öğrencilerin ve personellerin işe gidip gelme davranışları ve Üniversitelerin yüksek enerji ve su tüketimi, büyük miktarda emisyona ve çevre kirliliğine neden olmaktadır. Çoğu Üniversite ayrıca kampüs içi operasyonları sağlamak için kapsamlı bir altyapıya ve mal ve hizmet stoklarına sahiptir. Üniversiteler, toplanması ve işlenmesi enerji gerektiren ve emisyonlara neden olan, özellikle organik atıklar olmak üzere çok fazla atık üretir [12].

Literatürde öğrencilerin ulaşımındaki karbon ayak izinin ölçülmesi [13], toplu taşıma kullanımı, daha az enerji tüketen cihazlar, kaynakların verimli kullanılması, diğer olası uygulamaların yanı sıra boş odalarda ışıkları kapatması [14], Aynı zamanda su tüketiminin azaltılması [15], üniversitelerde suyun arıtılması [16] ve ağaç dikimi [17] gibi ile ilgili eylemleri de içermektedir. Tüm bu faaliyetler dikkate alındığında, üniversiteler potansiyel çevresel yükleri ve bu yüklerin minimize edilmesi için çevresel etki analiz çalışmalarının yürütülmesi önem arz eden kurumlar olarak göze çarpmaktadır. Bu çalışma, literatürde üniversitelerin potansiyel çevresel etkilerini LCA yöntemi ile inceleyen çalışmalara ait bir özet sunmaktadır. Böylece, üniversiteler için LCA yöntemini tanıtmayı ve kritik noktaları vurgulayarak çalışmacılara bir perspektif sunmayı hedeflemektedir.

Yaşam Döngüsü Analizinin tarihsel gelişimi:

LCA fikri, çevresel bozulmanın ve özellikle kaynaklara sınırlı erişimin endişe yaratmaya başladığı 1960'larda ortaya çıktı. LCA olarak kabul edilen ilk çalışmalar, kaynak ve enerji verimliliği, kirlilik kontrolü ve katı atık gibi çevresel konuların geniş kamuoyunu ilgilendiren konular haline geldiği bir dönem olan 1960'ların sonu ve 1970'lerin başlarına dayanmaktadır [18].

ilk çalışmalardan biri, 1969 yılında Coca Cola Şirketi için Midwest Araştırma Enstitüsü (MRI) tarafından yürütülmüştür. Aynı enstitünün 1974 yılında ABD Çevre Koruma Ajansı için yaptığı çalışmalar [19] bugün bildiğimiz şekliyle LCA'nın gelişiminin başlangıcı oldu.
1970'li ve 1980'li yıllarda farklı yöntemler kullanılarak ve ortak bir teorik çerçeve olmadan üniversite ve sanayi arasındaki işbirliğiyle gerçekleştirildi.
1990-2000 yıllarda dünya çapında bilimsel faaliyetlerde ve koordinasyon faaliyetlerinde dikkate değer bir büyüme görüldü; bu on yılda düzenlenen ve üretilen LCA kılavuzları [20] geliştirilmiştir. Ayrıca ilk bilimsel dergi Journal of Cleaner Production, Resources, Conservation and Recycling, International Journal of LCA, Environmental Science & Technology, Journal of Industrial Ecology ve diğer dergilerde LCA hakkında yayınlanmaya başlamıştır. Çevresel Toksikoloji ve Kimya Derneği (SETAC), Kuzey Amerika ve Avrupa şubeleri aracılığıyla, LCA çerçevesinin, terminolojisinin ve metodolojisinin sürekli iyileştirilmesi konusunda işbirliği yapmak üzere LCA uygulayıcılarını, kullanıcılarını ve bilim adamlarını bir araya getirmede öncü ve koordine edici bir rol oynamaya başlamıştır. SETAC'ın yanı sıra, Uluslararası Standardizasyon Örgütü (ISO) da 1994'ten bu yana LCA'ya dahil olmuştur. SETAC çalışma grupları yöntemlerin geliştirilmesi ve uyumlaştırılmasına odaklanırken, ISO, yöntem ve prosedürlerin standartlaştırılması şeklindeki resmi görevi benimsemiştir. Şu anda iki uluslararası standart vardır:
LCA, Uluslararası Standardizasyon Örgütü (ISO) tarafından yayınlanan ISO 14040-2006 ve ISO 14044-2006'ya göre gerçekleştirilmektedir [21].
2014 yılında LCA'yı kuruluşlara özel olarak tanımlayan ISO 14040/44'e ek olarak ISO/TS 14072 yayımlandı (organizasyonel yaşam döngüsü değerlendirmesi, O-LCA) (Uluslararası Standardizasyon Örgütü, 2014). Bunun üzerine, Birleşmiş Milletler Çevre Programı'nın (UNEP) girişimi, Çevresel Toksikoloji ve Kimya Derneği (SETAC) ile birlikte 2015 yılında LCA veya kuruluşlar için UNEP/SETAC kılavuzu olarak bilinen bir kılavuz yayınladı.
ISO/TS 14072 tarafından sağlanan kuruluşların LCA çerçevesine ve literatür taramasından elde edilen bulgulara dayanarak, üniversitelerin LCA'sına yönelik metodolojinin farklı yönleri tartışılmaktadır. Önerilen metodoloji, ISO/TS 14072'nin yapısına dayalı olarak sunulmaktadır ve aşağıdaki hususları kapsamaktadır:
1.Amaç ve kapsam
Amaç tanımı, LCA'nın temasını belirler ve kapsam tanımı için bir temel sağlar. Kapsam tanımı, hedef tanımına dayalı olarak gerçekleştirilir ve değerlendirilecek ürün veya sistem ile bu değerlendirmenin kapsamı vurgulanır. Kapsam, incelenecek sistemi, sistem sınırını, işlevini ve işlevsel birimini içermelidir [22].
2. Yaşam döngüsü envanteri (LCI)
Envanter analizi, incelenen sistemin modellenmesi için verilerin toplanması, işlenmesi ve analizi ile ilgilidir. Malzeme girdileri arasında ham maddeler, enerji ve doğal kaynaklar yer alırken, ürünler, emisyonlar ve atıklar malzeme çıktılarına örnektir [23].
3. Yaşam döngüsü etki değerlendirmesi (LCIA).
Çevresel etkilerin öneminin vurgulandığı, envanter analizi sonuçlarını kapsayan, sonuçların yorumlanması için gerekli bilgiyi sağlayan basamaktır. LCI'da kullanılan akışların fiziksel miktarına dayalı olarak ürün sisteminin potansiyel çevresel etkilerinin ölçülmesini amaçlamaktadır [24].
4. yorumlama
LCA'nın son aşamasıdır ve çalışmanın sonucunun analizini ve yorumlanmasını içerir. Yorumlama, verilerin kalitesi, yapılan varsayımlar ve çalışmanın amacı ve kapsamı dikkate alınarak yapılır [25].

II. MATERYAL VE YÖNTEM

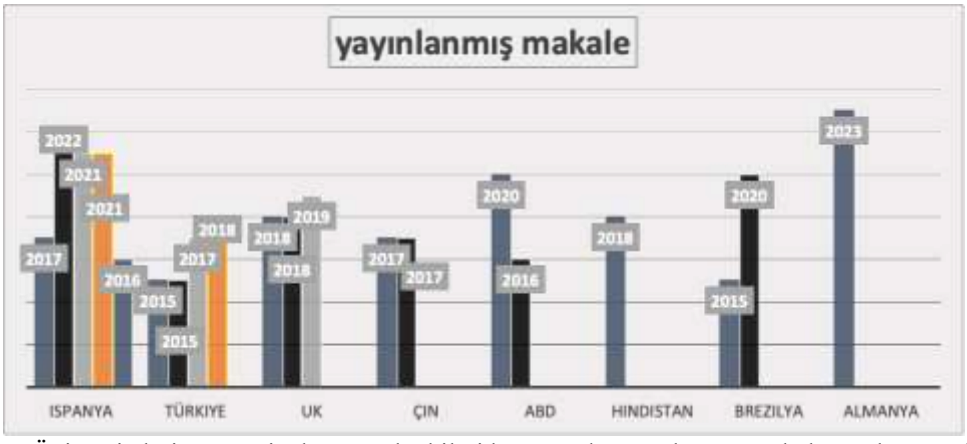
üniversitelerin çevresel değerlendirmesine yönelik mevcut yaklaşımlara genel bir bakış sağlamak için bir literatür taraması yapılmıştır. Literatür taramasının amacı, şu ana kadar kullanılan metodolojik yaklaşımların yanı sıra üniversitelerin sıklıkla değerlendirilen faaliyetlerini ve değerlendirilen potansiyel çevresel etkileri belirlemekti. Bu amaçla, bir üniversiteyi, bir kampüsü veya fakülteyi çevresel olarak değerlendiren yayınlar belirlenmiştir. Daha sonra bu yayınlar metodoloji seçimleri, envanterlerinde yer alan faaliyetler, ürünler ve değerlendirdikleri çevresel etki kategorileri açısından incelenmiştir.

yaptığmız çalışmada, 2015-2023 yılları arasında yayınlanan yerli ve ulusalarası akademik makaleler taranmıştır. Google Scholar, scince direct ve Web Of Scince veri tabanları kullanılarak "üniversite kampüsü", "Yaşam Döngüsü Analizi (LCA)" ve "sürdürülebilirlik" anahtar kelimeleri ile arama yapılmıştır. Elde edilen makaleler, LCA uygulamaları, bulguları ve önerileri açısından değerlendirilmiştir.

III. BULGULAR

Yayınların Amaç ve Kapsam yönünden incelemesi:

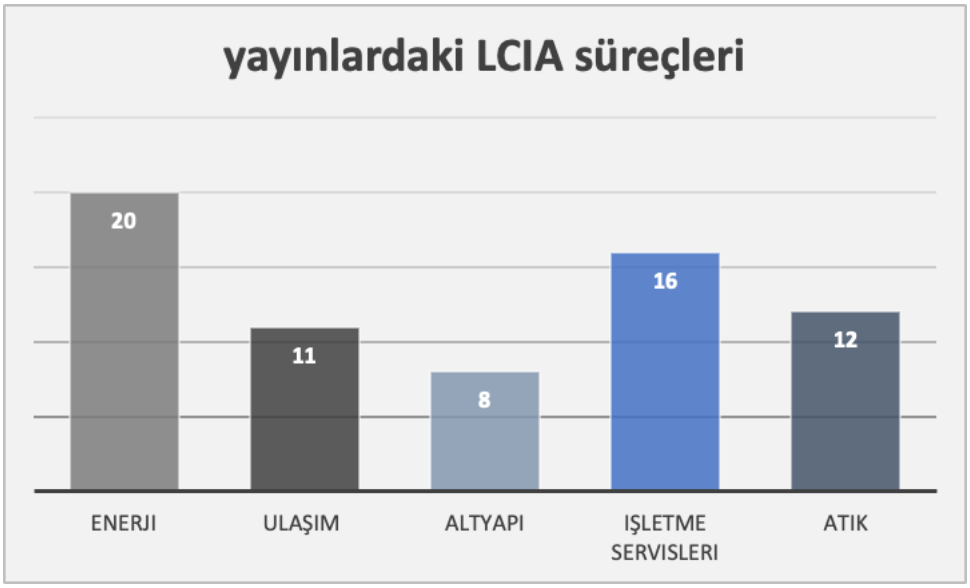
Detaylı analiz 20 makaleyi incelerken, Şekil-1'de sadece 8 ülke belirlenmiştir. Çalışmaların kaynaklarına bakıldığında, yayınların yaklaşık %25'inin İspanya'dan geldiği görülmektedir. Liste Türkiye, Çin, UK ve ABD ile devam etmektedir.



Şekil 1. Yıllara Göre Üniversitelerin potansiyel çevresel etkileri konusunda yayınlanmış makale sayıları ve ülke bazlı dağılım.

Literatür taraması için dikkate alınan yayınlardan çoğu yaşam döngüsü değerlendirmesi için tamamen LCA'ya yöntemine dayanmaktadır. İncelenen yayınların bir kısmında [32,45] LCA'nın özellikle karbon ayak izi hesabı amacıyla diğer metodolojilerle birlikte kullanıldığı belirtilmektedir. Çalışmanın bir kısmı ise [40] sera gazı değerlendirmesine odaklanmaktadır.

Yayınların yaşam döngüsü envanterleri (LCI'ler), Seçilen makaleler (20), şekil 2'de özetlendiği gibi, farklı kategorilere ayrılmaktadır. enerji tedariği, altyapı, işletme servisleri (su , yemek), ulaşım ve atıktır. her bir çalışmada yer alan kilit alanları belirlemek için analiz edildi.

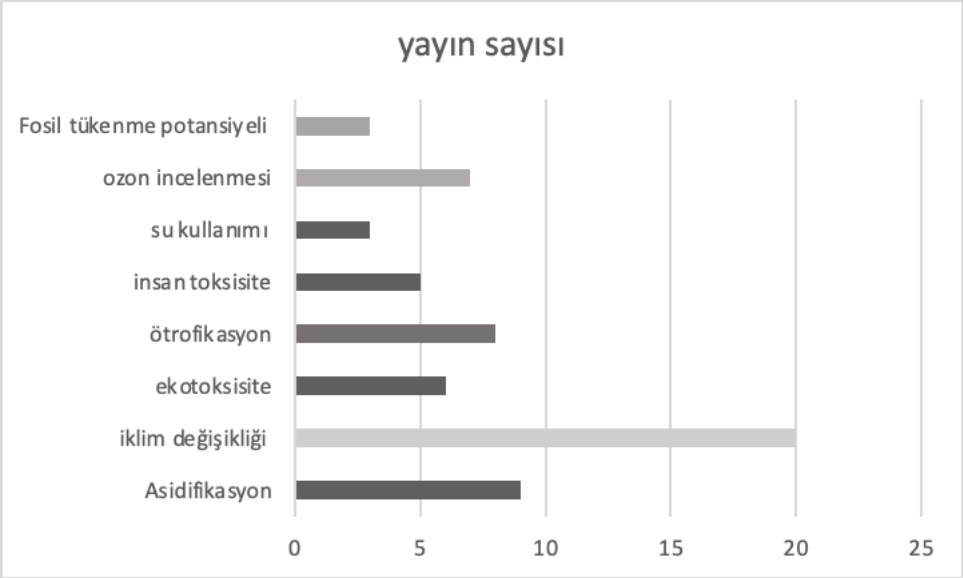


Şekil 2. Literatür taramasının sonuçları, Yaşam döngüsü envanterine dahil edilen süreçler.

20 çalışmanın tamamının (%100) üniversitelerin LCA'sında "enerji"yi dikkate aldığı görülmektedir. Bunun nedeni, "enerji"nin genellikle üniversitelerin çevresel performansına en büyük katkıyı sağlayan faktör olmasıdır. Diğer yandan, "altyapı"yı inceleyen makalelerin çoğu da "enerji" konusuna değinmektedir; çünkü altyapı ve enerji tüketimi arasındaki güçlü ilişki nedeniyle bu iki alan genellikle birbirine bağlıdır.
"Ulaşım" konusu, diğer tüm alanlarla olan bağlantısı nedeniyle makalelerin %55'sinde ele alınmıştır. Kampüs içerisinde çeşitli ulaşım türlerinin bulunduğu ve bunun LCA sürecine dahil edilmesi gerektiği gözlemlenmiştir. Ulaşımla ilgili olarak, üniversitenin kendi araç filosunun kullanımı ve öğrenci ile personelin işe gidip gelme davranışları değerlendirilmektedir. Yurt dışında kalmak gibi diğer ulaşım faaliyetleri yaşam döngüsü envanterine nadiren dahil edilmektedir. Bazı yayınlarda ise herhangi bir ulaşım faaliyeti yer almamaktadır [26, 27].
Bir diğer önemli konu ise çalışmaların %60'inde ele alınan "atık"tır. Üniversitelerin atık ve emisyonlarına ilişkin olarak, Çoğu zaman atık akışlarının bölünmez o yüzden bunlara katı atık olarak kabul ediyoruz. Bazı yayınlar atıkların kategoriye ayırarak bahsetmişti diğer üniversiteler ise plastik kullanımını azaltmaya yönelik olarak odaklanmıştır [35, 42].
Yayınların Yaşam döngüsü envanter incelemesi:
Yayınların yaşam döngüsü envanterleri (LCI'ler), tekrarlanan modeller olarak tanımlanan farklı kategorilere ayrıldı: enerji tedariği, ekipman, altyapı, işletme malzemeleri, ulaşım ve atık.
Genel olarak, üniversitenin LCA'sı, özellikle çalışmanın sınırları dahilinde farklı binalar, hizmetler ve altyapılar dikkate alındığında, büyük miktarlarda farklı türde verilerin toplanmasını içerir.
İncelenen literatürde birçok farklı veri kaynağı belirlendi ancak en çok alıntı yapılan veri tabanı Ecoinvent oldu [38, 40, 42, 44].
Ecoinvent, dünya çapında 5000'den fazla kuruluş tarafından kullanılan, dünyanın en ünlü LCA veritabanlarından biridir. Veritabanı, şu anda 20.000'den fazla güvenilir veri seti ile enerji tedariği, kaynak çıkarımı, malzeme tedariği, kimyasallar, metaller, tarım, atık yönetimi hizmetleri ve ulaştırma hizmetlerine ilişkin uluslararası endüstriyel yaşam döngüsü envanter verilerini içermektedir [47]. Binaların kullanım aşaması genellikle enerji ve su tüketimi şeklinde ele alınırken, yapı malzemelerinin temini, inşaat aşaması ve ömrünün sona ermesi gibi diğer süreçlerin çevresel etkileri nadiren dikkate alınmaktadır [48].
Kullanım aşaması dışındaki diğer yaşam döngüsü aşamalarının etkisini düşük olarak sınıflandırırlar ve bu nedenle çoğu çalışma bunları LCI'ye dahil etmezler.
Yayınların Yaşam döngüsü etki kategori yönünden incelemesi:
Mevcut çalışma, üniversitelerin %90'ının, ton CO_2 eşdeğeri (CO_2) cinsinden ölçülen Küresel Isınma Potansiyeli (GWP) gibi göstergeleri kullanarak karbon ayak izini araştırmak için LCA'yı kullandığını göstermiştir. LCA için izlenen yaklaşımlarla ilgili olarak, makalelerde LCA'nın uluslararası standardizasyonunu sağlayan ISO 14040, ISO 14044 ve ISO 14072 gibi doğrudan LCA, çevre yönetimi ve karbon yönetimi ile ilgili standartlardan bahsedilmiştir [49].
8 ülkeden 20 çalışmayı kapsayan bu incelemede, üniversite kampüs operasyonlarıyla ilgili LCA araştırmasını yürütmüştür. İncelenen makalelerde, en fazla kullanılan etki değerlendirme yöntemleri, Hibrit LCA (HLCA), malzeme akış analizi (MFA), Kıyaslama (BEN) ve Yaşam Döngüsü Maliyet Analiz (LCC) yöntemlerdir, Ayrıca yaygın olarak kullanılan yaşam döngüsü etki değerlendirme metotları ise, CML ve ReCiPe metotlarıdır.
İncelenen yayınlarda, yüksek oranda amaç yalnızca sera gazı emisyonunu incelemektir ve çalışmaların yaklaşık %46,7'si Sera Gazı Protokolü rehberliğini ve kapsamlarını izlemiştir Sera Gazı Protokolü, dünya çapında Karcon Ayak İzi'nin değerlendirilmesine yönelik en yaygın kılavuzlardan biridir [50].
Yazılım kullanımı açısından, dünya çapında yaygın olarak kullanılan GaBI ve SimaPro, veritabanlarının daha doğru ve güvenilir olduğu belirtilerek binalar ve enerji konularına odaklanan dört makalede anılmıştır [26,42]. Ayrıca, ücretsiz bir yazılım olan OpenLCA'nın kullanımı, bu eserlerin bilimsel yaklaşımlara öncelik verdiğini göstermektedir.

Metodolojinin analizinde daha önce açıklandığı gibi, yayınların çoğu sera gazı değerlendirmeleridir. Yaşam döngüsü etki değerlendirmesi (LCIA) sırasında tüm yayınlarda yalnızca "iklim değişikliği" değerlendirilmekte ve kg CO_2 eşdeğeri cinsinden ifade edilmektedir. Bazı yayınlar birkaç orta nokta etki

kategorisini değerlendirmektedir. Bueno ve ark. (2021) [44] orta nokta kategorilerinin 'insan toksisitesi', 'ekotoksisite' ve 'kaynaklar' olmak üzere üç uç nokta kategorisini de değerlendirmektedir. Değerlendirilen etki kategorilerine ilişkin literatür taramasının sonuçları Şekil 3'te sunulmaktadır.



Şekil 3. Literatür taramasının sonuçları, Etki kategorileri değerlendirmeler.

IV. SONUÇLAR

Bu makalede, 2030 Sürdürülebilir Kalkınma hedeflerinin Birleşmiş Milletler tarafından belirlenen 17 Sürdürülebilir Kalkınma Hedefi çerçevesinde üniversitelerin sürdürülebilirlik açısından oynadığı kritik rol vurgulanmaktadır. Ayrıca öğrenci ve çalışan sayısı ve şehrin konumu gibi bazı sınır koşulları da farklılık göstermekteydi. Bazı YÖK'ler çoğunlukla çevrimiçi öğretim sunarken, diğerleri öğretim ve araştırma faaliyetlerini kampüste sunar. Ek olarak, metodoloji şu anda YÖK'lerin boyutu, yapısı ve çıktılarındaki farklılıklar nedeniyle farklı YÖK'lerin doğrudan karşılaştırılmasına olanak sağlamamaktadır. Ancak kuruluşların ISO/TS 14072'ye göre hazırlanan diğer tüm LCA çalışmaları için de durum aynıdır. Bu çalışmada, 2015 – 2023 yılları arasında yayınlanmış toplam 20 makale ele alınmıştır.

Seçilen çalışmaların çoğunda çevresel göstergelerle herhangi bir senaryo ve hatta trend analizi yapılmamıştır. Fonksiyon birimi ile ilgili olarak, çalışmaların yaklaşık %20'sinde öğrenci sayısı dikkate alınmış, ardından metrekare başına yoğunluk göstergeleri de dikkate alınmıştır.

Yaşam Döngüsü Analizi (LCA), üniversitelerin çevresel etkilerini değerlendirmek için kullanılan standart bir yöntemdir. LCA, enerji tüketimi, atık yönetimi ve ulaşım gibi üniversite kampüslerinin ana faaliyetlerini inceleyerek daha sürdürülebilir uygulamalara yönelme imkanı sunar. Araştırmada, 20 çalışmanın tamamında enerji faktörünün ele alındığı görülmüştür. Bunun nedeni, enerjinin genellikle üniversitelerin çevresel performansına en büyük katkıyı sağlayan faktör olmasıdır. Ayrıca, altyapı ve enerji tüketimi arasındaki içsel ilişki nedeniyle birçok çalışma bu iki alanı birlikte ele almaktadır.

LCA yöntemleri ve uygulamaları açısından, dünya çapında yaygın olarak kullanılan GaBI ve SimaPro yazılımları, veri tabanlarının doğruluğu ve güvenilirliği ile öne çıkmıştır. Ayrıca, ücretsiz bir yazılım olan OpenLCA'nın kullanımı, bilimsel yaklaşımların tercih edildiğini göstermektedir.

Son olarak, üniversitelerin çevresel etkilerini değerlendirme ve azaltma konusunda LCA'nın önemli bir araç olduğu ve sürdürülebilir kalkınma hedeflerine ulaşmada kritik bir rol oynadığı belirtilmiştir. Aynı zamanda gelecekte bütünsel bir yaşam döngüsü sürdürülebilirlik değerlendirmesi yapılabilmesi için metodolojinin yalnızca çevresel değil, sosyal ve ekonomik boyutları da kapsayacak şekilde genişletilmesi gerekmektedir. Bu çalışmalar, üniversitelerin çevresel sürdürülebilirliği sağlama çabalarının artırılmasına yönelik önemli bir adım olarak değerlendirilmektedir.

TEŞEKKÜR

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AHP ile Otomobil Seçimine Yönelik Bir Karar Destek Sistemi

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Özet – Günümüzde otomobiller, günlük hayatın ve iş hayatının getirdiği şartlar sebebiyle ulaşımda artan bir öneme sahiptirler. Otomotiv pazarındaki teknolojik gelişmelerin sonucunda tüketiciler bu yeni teknolojiye sahip araçları satın almaya ve kullanmaya yönelmektedirler. Bununla birlikte müşteriler araç tercihlerini yaparken farklı özellik ve donanıma sahip birçok araçtan hangisini satın alacağına dair bir karar vermede zorluk çekmektedirler. Öyle ki karar verme, ihtiyaçlar veya beklentilere göre bilinçli veya bilinçsiz bir seçim yapma olup zor bir süreçtir. Bu noktada, daha etkin kararlar almak için modern yaklaşımlar dikkate alınmaktadır. Bu bağlamda çalışmada, çok kriterli karar verme yöntemlerinden biri olan Analitik Hiyerarşi Süreci (AHP) ile otomobil seçimi için bir karar destek sistemi (KDS) geliştirilmiş ve önerilmiştir. Bu sistem, müşterilerin otomobil seçiminde dikkate aldıkları ön koşul veya kriter verilerini alarak müşteriler için en uygun karar önerisini başarılı bir şekilde sunabilmektedir. Sonuç olarak, AHP yönteminin otomobil seçiminde kullanılabileceğini göstermesi bakımından çalışmanın yararlı olacağı düşünülmektedir.

Anahtar Kelimeler – Otomobil seçimi, analitik hiyerarşi süreci, karar destek sistemi, çok kriterli karar verme

I. GİRİŞ

İnsan hayatı boyunca doğru karar vermek oldukça önemli olmuştur. Teknolojinin de gelişmesiyle birlikte işletmelerin veya kurumların rekabet ortamında varlıklarını sürdürebilmeleri için karmaşık, çözülmesi zor problemlere etkin ve doğru çözümler üretebilmeleri gerekmektedir. Sözkonusu çözümleri veya kararları, sezgisel yöntemler gibi geleneksel yöntemlerden ziyade daha modern teknik ve yöntemler kullanarak vermek durumundadırlar. Bu noktada, bilgiyi temin etmeli, elde ettiği bilgileri analiz etmeli ve daha ayrıntılı bir keşif sürecinden geçirerek en etkin ve doğru karar yöntemlerinden birinden yararlanılmalıdır. Çünkü günümüzde problemler her geçen gün daha da karmaşık bir hal almaktadır. Bu problemlerin çözümü için nitel ve nicel verilere ihtiyaç olması, karar sürecince çok fazla kriter olması çok kriterli karar verme tekniklerinin gelişmesine ve kullanılmasına sebep olmuştur. Çok kriterli karar verme teknikleri ile nicel veya nicel olmayan ölçütleri birlikte analiz etme ve birçok alternatif çözüm kümesi içerisinden bir tanesini tercih edebilme imkanına sahip olabilmektedir. Araştırma sonuçları, birçok kararın sezgisel yöntemle alınmasıyla birlikte zor ve karmaşık kararların bu yöntemle alınmasının zor olduğunu ortaya koymaktadır. Bu noktada, çok kriterli karar verme yöntemlerinden biri olan AHP yöntemi gittikçe daha yaygın kullanılmaya başlanmıştır. AHP yöntemi özellikle, karar süreçlerinde objektif verilerin yetersiz olduğu durumlarda kullanılmaktadır. Böylece, karar veren kişinin şahsi kararları ve tecrübeleri sürece entegre edilebilmektedir [1].

Günümüz otomotiv sektöründe ise, bir otomobilin tercih edilmesi tek bir özelliğine bağlı değildir. Bunu belirleyen başka faktörler de vardır. Marka, model, yıl, yakıt türü, motor hacmi, vites türü, fiyatı, performansı, satış sonrası hizmetleri vs. Bunun sonucunda kullanıcılar için otomobillerde özellik seçimi önem kazanmıştır. Özellikle artan fiyatların ön plana çıktığı son zamanlarda, müşterilerin araç seçerken hangi özelliğe daha çok önem vermesi kararı müşterileri bir hayli zorlamıştır. Çünkü, günümüzde araç

seçimindeki özellik ve seçenekler fazlasıyla artmıştır. Bu seçeneklerin hangisinin seçilmesinin gerektiği de kullanıcılar için oldukça önemli hale gelmiştir.

Bu çalışmada, otomobil alım sürecinde daha iyi kararlar almak, doğru seçimi yapabilmek ve birçok seçenek arasından en doğru karar vermeyi desteklemek için AHP yöntemi kullanılarak bir KDS sistemi geliştirmek amaçlanmıştır. Ayrıca, kullanıcının istediği kriterlere en uygun seçeneklerin sunularak kullanıcının otomobil için en doğru karar vermesini sağlamak ve bunu devamlılık haline getirerek KDS sistemini otomobil alanında entegre etmek amaçlanmıştır.

II. LİTERATÜR TARAMASI

Literatürde konuyla ilgili bazı çalışmalar mevcuttur. Örneğin, otomotiv sektöründe iş yapan bir şirkette tedarikçi performansının analizi ve değerlendirilmesi üzerine bir çalışma yapılmıştır. Bu şirketin tedarikçilerinin performansı Bulanık AHP yönteminden yararlanılarak araştırılmıştır [2]. Başka bir çalışmada, akıllı cep telefonları içerisindeki mevcut alternatiflerin 18-25 yaş aralığındaki gençler tarafından tercih sıralaması incelenmiştir. Çalışmada çok kriterli karar verme tekniklerinden olan AHP ve PROMETHEE'den yararlanılmıştır. Elde eden sonuçlar, telefon tercih sürecinde servis imkânının en başta gelen ve önemli bir kriter olduğunu göstermiştir [3].

Bir diğer çalışmada, bir firmanın sahip olduğu bir alışveriş web sayfasının müşterilerine sunduğu kaliteli hizmetin daha hızlı ulaşması sağlanmak istenmiştir. Bunun için belirlenen kriterler AHP ile ağırlıklandırılmış ve TOPSIS yöntemi ile alternatif çözümler arasından seçim gerçekleştirilmiştir. Elde edilen sonuçlara göre, uzmanların görüşlerine dayanarak şirketlerin bir 3PL firma tercih ederken en çok dikkate aldıkları kriterin "maliyet kriteri" olduğu görülmüştür [4]. ATM yerleşim noktası için KDS geliştirilen çalışmada, ATM cihazlarının yerleştirilmesi için düşünülen aday noktalar arasından seçim yapmada yardımcı olması amaçlanmıştır. AHP yöntemiyle farklı kriterlere sahip adaylar arasından en uygun aday seçim mantığı gösterilmiştir. Sonuca göre bir kriter listesi çıkarılmıştır. Eğer belirlenen ilk kriterlere göre gerekiyorsa alt kriterler değerlendirilmiş ve listelenmiştir. Tüm bunların sonucunda ise projede ATM yerleştirirken KDS ile en uygun yeri seçerek ATM sayısı ve masrafların minimize edilmiştir [5].

AHP tabanlı bir karar destek yazılımının geliştirilmesi çalışmasında, kullanıcı eğitimi, kullanım kolaylığı ve Türkçe dil desteğine sahip AHP tabanlı bir KDY geliştirilmiştir. Elde edilen sonuçlar, geliştirilen yazılım projesinin, diğer karar destek yazılımları ve AHP ile uyumlu, kullanıcı eğitimi ve kullanım kolaylığı bakımından birtakım üstünlüklere sahip olduğunu göstermektedir. Böylece AHP ile hızlı, kolay ve daha anlaşılır karar modelleri oluşturulması sağlanmıştır [6]. Bir başka çalışmada, Kırşehir'de hizmet veren üretim işletmelerinden bir un fabrikası üzerinden bir araştırma yapılmıştır. Sözkonusu işletmede üretime girecek olan çok farklı tiplerdeki buğdaylar içerisinden en uygun olanı tespit edilmiştir. Bu belirlenme sürecinde AHP yöntemi ile bir seçim modeli geliştirilmiştir. ÇKKV tekniklerinden AHP yöntemi ile geliştirilen modelin desteğiyle karar verici kişilere destek olabilmek ve zamandan tasarruf etmelerini sağlayabilmek amacıyla un fabrikasında üretime girecek olan buğday seçimi için bir KDS geliştirilmiştir [7].

III. MATERYAL VE YÖNTEM

A. Çalışmanın Amacı

Bu çalışmada, otomotiv firmalarında yer alan araçların firma yetkili satıcıları tarafından kullanılacak ve yeni bir araç satın almak isteyen kullanıcıların istediği kriterlerde araçlar ile kavuşturulmasını sağlayacak bir KDS geliştirilmesi amaçlanmaktadır. Bu sistem ile hem müşteri memnuniyetlerinin artırılması hem de araçların satılarak firmaların karlılık oranlarının arttırılması hedeflenmektedir. Burada karar vericinin amacı beklentilerini karşılayacak bir araç satın almaktır. Satıcının amacı ise elindeki aracı müşteri ile buluşturmak ve karlılık oranını arttırmaktır. Ancak birçok çalışma gösteriyor ki kullanıcılar araç alma konusunda çokta fikir sahibi değildir. Bu sebeple özellikle kullanıcılara bu konuda destek sağlayacak bir KDS tasarımı düşünülmüştür.

B. Veriseti

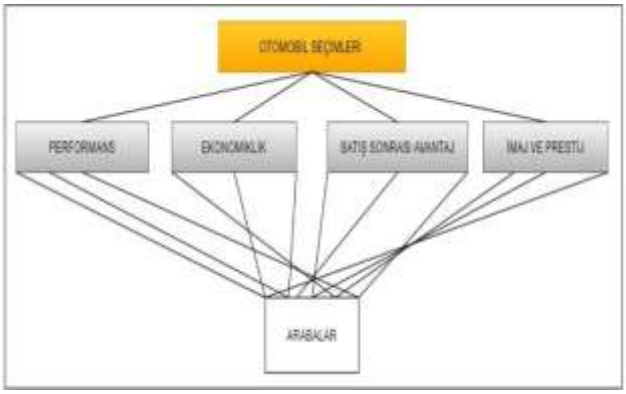
Çalışmada, toplamda 153129 adet (satır) veri kullanılmıştır. Sözkonusu veriler 12 başlıktan (sütun) oluşmuş olup sırasıyla "marka, model, yıl, km, vites türü, motor türü, yakıt, fiyat, performans, ekonomiklik, satış sonrası ve imaj"dır. Verilerin bir kısmı Çizelge 1'de verilmiştir.

Çizelge 1. Verilerin bir kısmı

id	Marka	Model	Model_Yili	KM	Vites_Turu	Motor_Turu	Yakit	Fiyat	Performans	Ekonomiklik	SatisSonr	imaj
1	FORD	FOCUS	2018	34664	Otomatik	1	Dizel	60.000	0,93	0,518	0,345	0,983
2	AUDi	A3	2018	62317	Manuel	1,4	Dizel	126.899	0,562	0,827	0,759	0,722
3	VOLKSWAGEN	POLO	2019	15426	Otomatik	1,5	Dizel	604	0,485	0,062	0,933	0,888
4	HYUNDAi	ELANTRA	2015	27719	Otomatik	1,2	Benzin	104.354	0,802	0,063	0,61	0,543
5	FORD	KUGA	2018	35106	Otomatik	1	Dizel	38.831	0,94	0,852	0,687	0,192
6	PEUGEOT	3008	2018	42936	Otomatik	1,4	Dizel	92.092	0,833	0,402	0,463	0,804
7	VOLKSWAGEN	TiGUAN	2016	29786	Manuel	1,5	Benzin	219.728	0,07	0,291	0,183	0,782
8	BMW	5 SERiSi	2014	218325	Otomatik	1,6	Dizel	54.844	0,655	0,302	0,48	0,358
9	OPEL	ASTRA	2016	89679	Manuel	1,6	Dizel	181.724	0,989	0,528	0,574	0,268
10	BMW	5 SERiSi	2014	97364	Otomatik	1,6	Dizel	152.806	0,405	0,135	0,279	0,387

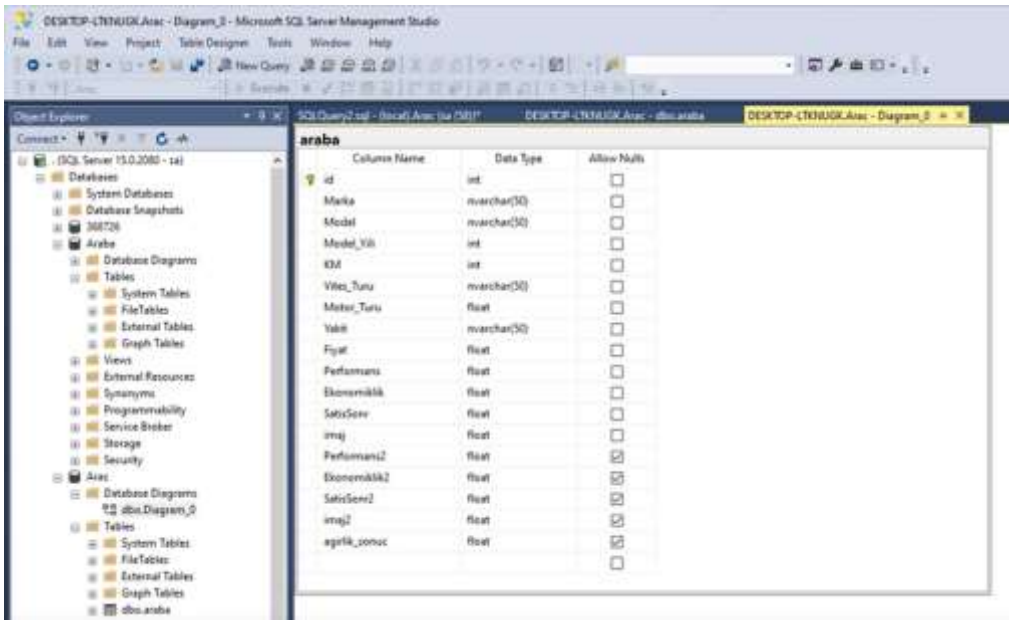
C. Kullanılan Yöntem ve Araçlar

Otomobil satın almak isteyen bireylerin aradıkları özellik ve beklentiler ile satıcı bilgisinin değerlendirilmesi için AHP yöntemi kullanılmıştır. Bu değerlendirmeler sonucunda kriter ağırlıkları ortaya çıkarılmıştır. Bu kriter ağırlıkları ile alternatif arabalar arasında müşteriye aramış olduğu kriterlere göre araçlar sunulmaktadır. Bu durum müşterilerin araç seçimde büyük bir kolaylık sağlamaktadır. Böylece hem müşteri memnuniyetinin hem de firma karlılığının artmasına katkı sunulmaktadır. Aynı zamanda karar vermede zorlanan müşteriler için de bir kolaylık sağlanmış olmaktadır. Karar probleminde kriterler hiyerarşik bir yapıya daha uygun olduğu için AHP yöntemi çözümde kullanılmıştır. Karar probleminde 4 ana kriter, 10 alt kriter bulunmaktadır. KDS sistemi ile kriterleri belirleyerek istenilen arabaları görmek için birçok seçenekleri görebilecekler ve karar verme konusunda kendilerine yararlı olacaktır. Sistem insanların kriterlerine tam olarak cevap verebilecek ve araba alma konusunda saatlerce arama yapmaktan kurtararak zaman konusunda da tasarruf ve kolaylık sağlayacaktır. Müşterilerin aramış olduğu aracın en doğru şekilde ortaya çıkarılabilmesi için 4 ana kriter ortaya koyulmuştur. Bu kriterler şu şekilde sıralanmaktadır; *performans, ekonomiklik, satış sonrası avantaj ve* son olarak *imaj ve prestij* kriterleridir. Müşterilerin bu 4 kriteri 10 puan üzerinden puanlaması istenmektedir. Daha sonra müşteriye aramış olduğu aracın motor gücünü, vites türünü, yakıt çeşidini ve fiyat aralığını da sorarak en uygun araçların sıralanması ve müşteriye araç seçiminde yardım etmesi amaçlanmaktadır. AHP modeli müşteri açısından maksimum karlılık sağlarken bunun yanısıra minimum maliyet ile müşteriye en doğru sonuçları listelemektedir. Uygulamanın geliştirilmesi için Visual Studio, C# Dili Windows Forms Uygulamaları, Mssql Server Veritabanı Hizmetleri ve Diagrams.Net araçlarından yararlanılmıştır. Uygulamanın geliştirilmesi sürecinde, öncelikle problemin hiyerarşisi tasarlanmıştır (Şekil 1).



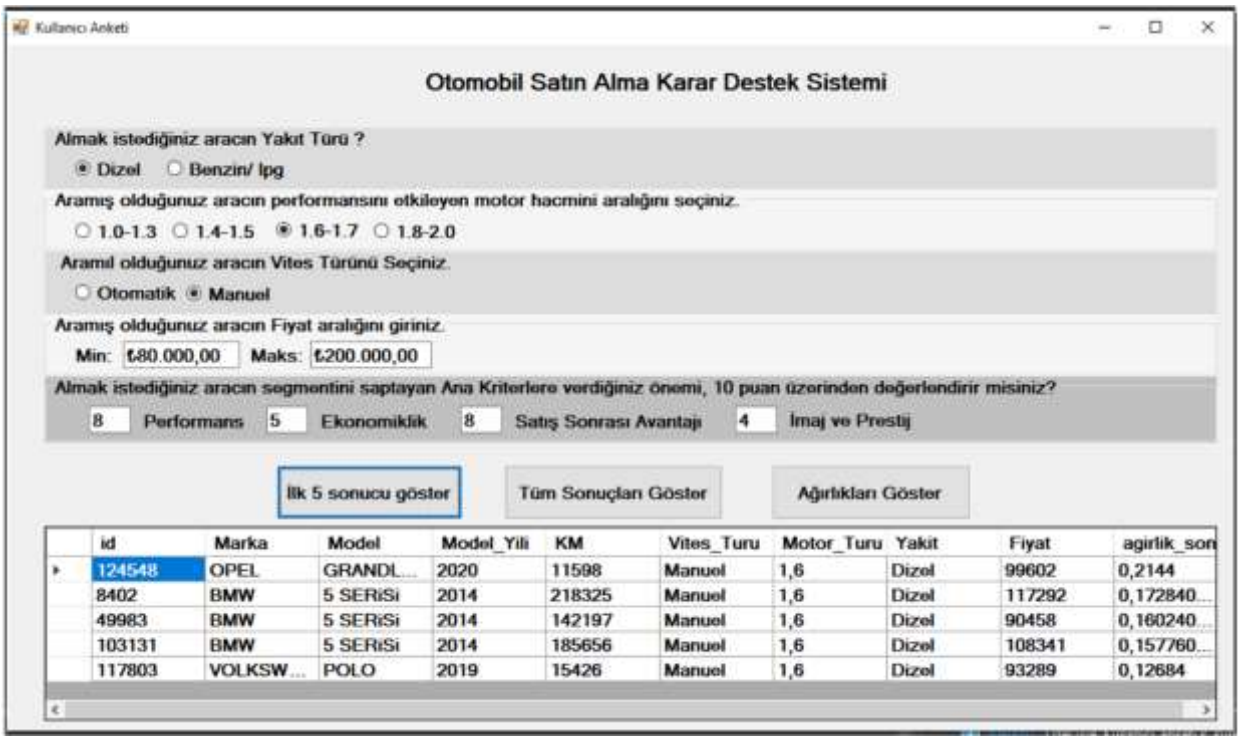
Şekil 1. Problemin hiyerarşisi

Daha sonra modelin SQL tasarımı gerçekleştirilmiştir (Şekil 2).



Şekil 2. Modelin SQL tasarımı

Ve son olarak da geliştirilen KDS'nin arayüzü (Şekil 3) tasarlanmış ve test edilmiştir.



Şekil 3. Otomobil Satın Alma KDS Arayüzü

Modelin arayüzünde, bir satış temsilcisi müşteriye sorular yönelterek bu soruları cevaplamasını istemektedir. Verilecek cevaplara göre müşteriye uygun araçlar listelenecektir. Program kapsamında müşteriye yöneltilen sorular ve cevapların şöyle olması beklenmektedir:

- İlk soru; "Almak istediğiniz aracın yakıt türü nedir?" olmuştur müşterilerin benzin/lpg veya dizel cevaplarından bir tanesini seçmesi beklenmektedir.

- Bir sonraki soru ise “Aramış olduğunuz aracın performansı etkileyen aracın motor hacmi aralığını belirtir misiniz” sorusuna müşterilerin “1.0-1.3, 1.4-1.5, 1.6-1.7, 1.8-2.0” seçeneklerinden bir tanesini seçmesi beklenmektedir.
- Bir diğer soruda ise “Aramış olduğunuz aracın vites türünü seçiniz.” olmuştur. Bu soruyu yanıt vermeleri istenmektedir.
- Son olarak ise, ““Aramış olduğunuz aracın giriniz.” olmuştur. Müşterilerden alacakları aracın fiyat aralığını belirtmeleri beklenmektedir.

Bu soruların sonunda müşterinin belirttiği kriterlere göre “Aracın performansına, ekonomikliğine, satış sonrası avantajına ve imajına” 10 üzerinde vereceği puanlar karşısında müşteriye beklentilerini karşılayacak araçların sıralanması sağlanacaktır. Bu işlemler bittikten sonra müşteri kendi seçimlerini kendi istekleri doğrultusunda gerçekleştirmiş olacaktır ve bu sayede müşteriyi sürece dahil ederek daha doğru kararlar almasına destek olunarak daha memnun kalması sağlanmaktadır.

IV. SONUÇ VE ÖNERİLER

Bu çalışmada, otomotiv firmalarının müşterilerin beklentilerini karşılayacak satış temsilcisine olan ihtiyacı ortadan kaldırarak kişi bazlı satış stratejisinden program bazlı satış stratejisine geçişini hızlandırmak hedeflenmektedir. Bu sayede firmalar açısından kalifiye satış temsilcisinin işten ayrılması sonucunda ortaya çıkabilecek memnuniyetsizlikler bertaraf edilmiş olacaktır. Bunun için firmalar bu sistemin gerekli alt yapısını oluşturmalıdır.

Çalışmada geliştirilen ve oluşturulan KDS alt yapısı sayesinde, firmaların satış temsilcisinden bağımsız olarak karlılığı korunabilmekte ve bir destek aracı olarak müşterilerin doğru kararı vermelerini sağlamaktadır. Geliştirilen KDS’nin müşterilerin beklentileri doğrultusunda en uygun araçları sıralaması müşterilere araç seçimde oldukça kolaylık sağlamaktadır. Ayrıca bu kolaylık müşterilerin firmaya olan güvenini ve bağlılığını arttırmaktadır. Bu tarz karar destek sistemleri, müşterilerin en doğru karar vermelerini sağlayacağı ve müşteri memnuniyetini arttıracağı gibi firmalara da itibar ve yüksek kazanç imkanı sağlayacaktır.

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Sürtünme kompozitlerinde AHP-ARAS Hibrit yöntemi ile ideal dolgu malzemesinin belirlenmesi

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Özet – Sürtünme kompozitleri elde etmek için elyaf, reçine ve kok kömürü tozundan %45'lik kısmı sabit tutulmuş ve %55 lik kısmı barit, kalsit, salyangoz kabuğu tozu, yengeç kabuğu tozu, midye kabuğu tozu ve andız kozalağı tozları farklı oranlarda karıştırılarak 14 numune elde edilmiştir. Elde edilen numunelerin sürtünme katsayısı, aşınma oranı, sertlik, yoğunluk, su emme ve yağ emme özelliklerini performans kriterleri olarak kabul edilmiş ve bu kriterlere çok krtiterli karar verme yöntemi uygulanmıştır. Bunun için öncelikle AHP yöntemiyle kriterlerin bağıl ağırlıkları belirlenmiştir. Kriterlerin bağıl ağırlıkları; sürtünme katsayısı (0.450), aşınma oranı (0.235), sertlik (0.122), yoğunluk (0.099), su emme (0.041) ve yağ emme (0.053) olarak bulunmuştur. **λmax:**6.27, **CI:**0.0539, **CR:**0.044 olarak hesaplanmıştır. AHP'den elde edilen sonuçlardan faydalanılarak ARAS yöntemiyle numunelerin optimallik fonksiyon değerlerinin hesaplanması yapılmıştır. Uygulanan çok krtiterli karar verme yöntemi sonucunda B25S30 (%25 barit, %30 salyangoz kabuğu tozu) ideal dolgu malzemesi olarak belirlenmiştir.

Anahtar Kelimeler – AHP, ARAS Metodu, Çok kriterli karar verme, İdeal dolgu malzemesi, Kompozit malzeme

I. GİRİŞ

İnsanlar hayatları boyunca her gün çeşitli kararlar vermek zorundadırlar. İşletmeler de yaptıkları üretim ve hizmetle ilgili sürekli kararlar alırlar. Bu kararlar genellikle en iyiyi, en uygunu, en ucuzu temin etmek ve bunun sonucunda da amaçları doğrultusunda üretmeyi hedeflemek için olabilmektedir. Bu hedeflere ulaşmak için alınan kararlar her zaman en doğru karar olmayabilir. Gerek bireysel, gerek yönetsel gerekse de toplumu etkileyecek düzeyde kısaca her seviyede doğru ve etkili karar verme önemli bir beceri olarak kabul edilmektedir. Doğru karar vermede karar vericinin becerisini oluşturan akıl, sezgi ve deneyimlerini doğru kullanabilme yetisinin önemi bilinmekle beraber günümüzde zorlaşan ve karmaşıklaşan karar süreçlerinin karar vericinin daha etkin, hızlı ve doğru karar almasına olanak sağlayacak karar verme araçları ile desteklenmesi gerekmektedir [1]. Karar verme süreci, zihinsel ve fiziksel faaliyetler içerisinde "karar" kısmına gelene kadar ki izlenilen yol olarak ifade edilir. İzlenen yol; amaçların belirlenmesi ve problemin tanımlanmasıyla başlar. Alternatiflerin değerlendirilmesi ve probleme uygun olanın seçilmesi ile devam etmektedir. Son olarak da karar vererek bitmektedir. Karar vericiler, pek çok kıstası dikkate aldığında yapabileceklerini göz önüne alarak bir ya da birden fazla seçeneği uygun görebilir. Ancak mevcut alternatifler arasında en uygun olanı seçmek zorundadırlar[2]. Karar verme olayının gerçekleşebilmesi için öncelikle birden fazla alternatifin mevcut olması gerekmektedir. Bu alternatiflerin doğru şekilde belirlenebilmesi için de "problem" en iyi şekilde tanımlanmalıdır. Problem genellikle karmaşık bir yapıya sahiptir ve birden fazla kriter içermektedir[3].

Bilimsel gelişmeler, zorlu rekabet koşulları, işletmelerin hayatlarını devam ettirebilmesi ve işletme yöneticilerinin karmaşık karar problemleri karşısında doğru ve yerinde karar verme zorunluluğunu gerekli kılmıştır[4]. Çok kriterli karar verme (ÇKKV), günümüzde aslında fark etmeden kullandığımız karar verme

süreçlerinin temelini oluşturduğu yöntemler bütünüdür. Karar verme sürecinde fayda beklentisini en yukarda tutan ve tercih yaparken amaca uygun en doğru seçeneği elde etmemize olanak sağlayan, analiz etme alternatiflerini oluşturmaktadır. Karar problemlerimizin çözümünde daha mantıksal ve bilimsel seçim tekniklerinden yararlanmamız gerekebilir. Tam bu noktada (ÇKKV) yöntemleri daha sağlıklı ve nitelikli değerlendirmeler yapabilmemizi sağlamaktadır[5]. ÇKKV yöntemleri ile karar vericiler, sayısal ifade edilen veriler ile sözel verileri birlikte kıyaslayabilmekte ve çok sayıdaki alternatif arasından belirlenen kriterler çerçevesinde optimum fayda sağlayacak olanını seçebilmektedirler[4].

Bu çalışmada 6 farklı organik dolgu malzemesi ile elde edilen 14 farklı numunenin sertlik, yoğunluk, aşınma direnci ve sürtünme katsayısı, su emme, yağ emme özellikleri incelenmiştir. Daha sonra 6 farklı organik dolgu malzemesi ile elde edilen 14 farklı numunenin incelenen özelliklerine göre AHP (Analytic Hierarchy Process), ve ARAS (Additive Ratio ASsessment) yöntemi kullanılarak numunelerin tüm incelenen özellikleri dikkate alınarak ideallik sıralaması yapılmıştır.

II. MATERYAL VE YÖNTEM

A. Çok Kriterli Karar Verme (ÇKKV)

ÇKKV yaklaşımında, gerçekçi alternatifleri belirlemek için önce problemin tanımlanması ve daha sonra ÇKKV yapılması gerekmektedir. Karar vermede yer alan aktörlerin belirlenmesi, değerlendirme kriterlerinin seçilmesi ve tüm alternatiflerin kriterler kümesine göre değerlendirilmesi çok önemlidir[6]. ÇKKV yöntemleri genellikle, aynı anda birden fazla kriteri göz önünde bulundurmak için her bir kritere göreli önemine göre ağırlık veren bir ağırlıklandırma sistemi kullanır. Bir ağırlıklandırma sisteminin kullanımı, öznel doğası nedeniyle tartışmalı olsa da, ağırlıklar, bölgesel hedefleri ve öncelikleri etkin bir şekilde dâhil ederek, çeşitli kriterlerin göreceli önemini tahsis etmek için önemli bir araç olarak da hizmet edebilir[7]. ÇKKV, çoklu ve genellikle birbiriyle çelişen kriterlerle karakterize edilen sonlu bir karar şemaları setini değerlendirmede, seçmede veya sıralamada en iyi kararları almak için yaygın olarak kullanılmaktadır[8, 9]. Karar verme, ilgili herkesin ulaşacağı amaç ve hedeflerden kaynaklanan bir dizi kısıtlamayı mümkün olduğunca tatmin ederek en uygun alternatifi seçme sürecidir[10]. Literatürde farklı amaçlar için kullanılan birçok ÇKKV metodu vardır. Bunlardan bazıları ile yapılmış çalışmalar Tablo 1'de verilmiştir.

Tablo 1. Malzeme seçiminde ÇKKV yöntemlerinin önceki uygulama çalışmalarının gözden geçirilmesi[11].

Yazarlar	Metodlar	Uygulamalar
Maity SR ve Shankar S(2015)	PROMETHEE II	Optimum takım çeliği malzemesini seçme
Aditya C ve ark. (2013)	TOPSIS ve doğrusal olmayan SAW	Ultrasonik dönüştürücü ve aktüatör uygulamaları için en uygun piezoelektrik malzemeyi seçme
AL-Oqla FM ve ark. (2015)	AHP ve TOPSIS	Doğal lifli kompozitler için en uygun takviye koşulunun seçilmesi
Asodariya H ve ark. (2018)	AHP, entropi yöntemi, COPRAS ve TOPSIS	Volan için en uygun malzemeyi seçme
Athawale VM ve Chakraborty S (2012)	SAW, WPM, AHP, TOPSIS, GTMA, VIKOR, ELECTRE II, PROMETHEE II, GRA ve ROVM	Yelken direği, volan ve kriyojenik depolama tankı için en uygun malzemeleri seçme
Bai SW ve ark. (2018)	AHP ve TOPSIS	Granit kesme işlemi için uygun kesme sıvısının seçilmesi
Çalışkan H (2013)	Genişletilmiş PROMETHEE II, TOPSIS ve VIKOR	Optimum bor bazlı tribolojik sert kaplama malzemelerinin seçilmesi
Çalışkan H ve ark. (2013)	EXPROM2, TOPSIS ve VIKOR	Sert frezeleme koşullarında çalışan takım tutucu için en uygun malzemeyi seçme
Deshmukh D ve Angira M (2019)	Ashby, TOPSIS ve VIKOR	RF-MEMS şönt kapasitif anahtarlar için en uygun anahtarlama yapısı malzemesinin seçilmesi

Elevli B ve Öztürk H (2019)	PROMETHEE-GAIA	Türkiye, Dilovası bölgesindeki sulardaki ağır metal kontaminasyonlarının değerlendirilmesi
Khorshidi R ve Hassani A (2013)	TOPSIS ve PSI	Arzu edilen mukavemet ve işlenebilirlik kombinasyonunu elde etmek için optimal Al/SiC kompozitinin seçilmesi
Patel PB ve ark. (2018)	PSI	Polilaktik asit malzemesi için kaynaşmış biriktirme modellemesinin optimal proses parametrelerinin seçilmesi
Peng AH ve Xiao XM (2013)	PROMETHEE ve ANP	Muylu yatağı için en uygun malzemeyi seçme
Teraiya V ve ark. (2018)	TOPSIS, COPRAS, VIKOR, vb.	Biyel kolu için en uygun malzemeyi seçme
Yang WC ve ark. (2019)	Farklı MADM yöntemleriyle birleştirilmiş malzeme seçim yöntemi (SAW, TOPSIS, GRA, PSI, WPM ve PROMETHEE)	Otomotiv tekerlekleri için en uygun magnezyum alaşımlı malzemeyi seçme
Zafarani HR ve ark. (2014)	AHP	En iyi güç ve işlenebilirlik kombinasyonuna sahip optimal Al-SiC kompozitini seçme

Günümüzde yaygın olarak kullanılan asbestsiz organik sürtünme malzemeleri, genellikle deneme yanılma yoluyla ve üreticilerin önceki deneyimleri ile birleştirilmiş karmaşık formülasyonlara sahip çok bileşenli polimer matrisli kompozittir. Geleneksel tek kriterli karar verme, faydalı olmayan kriterlerin minimize edilmesi ile faydalı kriterlerin maksimize edilmesi gerçeğine dayanan basit bir iştir. Fakat mevcut fren balatası kompozit alternatiflerinin birkaç çelişkili kriter bazında sıralanması karmaşık bir iştir. Bu nedenle, çoklu ve karşıt kriterler temelinde mevcut bir dizi alternatiften performans değerlendirmesi ve optimizasyon, karmaşık bir karar verme görevidir, bu nedenle, birbiriyle çelişen birden fazla kritere karşı karar verirken araçların optimize edilmesinden yardım almak gerekir[12]. Sürtünme malzemelerinin performans değerlendirmesi, malzemenin çelişen özelliklerdeki performans sıralamasına bağlıdır. Seçilen malzemenin tüm performans özelliklerinde en iyi veya en zayıf olması şart değildir. Bu nedenle malzeme seçimi için performans sıralaması zordur. ÇKKV tekniğinin uygulanmasıyla, dengeleme ve sıralama yöntemi, performans parametrelerini optimize ederek seçilen sürtünme malzemelerini sıralayabilir[13].

Bu çalışmada, %45'lik kısmı sabit oranlarda elyaf, reçine ve kok kömürü tozundan oluşturulan sürtünme malzemelerine, %55'lik kısmı 6 farklı organik dolgu malzemesi kullanılarak elde edilen 14 farklı numunenin sertlik, yoğunluk, aşınma oranı, sürtünme katsayısı, su emme ve yağ emme özellikleri deneysel olarak incelenmiştir. Numunelerin (numune kodlarındaki rakamlar malzeme % sini ifade etmektedir) deneysel sonuçları Tablo 2'de verilmiştir. Daha sonra incelenen 14 farklı numunenin performans sıralamasını yapabilmek için öncelikle AHP metodu ile kriterlerin ağırlık hesaplaması yapılmıştır. Devamında ise ARAS metodu ile performans sıralaması yapılmıştır.

Tablo 2. Numunelerin deneysel sonuçları

Numune Kodu	Sürtünme Katsayısı	Aşınma Oranı ($cm^3.N^{-1}.m^{-1}$) $x10^{-7}$	Sertlik (HRR)	Yoğunluk (g/cm^3)	Su Emme (%)	Yağ Emme (%)
	0.450	**0.235**	**0.122**	**0.099**	**0.041**	**0.053**
A55	0.32	29.93	84.52	1.50	5.25	8.73
B55	0.39	1.03	92.91	2.38	0.86	0.60
K55	0.36	2.23	100.75	2.02	1.52	1.02
M55	0.32	0.72	113.45	2.02	1.46	2.43
S55	0.33	0.69	98.82	2.03	1.03	0.73
Y55	0.36	1.28	113.62	1.71	14.43	9.89
B25A30	0.54	5.33	85.32	1.82	5.02	3.65
B25M30	0.31	0.42	93.76	2.24	0.69	0.50
B25S30	0.34	0.21	105.45	2.25	0.08	0.07

B25Y30	0.28	0.36	102.78	2.04	0.71	0.50
K25A30	0.59	36.81	106.20	1.74	4.22	10.24
K25M30	0.31	0.32	114.33	2.08	0.26	0.20
K25S30	0.36	1.09	110.40	2.07	0.31	0.23
K25Y30	0.32	0.45	105.93	1.90	0.19	0.04

A: Andız kozalağı tozu, B:Barit tozu, K:Kalsit tozu, S: Salyangoz tozu, Y:Yengeç tozu, M:Midye tozu

1. AHP Yöntemi

Analitik hiyerarşi süreci (AHP), 1970'ler de Pittsburgh Üniversitesi'nde profesör olan Mimar Thomas L. Saaty tarafından geliştirilmiştir. ÇKKV'nin en yaygın araçlarından biri olarak kabul edilir[14]. Genel olarak, AHP bir yapıyı tanımlamak için literatürden ve ampirik deneyimlerden gelen bilgileri kullanır ve karar vericilerden alınan ikili karşılaştırma bilgilerini karar vermeyi modellemek için uygular[15]. AHP, doğru oran ve ölçek önceliklerini elde etmek için ikili karşılaştırmalar kullanılır [16]. AHP'nin ana avantajı, hiyerarşik yapıyı sürdürmek ve parametrelerin önemi hakkında toplu bir izlenim yaratmaktır[17]. AHP'nin en önemli avantajlarından biri oran ölçekleri ile maddi olmayan ölçütlerin de ölçülmesine olanak tanımasıdır. Yöntemin bir diğer avantajı ise hiyerarşik yapının kurulması ile problemin oldukça detaylı bir şekilde gözler önüne serilebilmesidir[18]. Yöneylem araştırması ve yönetim biliminde, çok düzeyli hiyerarşik hedefler, kriterler, alt kriterler ile alternatifler ve ikili karşılaştırmalar kullanarak yapılandırılmamış ve karmaşık problemlerle başa çıkmak için yaygın olarak kullanılan bir yönetim aracıdır. AHP, yargıları ikili karşılaştırma şeklinde ifade etmek için baskınlık birimleri olarak işlev gören göreli önemin, temel bir ölçeğini sağlar. Karar problemlerinin amacına göre kriterlerin tercih ilişkisi adı verilen ikili karşılaştırma matrisinin oluşturulması ve ardından alternatiflerin her bir kritere göre ikili karşılaştırma matrislerinin oluşturulması AHP'nin temel prosedürüdür[19]. AHP'nin malzeme seçiminde kullanımı ile ilgili literatür özeti Tablo 3'de özet olarak verilmiştir.

Tablo 3. Malzeme seçiminde AHP ağırlıklandırma yönteminin uygulama incelemesi[20].

Yazarlar	***Uygulamalar***	***Kriterler***
AL-Oqla ve diğerleri	Doğal lifli kompozitlerin optimal takviye koşulunun seçilmesi	Maksimum Çekme Mukavemeti, maksimum kesme gerilimi ve kopma uzaması
Çalıskan	Optimum bor bazlı tribolojik sert kaplama malzemelerinin seçilmesi	Sertlik (H), Young modülü (E), elastik geri kazanım, sürtünme katsayısı, bir alt tabakaya yapışma için kritik yük, H/E ve H3/E2
Çalışkan ve ark.	Sert frezeleme koşullarında çalışan takım tutucu için en uygun malzemeyi seçme	Young modülü, basınç dayanımı, kırılma tokluğu, mekanik kayıp katsayısı, sertlik ve maliyet
Dehghan-Manshadi ve ark.	Kriyojenik depolama tankı için en uygun malzemeleri seçme	Tokluk indeksi, akma dayanımı, Young modülü, yoğunluk, termal genleşme katsayısı, termal iletkenlik ve özgül ısı
Jee ve Kang	Volan için en uygun malzemelerin seçilmesi	Yorulma sınırı, kırılma tokluğu, birim kütle başına fiyat ve parçalanma yeteneği
Khabbaz ve ark.	Yelken direği için en uygun malzemeleri seçme	Özgül güç, özgül modül, korozyon direnci ve maliyet kategorisi
Khorshidi ve Hassani	Arzu edilen mukavemet ve işlenebilirlik kombinasyonunu elde etmek için optimal Al/SiC kompozitinin seçilmesi	Basınç dayanımı, anlık yoğunluk katsayısı, anlık gerinim sertleştirme üssü ve şekillendirilebilirlik gerilme indeksi
Kumar ve Singal	Küçük hidroelektrik santrallerinde baraj kapağı malzemesinin seçilmesi	Akma mukavemeti, ömür, kalınlık, maliyet ve bakım maliyeti
Li ve ark.	Optimum kesici takım malzemelerinin seçilmesi	Sertlik, Young modülü, aşınma direnci, kırılma tokluğu, termal kararlılık, yoğunluk, termal iletkenlik ve termal genleşme katsayısı
Mansor ve ark.	Otomotiv fren kolu tasarımı için hibrit doğal ve cam elyaf takviyeli polimer kompozit malzeme seçimi	Performans, ağırlık ve maliyet

Mastura ve ark.	Otomotiv viraj denge çubuğu için "Yeşil" doğal elyaf kompozitler için termoplastik matrislerin seçilmesi	Yoğunluk, Young modülü, kırılma tokluğu, termal iletkenlik, uzama, çekme dayanımı, darbe dayanımı, kimyasal direnç, su emme ve maliyet
Rathod ve Kanzaria	Optimum faz değişim malzemesinin seçilmesi	Gizli Isı, yoğunluk, özgül ısı, özgül ısı, termal iletkenlik ve maliyet
Socaciu ve ark.	Araçta bulunanların termal konforunu korumak için faz değiştiren malzemelerin seçilmesi	Faz değişim sıcaklığı, gizli füzyon ısısı, özgül ısı kapasitesi, termal iletkenlik, katı ve sıvı için yoğunluk ve maksimum çalışma sıcaklığı
Tian ve ark.	İç ortam özellikleri kapsamında yeşil dekorasyon malzemelerinin seçilmesi	Görsel, akustik, dokunsal, koku alma; mimari fizik ve yaşayan beden
Wang ve ark.	Termal enerji depolaması için düşük sıcaklıkta faz değiştiren malzemelerin seçilmesi	Gizli, özgül ısı, termal iletkenlik, aşırı soğutma derecesi, yoğunluk ve maliyet
Zafarani ve ark.	En iyi güç ve işlenebilirlik kombinasyonuna sahip optimal Al-SiC kompozitini seçme	Basınç gerilimi, anlık yoğunluk katsayısı, anlık gerinim-sertleşme üssü ve gerilim işlenebilirlik indeksi

AHP, özellikle hiyerarşik karar vermede, çok kriterli karar analizinde (ÇKKA) güçlü bir araçtır. AHP, bir karar problemini farklı seviyelerdeki bileşenlere ayırır. Ayrıştırma, derinlemesine, kapsamlı ve organize karar verme süreci sağladığı için karar analizinde önemlidir. Karar vericiler, değer yargılarına dayalı olarak, aynı seviyedeki unsurların, hemen daha yüksek seviyedeki bir unsura göre ikili karşılaştırmalarını ortaya çıkarır[21]. Karar, değerlendirme kriterlerinin türetilmiş ağırlıkları (*w)* kullanılarak verilir[22]. AHP, kriterleri hesaplamak için ikili bir matris kullanır. Ayrıca, kararların tutarlılık oranı (*CR*), tutarlılık indeksi (*CI*) ve rastgele tutarlılık indeksi (*RI*) kullanılarak belirlenir. CR, ikili karşılaştırma matrisinde elde edilen değerlerin rastgele olasılığını sunar. Karşılaştırma için *'n'* sayı kriteri belirlenirse aşağıdaki adımlar kullanılır[23].

Adım 1:Karşılaştırma Matrisinin Oluşturulması

Problemde yer aldığı düşünülen faktörlerin tespit edilmesi amacıyla literatürden veya uzman görüşlerinden yararlanılabilir. AHP yönteminde, birden fazla faktör için (n*n) ikili karşılaştırma matrisi oluşturmak için, "i" faktörünü "j" faktörüne göre önem derecesi "a" olarak belirlenmişse, j elemanının i elamanına göre önem derecesi "1/a" olacaktır. $a_{ij}=1/a_{ji}$ olduğu varsayılır. Tablo 5'de a_{ij}'nin ikili karşılaştırma matrisindeki değerlendirme değerleri Tablo.4'de verilen Saaty (2008) ölçeğinden alınmıştır[24].

Tablo.4 Saaty'nin Önem Ölçeği[15, 22, 25]

Önemin Gücü	Tanımlama	Açıklama
1	Eşit önem	İki aktivite, hedef 1'e eşit katkıda bulunur.
3	Ilımlı önem	Deneyim ve yargılama, bir aktiviteyi bir başkasına biraz tercih eder.
5	Güçlü önem	Deneyim ve yargılama, bir aktiviteyi diğerine şiddetle tercih eder.
7	Çok güçlü önem	Bir aktivite güçlü bir şekilde tercih edilir ve egemenliği pratikte gösterilmiştir.
9	Aşırı önem	Bir aktiviteyi bir başkasına tercih eden kanıtlar mümkün olan en yüksek onaylama sırasıdır.
2,4,6,8	İki bitişik yargılama arasındaki ara değerler	Bir uzlaşma gerektiğinde.

Öneminin gücü Tablo 4'de gösterilen, önceden tanımlanmış Tablo 5'de verilen performans tanımlama kriterlerine dayalı olarak ikili kararları değerlendirerek ikili karşılaştırma matrisi Tablo 6'da oluşturulmuştur.

Tablo 5. Bu çalışmada uygulanan performans tanımlama kriterlerinin (PTK'ler) açıklamaları.

PTK-no.:	***PTK; performans üzerindeki etkileri***	***PTK'nin tanımı***
PTK-1	Sürtünme katsayısı (yüksek daha iyi)	Sürtünme katsayısı, kinetik enerjiyi ısı enerjisine dönüştürebilmek için önemlidir. Bu sebeple yüksek olması tercih edilir.
PTK-2	Aşınma Oranı (düşük daha iyi)	Malzemenin ömrünü etkiler. Düşük olması artan yoğunluk ve uzun kayma mesafesi ve sürtünme için önemlidir.
PTK-3	Rockwell sertliği (HRr) (yüksek daha iyi)	Genellikle penetrasyon/çizilme ile plastik deformasyona karşı malzeme direnci. Daha yüksek sertlik, aşınma direncini artırır[26].
PTK-4	Yoğunluk (ρ) (g/cc) (yüksek daha iyi)	Malzemenin birim hacmindeki kütle oranıdır. Aşınma oranını düşürür.
PTK-5	Su emme (WS) (%); (düşük daha iyi)	Oda sıcaklığında malzeme tarafından emilen su miktarının oranı olarak tanımlanır. Düşük olması yol şartlarında sürtünme malzemesinin su emmemesi açısından önemlidir.
PTK-6	Yağ emme (WS) (%); (düşük daha iyi)	Oda sıcaklığında malzeme tarafından emilen yağ miktarının oranı olarak tanımlanır. Düşük olması olası yağ kaçaklarında sürtünme malzemesinin yağ emmeyip sürtünme katsayısı azaltmaması açısından önemlidir.

Tablo 6. İkili karşılaştırma matrisi

	PTK-1	**PTK-2**	**PTK-3**	**PTK-4**	**PTK-5**	**PTK-6**	∑
PTK-1	**1**	3	5	5	7	7	28.000
PTK-2	1/3	**1**	3	3	5	5	17.333
PTK-3	1/5	1/3	**1**	2	3	3	9.533
PTK-4	1/5	1/3	1/2	**1**	3	3	8.033
PTK-5	1/7	1/5	1/3	1/3	**1**	1/2	2.510
PTK-6	1/7	1/5	1/3	1/3	2	**1**	4.010
∑	**2.019**	**5.067**	**10.167**	**11.667**	**21.000**	**19.500**	**6**

Adım 2: Normalize matrisin oluşturulması

Tablo 6'da verilen ikili karşılaştırma matrisindeki değerlerden, denklem (1) kullanılarak Tablo 7'de verilen normalleştirilmiş bir ikili karşılaştırma matrisi hesaplanmıştır. Son olarak bağıl ağırlıklarını (w_i) bulmak için denklem (2) kullanılmıştır.

$$C_{ij=}\frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}} \tag{1}$$

$$w_{i=}\frac{1}{n}\sum_{j=1}^{n} c_{ij} \;\; i = 1,2,3,\ldots,m \tag{2}$$

Tablo 7. Normalize Matrisi

							w_i
PTK-1	0.495	0.592	0.492	0.429	0.333	0.359	**0.450**
PTK-2	0.165	0.197	0.295	0.257	0.238	0.256	**0.235**
PTK-3	0.099	0.066	0.098	0.171	0.143	0.154	**0.122**
PTK-4	0.099	0.066	0.049	0.086	0.143	0.154	**0.099**
PTK-5	0.071	0.039	0.033	0.029	0.048	0.026	**0.041**
PTK-6	0.071	0.039	0.033	0.029	0.095	0.051	**0.053**
∑	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Adım 3: Tahmini ağırlık değerlerinin tutarlılığını kontrol etmek için tutarlılık oranı (*CR*) denklem (4) ile hesaplanır. Bunun için ilk önce, her matris için özvektörü *(λ_i)* ve maksimum özdeğeri *(λ_{max})* hesaplanır; ardından, tutarlılık indeksi *(CI)* denklem (3) ile hesaplanır.

$$CI = \frac{\lambda_{max} - n}{n-1} \tag{3}$$

Burada λ_{max} ikili karşılaştırma matrisinin en büyük öz değeridir ve 'n' matrisin boyutudur.

Son olarak, ikili karşılaştırma matrisinin tutarlılığını sağlamak için tutarlılık kararı, tutarlılık oranı (CR) ile 'n'nin uygun değeri için kontrol edilmelidir.

$$CR = \frac{CI}{RI} \tag{4}$$

Burada *'RI'* rastgele tutarlılık indeksidir. Farklı 'n' sayıları için *RI* değerleri Tablo 8'de sunulmuştur.

Tablo 8. 'n' Sayıları için Rastgele Tutarlılık İndeksi değeri [25]

n	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
RI	0	0.58	0.90	1.12	**1.24**	1.32	1.41	1.45	1.51

RI: rastgele tutarlılık indeksi

CR ≤ 0.10 ise, tutarlılık derecesi tatmin edicidir. CR ≥ 0.10 ise, önemli tutarsızlıklar vardır. Böyle bir durumda AHP anlamlı sonuçlar vermeyecektir[23].

AHP yöntemi ile yapılan hesaplamalar neticesinde tutarlılık oranı *CR: 0.044* çıkmıştır. Bu değer *0.10* den küçük olduğundan kriterlere ait hükümlerin tutarlı olduğu görülmüştür. AHP ile gerçekleştirilen analizler sonucunda kriter ağırlıklarının sırasıyla; 0.450, 0.235, 0.122, 0.099, 0.041 ve 0.053 olduğu tespit edilmiş ve Tablo 9'da belirtilmiştir.

Tablo 9. AHP Metodunun Sonuçları

	Sürtünme Katsayısı	**Aşınma Oranı**	**Sertlik**	**Yoğunluk**	**Su Emme**	**Yağ Emme**
Ağırlık	0.450	0.235	0.122	0.099	0.041	0.053
λmax: 6.27		**CI:** 0.0539		**CR:** 0.044		**RI:** 1.24

2. ARAS(Additive Ratio ASsessment) Yöntemi

ARAS yöntemi, Zavadskas ve Turskis tarafından çok kriterli karar verme problemlerinin çözümüne yeni bir yaklaşım sunmak amacıyla geliştirilmiştir. ÇKKV yöntemlerinin bir çoğu ideal pozitif ve ideal negatif çözüme olan uzaklıkları dikkate alarak, mevcut çözümlerin fayda fonksiyonu değerlerini ideal pozitif alternatif çözüm değeri ile karşılaştırma esasına dayanırken, ARAS yönteminde alternatiflerin fayda fonksiyonu değerleri optimal durumdaki alternatife ait fayda fonksiyonu değeri ile karşılaştırılmaktadır. Bu sebeple ARAS yöntemi, çok kriterli karar verme yöntemleri içerisinde oransal derecelendirme hedefine en uygun yöntem olarak görülmektedir. ARAS yöntemi, çok kriterli karar verme problemlerinde 4 adımda uygulanmaktadır[1, 4].

1.Adım: Karar matrisinin oluşturulması

ARAS yönteminde karar matrisinin oluşturulmasında öncelikle probleme ait kriterlerin ve alternatiflerin belirlenmesi gerekir. Karar matrisi *m* tane alternatif ve *n* tane kriterden meydana gelmektedir[27, 28].

$$X = \begin{bmatrix} \chi_{01} & \chi_{02} & \cdots & \chi_{0n} \\ \chi_{11} & \chi_{12} & \cdots & \chi_{1n} \\ \vdots & \vdots & \cdots & \vdots \\ \chi_{m1} & \chi_{m2} & \cdots & \chi_{mn} \end{bmatrix}; \qquad i = 0,1,\ldots,m;\ \ j = 1,2,\ldots,n \tag{5}$$

Eşitlik (5) yardımıyla oluşturulan karar matrisi aşağıdaki gibidir;

$$X = \begin{bmatrix} \mathbf{0.59} & \mathbf{0.21} & \mathbf{114.33} & \mathbf{2.38} & \mathbf{0.08} & \mathbf{0.04} \\ 0.32 & 29.93 & 84.52 & 1.50 & 5.25 & 8.73 \\ 0.39 & 1.03 & 92.91 & 2.38 & 0.86 & 0.60 \\ 0.36 & 2.23 & 100.75 & 2.02 & 1.52 & 1.02 \\ 0.32 & 0.72 & 113.45 & 2.02 & 1.46 & 2.43 \\ 0.33 & 0.69 & 98.82 & 2.03 & 1.03 & 0.73 \\ 0.36 & 1.28 & 113.62 & 1.71 & 14.43 & 9.89 \\ 0.54 & 5.33 & 85.32 & 1.82 & 5.02 & 3.65 \\ 0.31 & 0.42 & 93.76 & 2.24 & 0.69 & 0.50 \\ 0.34 & 0.21 & 105.45 & 2.25 & 0.08 & 0.07 \\ 0.28 & 0.36 & 102.78 & 2.04 & 0.71 & 0.50 \\ 0.59 & 36.81 & 106.20 & 1.74 & 4.22 & 10.24 \\ 0.31 & 0.32 & 114.33 & 2.08 & 0.26 & 0.20 \\ 0.36 & 1.09 & 110.40 & 2.07 & 0.31 & 0.23 \\ 0.32 & 0.45 & 105.93 & 1.90 & 0.19 & 0.04 \end{bmatrix}$$

Matris üzerinde x_{ij}, i, alternatifinin j, kritere göre gösterdiği performans değerini; x_{ij} ise j. kriterin optimal değerini göstermektedir. Kritere ilişkin optimal değer, karar probleminde bilinmiyorsa kriterin fayda veya maliyet özelliğine göre optimal değer eşitlik (6) yardımıyla hesaplanmaktadır[29].

$$\begin{aligned} &Eğer\ \max_i \chi_{ij}\ ise\ \chi_{0j} = \max_i \chi_{ij} \\ &Eğer\ \min_i \chi_{ij}^*\ ise\ \chi_{0j} = \min_i \chi_{ij}^* \end{aligned} \tag{6}$$

2.Adım: Normalize edilmiş karar matrisinin elde edilmesi

ARAS yönteminde $\bar{X}$ normalize edilmiş karar matrisi $\bar{X}_{ij}$ değerlerinden oluşmaktadır. $\bar{X}_{ij}$ değerleri, kriterlerin fayda veya maliyet özelliğine göre iki farklı şekilde hesaplanmaktadır. Kriter performansının maksimum olmasının istendiği (fayda) durumlarda eşitlik (7) kullanılırken, kriter performansının minimum olmasının istendiği (maliyet) durumlarda ise eşitlik (8) kullanılmaktadır [1, 4, 29].

$$\bar{x}_{ij} = \frac{\chi_{ij}}{\sum_{i=0}^{m} \chi_{ij}} \tag{7}$$

$$\bar{x}_{ij} = \frac{1/\chi_{ij}}{\sum_{i=0}^{m} 1/\chi_{ij}} \tag{8}$$

$$\bar{\boldsymbol{X}} = \begin{bmatrix} \mathbf{0.103} & \mathbf{0.183} & \mathbf{0.074} & \mathbf{0.079} & \mathbf{0.282} & \mathbf{0.302} \\ 0.056 & 0.001 & 0.055 & 0.050 & 0.004 & 0.001 \\ 0.068 & 0.037 & 0.060 & 0.079 & 0.026 & 0.020 \\ 0.063 & 0.017 & 0.065 & 0.067 & 0.015 & 0.012 \\ 0.056 & 0.052 & 0.074 & 0.067 & 0.015 & 0.005 \\ 0.058 & 0.055 & 0.064 & 0.067 & 0.022 & 0.017 \\ 0.063 & 0.029 & 0.074 & 0.056 & 0.002 & 0.001 \\ 0.094 & 0.007 & 0.055 & 0.060 & 0.004 & 0.003 \\ 0.054 & 0.091 & 0.061 & 0.074 & 0.033 & 0.024 \\ 0.059 & 0.183 & 0.068 & 0.075 & 0.282 & 0.173 \\ 0.049 & 0.105 & 0.067 & 0.068 & 0.032 & 0.024 \\ 0.103 & 0.001 & 0.069 & 0.058 & 0.005 & 0.001 \\ 0.054 & 0.119 & 0.074 & 0.069 & 0.087 & 0.060 \\ 0.063 & 0.035 & 0.072 & 0.069 & 0.073 & 0.053 \\ 0.056 & 0.083 & 0.069 & 0.063 & 0.119 & 0.302 \end{bmatrix}$$

Normalizasyon işleminin ardından eşitlik (9) ye göre hazırlanmış $\bar{X}$ normalize edilmiş karar matrisi elde edilmektedir[30].

$$\bar{X} = \begin{bmatrix} \bar{x}_{01} & \bar{x}_{02} & \cdots & \bar{x}_{0n} \\ \bar{x}_{11} & \bar{x}_{12} & \cdots & \bar{x}_{1n} \\ \vdots & \vdots & \cdots & \vdots \\ \bar{x}_{m1} & \bar{x}_{m2} & \cdots & \bar{x}_{mn} \end{bmatrix} \tag{9}$$

3.Adım: Ağırlıklandırılmış normalize edilmiş karar matrisinin oluşturulması

ÇKKV problemlerinde kriterlerin farklı önem derecelerine sahip olabileceklerinden hareketle ağırlıklandırma işlemi gerçekleştirilmektedir. Normalize edilmiş karar matrisinin kullanıldığı bu işlemde, kriterlerin ağırlıkları uzman görüşleri veya farklı yöntemler kullanılarak elde edilmekte ve normalize edilmiş değerlerin ağırlıklandırılması eşitlik (10) yardımıyla sağlanmaktadır. Formülde yer alan w_j, j kriterinin önem katsayısını ifade ederken $\bar{x}_{ij}$ ise j kriterinin normalize edilmiş değerini ifade etmektedir[1, 4, 29]. Eşitlik (10) ile elde edilen ağırlıklandırılmış normalize edilmiş karar matrisi ($\widehat{\boldsymbol{X}}$) aşağıda verilmiştir.

$$x_{ij} = \bar{x}_{ij} \,.\, w_j \qquad i = 0,1,2,\dots,m \tag{10}$$

$$\hat{X} = \begin{bmatrix} \mathbf{0.0464} & \mathbf{0.0430} & \mathbf{0.0090} & \mathbf{0.0078} & \mathbf{0.0115} & \mathbf{0.0160} \\ 0.0252 & 0.0003 & 0.0067 & 0.0050 & 0.0002 & 0.0001 \\ 0.0307 & 0.0086 & 0.0073 & 0.0078 & 0.0011 & 0.0011 \\ 0.0283 & 0.0040 & 0.0080 & 0.0067 & 0.0006 & 0.0006 \\ 0.0252 & 0.0123 & 0.0090 & 0.0066 & 0.0006 & 0.0003 \\ 0.0260 & 0.0130 & 0.0078 & 0.0067 & 0.0009 & 0.0009 \\ 0.0283 & 0.0069 & 0.0090 & 0.0056 & 0.0001 & 0.0001 \\ 0.0425 & 0.0017 & 0.0067 & 0.0060 & 0.0002 & 0.0002 \\ 0.0244 & 0.0214 & 0.0074 & 0.0074 & 0.0013 & 0.0013 \\ 0.0267 & 0.0430 & 0.0083 & 0.0074 & 0.0115 & 0.0092 \\ 0.0220 & 0.0248 & 0.0081 & 0.0067 & 0.0013 & 0.0013 \\ 0.0464 & 0.0002 & 0.0084 & 0.0057 & 0.0002 & 0.0001 \\ 0.0244 & 0.0279 & 0.0090 & 0.0069 & 0.0035 & 0.0032 \\ 0.0283 & 0.0082 & 0.0087 & 0.0068 & 0.0030 & 0.0028 \\ 0.0252 & 0.0196 & 0.0084 & 0.0063 & 0.0048 & 0.0160 \end{bmatrix}$$

III. BULGULAR

A. Optimallik fonksiyon değerlerinin hesaplanması

ARAS yönteminin son adımını her bir alternatif için optimal değer fonksiyonu hesaplanması ve alternatiflerin değerlendirilmesi işlemleri oluşturmaktadır. S_i, i. alternatifin optimal fonksiyon değerini ifade etmekle birlikte alternatiflere ait S_i değerleri eşitlik (11) yardımıyla elde edilmektedir:

$$S_i = \sum_{j=1}^{n} x_{ij} \,; \qquad i=0,1,\dots,m \tag{11}$$

Hesaplama sonrası elde edilen S_i değerleri arasında büyük olanlar daha etkin alternatifleri göstermektedir[1]. S_i değerinin elde edilmesinin ardından alternatiflere ait S_i değerlerinin S_0 optimal değerine oranlanması yoluyla K_i fayda dereceleri elde edilmektedir. Alternatiflere ait fayda derecesi, bir alternatifin optimallik fonksiyonu değeri ve en iyi alternatife ait optimallik fonksiyonu değerinin oranlanması yoluyla bulunmaktadır. İlgili işlem eşitlik (12) yardımıyla gerçekleştirilmektedir[29].

$$K_i = \frac{S_i}{S_0} \,; \qquad i = 0,1,\dots,m \tag{12}$$

Elde edilen $\boldsymbol{K_i}$ oranları içerisinde en yüksek değere sahip olanlar en iyi alternatifleri ifade ederken, en düşük değere sahip alternatifler ise en kötü alternatifleri ifade etmektedir[27].

Tablo 10. ARAS metoduyla elde edilen ideallik sıralaması

Kriterler için Optimum Değer ***(S₀)***	**0.134**		
Alternatifler	S_i	K_i	**Sıralama**
B25S30	0.106	0.793	1
K25Y30	0.080	0.600	2
K25M30	0.075	0.560	3
B25Y30	0.064	0.480	4
B25M30	0.063	0.472	5
K25A30	0.061	0.456	6
K25S30	0.058	0.432	7
B25A30	0.057	0.428	8
B55	0.057	0.423	9
S55	0.055	0.412	10
M55	0.054	0.403	11
Y55	0.050	0.373	12
K55	0.048	0.360	13
A55	0.037	0.279	14

AHP yöntemi kullanılarak elde edilen ve Tablo 9'da verilen sonuçlardan faydalanılarak ARAS yöntemi adımları ile elde edilen karar matrisi, normalize karar matrisi ve ağırlıklandırılmış normalize karar matrisine göre elde edilmiş sonuçlar tablo 10'da verilmiştir.

IV. SONUÇLAR

En ideal dolgu malzemesini tespit etmek için yapılan bu çalışmada, deneysel olarak elde edilen sonuçlar Tablo.2'de verilmiştir. İncelenen 6 farklı kıstas tek tek ele alındığında sürtünme katsayısına göre en ideal numune (en yüksek değere sahip) K25A30 kodlu numunedir. Aşınma oranı kritere ele alındığında en düşük değere sahip (en ideal) numune B25S30 kodlu numunedir. Sertlik kriterine göre K25M30 numunesi, yoğunluk kriterine göre B55 numunesi, su emme ölçütüne göre B25S30 numunesi, yağ emme kriterine göre ise K25Y30 numunesi ideal numuneler olarak ortaya çıkmıştır.

AHP'nin uygulanması sonucunda kriterlerin bağıl ağırlıkları; sürtünme katsayısı (0.450), aşınma oranı (0.235), sertlik (0.122), yoğunluk (0.099), su emme (0.041) ve yağ emme (0.053) olarak bulunmuştur. **λmax:**6.27, **CI:**0.0539, **CR:**0.044 olarak hesaplanmıştır. CR değeri ≤ 0.10 olduğundan kriterlere ait sonuçlar tutarlıdır.

AHP ile elde edilen bağıl ağırlıklar, ARAS yöntemine aktarılmış ve elde edilen ağırlıklandırılmış normalize karar matrisi elde edilmiştir. Kriterler için optimum değer (S_0), 0.134 olarak bulunmuştur. ARAS yöntemiyle elde edilen alternatifin optimal fonksiyon değeri (S_i) ve S_i değerlerinin S_0 optimal değerine oranlanması yoluyla, fayda dereceleri (K_i) hesaplanmıştır. K_i değerlerinin büyükten küçüğe sıralaması bütün kriterler için numunelerin ideallik sıralamasını vermektedir.

Altı farklı dolgu malzemesinden elde edilen 14 faklı numunenin incelenen 6 kritere göre en ideal dolgu malzemesini belirlemek için uygulanan ÇKKV sonucunda B25S30 ideal dolgu malzemesi olarak tespit edilmiştir.

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Electronic and Optical Properties of $BaNb_2O_6$ Compounds: Theoretical Study

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Abstract – In this study, we utilize WIEN2k and density functional theory (DFT) to investigate $BaNb_2O_6$ (BNO) compounds. Our results, which closely align with experimental data, identify the optimal lattice constants using the PBE-GGA method. We reveal that BNO possesses an indirect bandgap, with significant contributions from oxygen and niobium atoms. Furthermore, our analysis of the anisotropic optical properties, particularly in UV light reflection, highlights BNO's potential for various applications. This research not only uncovers the unique characteristics of BNO but also paves the way for similar analyses in other compounds, promising advancements in materials science.

Keywords – $BaNb_2O_6$ (BNO), Density Functional Theory (DFT), PBE-GGA Method, Indirect Bandgap, Optical Properties

I. INTRODUCTION

Solid-state compounds with the formula AB2O6, encompassing diverse main group and transition metal cations denoted as A and B, have been extensively studied. Researchers have unveiled their complex structures and physical properties. [1]

Niobate crystals, like $BaNb_2O_6$, are renowned ferroelectric materials prized for their remarkable pyroelectric coefficients, and electro-optic capabilities [2]

Layden (1967, 1968) identified temperature-dependent structural variations in BaNb2O6 (BNO) [3]. Chemical solution precipitation was used to produce (Sr, Ba)(Nb, Ta)2O6 (SBNT) thin films in 2001 [4] Scientists created tungsten bronze crystal systems by combining BaNb2O6 (BNO) with various chemicals and studying their characteristics [5–9] Yamaguchi et al. achieved pure hexagonal BNO utilizing simultaneous barium and niobium hydrolysis in 1985 [10]. Various techniques have been used to make pure or doped Strontium barium niobate ferroelectric films, and numerous features of this material have been studied [11–16]. Kim et al. used the solid state reaction technique in 2002 to generate BNO in orthorhombic and hexagonal structures. The electrical characteristics of the compounds were studied [17]. In 2005, BNO was produced utilizing sol-gel or urea techniques, and an X-ray analysis of the final product was performed [18,19]. The photoluminescence characteristics of Eu and Sm doped BNO compounds were studied [20–23].

While experimental studies on $BaNb_2O_6$ abound, theoretical investigations are limited. Our research utilizes WIEN2k to delve into the compound's electrical, structural, and optical characteristics, offering valuable insights into its future technological applications and expanding scientific comprehension of this compound.

II. Materials and Method

The investigation into the physical properties of the BNO system involved numerical computation using the Wien2k package [24],This software facilitated the implementation of Density Functional Theory (DFT) within the framework of the local spin density approximation (LSDA), specifically designed to address exchange-correlation effects.

III. Results and Discussion

BaNb2O6 exhibits a hexagonal crystal structure (see Figure 1), featuring a unique arrangement of barium, niobium, and oxygen ions. Niobium ions form distorted octahedra within this structure, sharing edges with adjacent octahedra and creating channels along specific crystallographic directions. These channels play a crucial role in dictating the material's electrical properties and contributing to its ferroelectric behavior. A comprehensive understanding of BaNb2O6's hexagonal structure is imperative for unlocking its technological applications and predicting potential phase transitions.

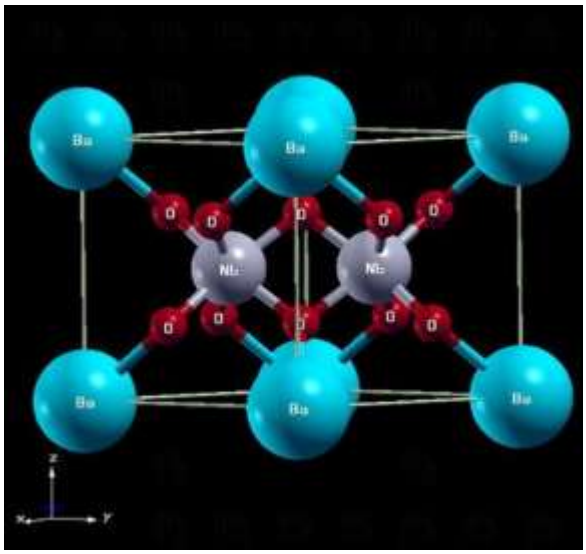


Fig. 1 BNO structure view

A. Volume Optimization

To attain the lowest total energy, reflecting the most stable crystal structure, volume optimization was performed. This process, depicted in Figure 1, was executed using four embedded potentials: Perdew–Burke–Ernzerhof (PBE), Local Spin Density Approximation (LSDA), Wu-Cohen Generalized Gradients Approximation (WC-GGA), and PBEsol-GGA, chosen for the exchange-correlation potential. The theoretical lattice constants obtained from this optimization are presented in Table 1 [25]

Table 1. The experimental and calculated lattice constants according to chosen exchange-correlation potential.

Lattice parameter	**Experimental**	**PBE-GGA**	**LSDA**	**WC-GGA**	**PBEsol-GGA**
a (Å)	5.3760001	5.3760023	5.3033446	5.3399208	5.3399208
b (Å)	5.3760001	5.3760023	5.3033446	5.3399208	5.3399208
c (Å)	5.6130000	5.6130075	5.5371415	5.5753301	5.5753301

The theoretical lattice constant obtained using the(PBE-GGA) potential closely matches the experimental findings.

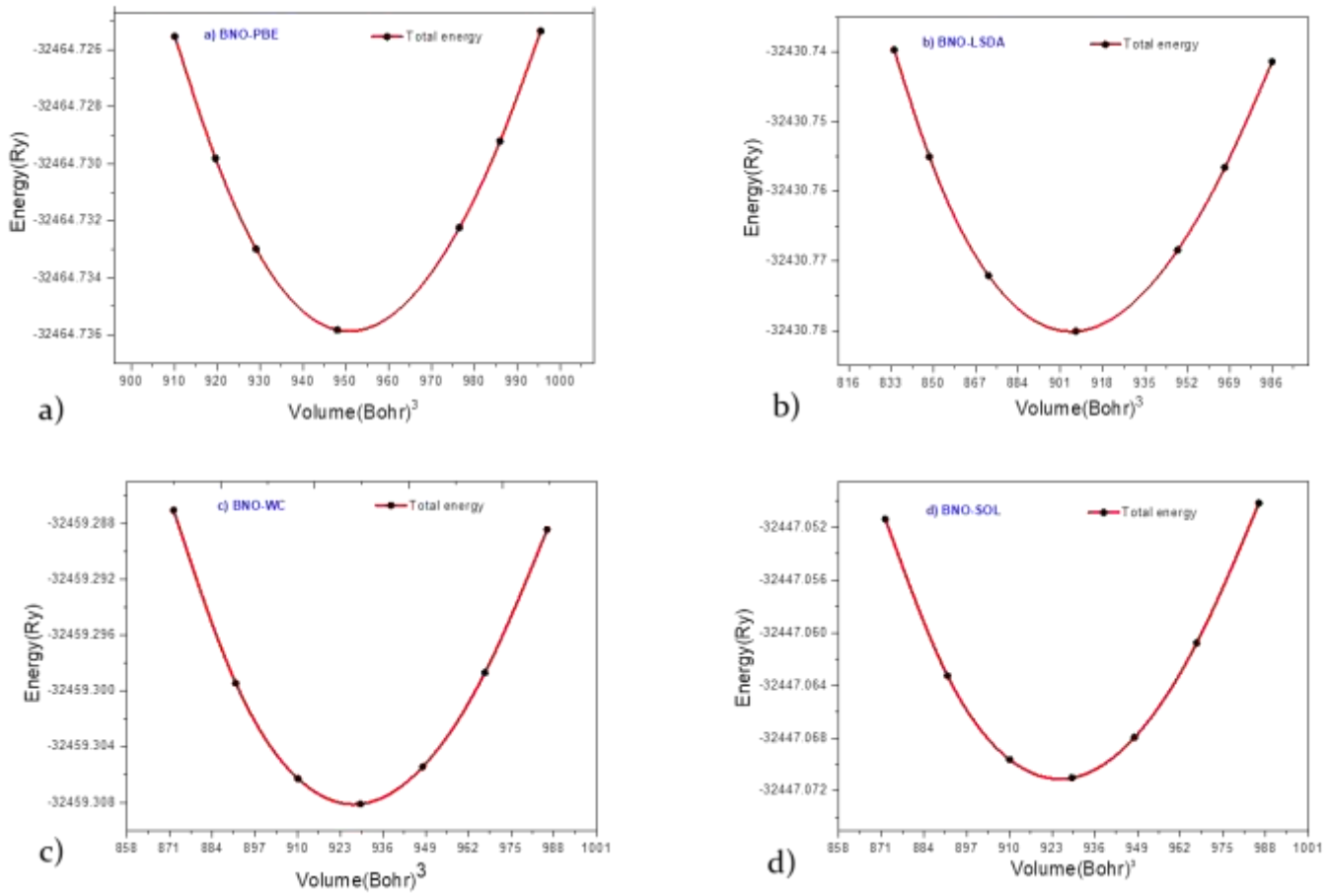


Fig. 2 Energy (eV) vs Volume . plots of BaNb2O6 under
(a) LSDA, (b) WC-GGA, (c) PBE-GGA, (d) PBEsol-GGA .

Fig. 2 Theoretical lattice constants for four potentials determined via WIEN2k, compared with experimental values for BaNb2O6 (Table 1). Evaluates agreement between theory and experiment."

B. Electronic Band Structure

Figure 3 showcases our electronic band structure analysis, revealing crucial energy levels and bandgap information for the crystal.

The VBtop (valence band top, in black) and CBbottom (conduction band bottom, in blue) span from Γ to K points in the high-symmetry Brillouin zone, outlining critical energy levels. The Y-axis denotes the forbidden energy bandgap, indicating where electronic transitions are restricted. Theoretical prediction sets the energy band gap at 4.1 eV, while experimental data (Jana, 2020) reports 3.76 eV[26]. This gap showcases an indirect transition mechanism.

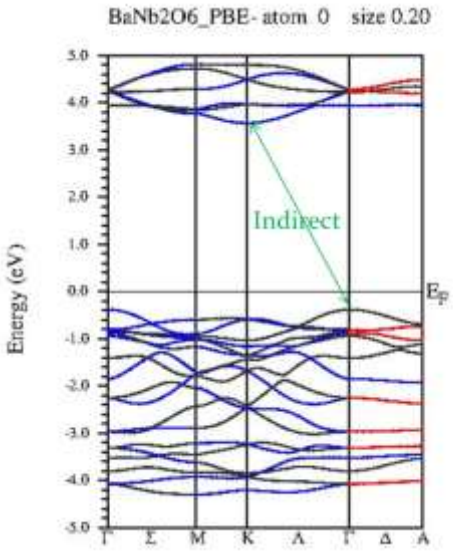


Fig. 3 Electronic band structure of $BaNb_2O_6$

C. Electronic Density of States

The total and partial density of states were calculated to understand the band structure. From (Fig 4.) Total density is ranging from -5eV to 7 eV**,**

The valence bands, ranging from -4 to 0 eV, exhibit strong electronic interaction between Nb and O atoms. According to the Fig 4. O_2 corresponds to the valence band, while Nb represents the conduction band, with Ba being negligible in this context.

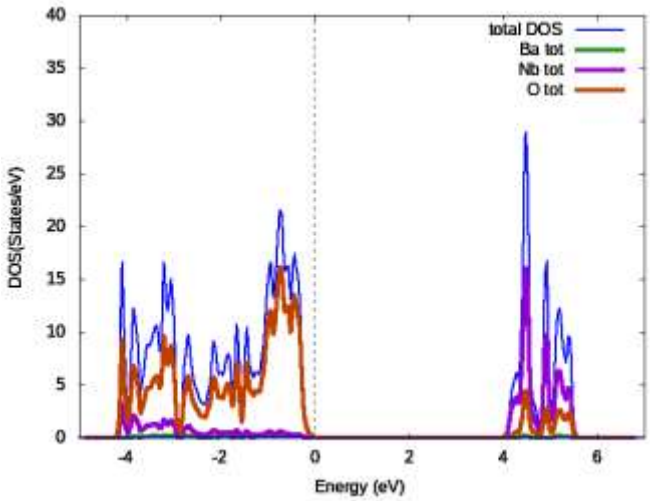


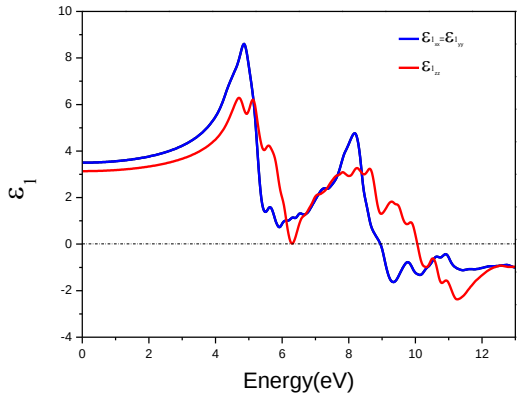
Fig. 4 Electronic density of BaNb2O6

D. Optical Properties

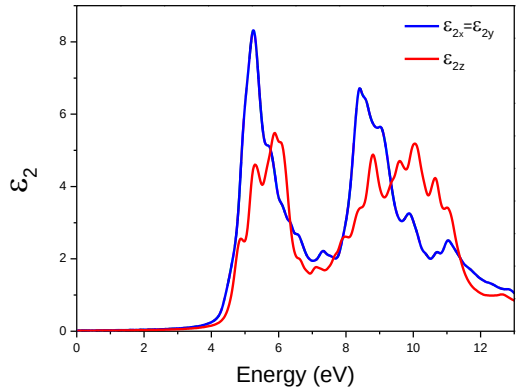
We analyze BNO's optical properties, considering its structure and orientation. Utilizing the dielectric tensor, we examine its interaction with electromagnetic radiation. Figure 5a shows the real part of the frequency-dependent dielectric function, providing insights into optical behavior and transition probabilities."

In addition, we delve into the imaginary part (Fig. 5.b) of the dielectric function to elucidate the energy band structure of BNO.

In the range of 3.7 to 7.0 eV, we observe transitions from the highest valence band to the lowest conduction band. This transition is particularly significant in materials exhibiting anisotropy. Notably, at 5.2 eV, we observe a prominent maximum peak indicative of specific electronic transition



a)



b)

Fig. **5** a) Real and b) imaginary part of the dielectric constant

The absorption coefficient versus energy is shown in Fig 6. there is no photon absorbance before 4eV . The wide absorption band is observed after 4 eV where the transition occurs.

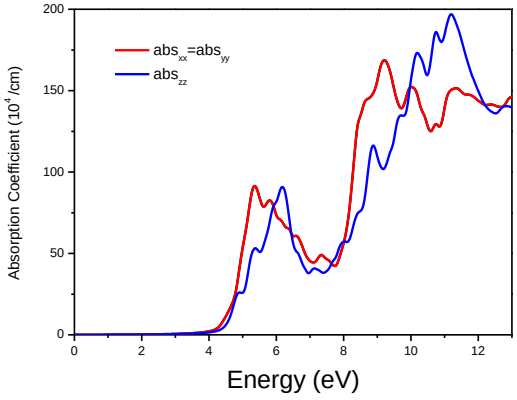


Fig. 6 Absorption coefficient of BNO

The energy loss function describes in fig 7, The energy loss of a very fast electron penetrating through the material

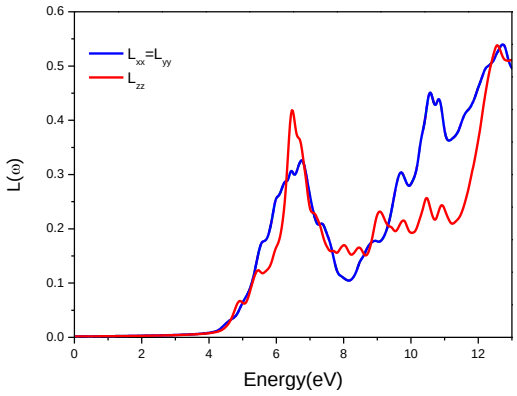


Fig. 7 Energy loss function coefficient of BNO

In Figure 8. showed that 35% of the incoming electromagnetic light are Reflected in UV region, and After 300 nm, 15% of electromagnetic wave was reflected.

It is noteworthy that the peaks are consistent with the energy in the electron energy loss function .

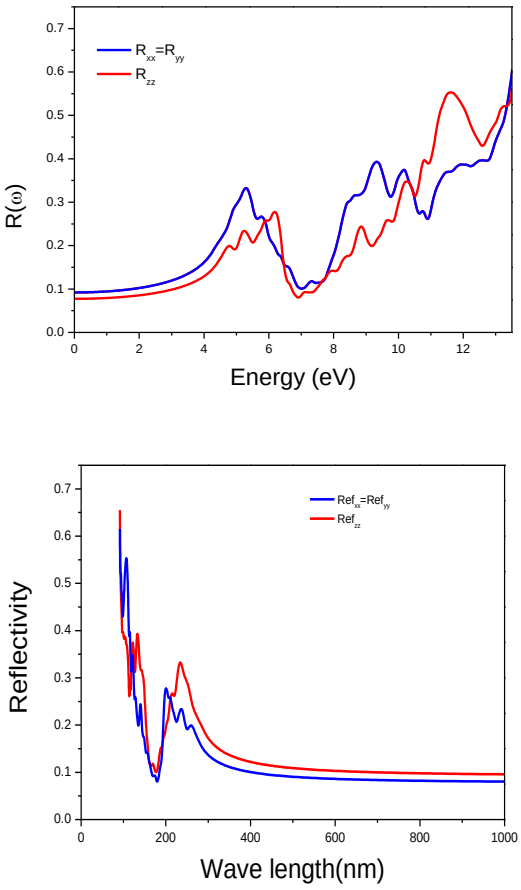


Fig. 8 Reflectivity of BNO

In Fig9. Materials with a high refractive index are sought in photovoltaic applications. The values of the static refractive index (1.7 , 1.8)

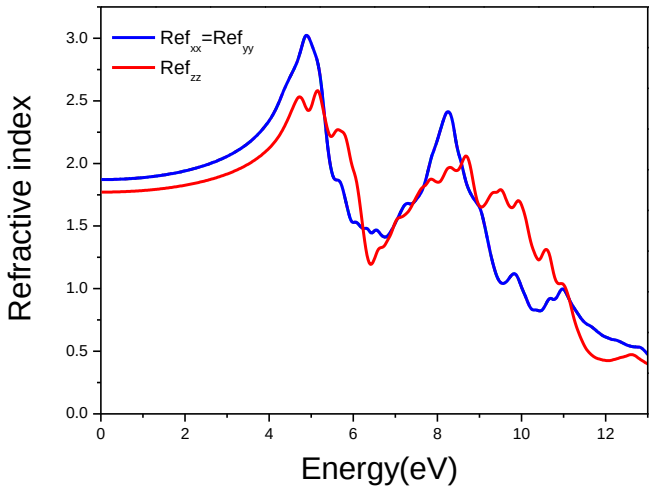


Fig. 9 Refractive index of BNO

In figure 10, Values Material's conductivity and interaction with light at different energy levels

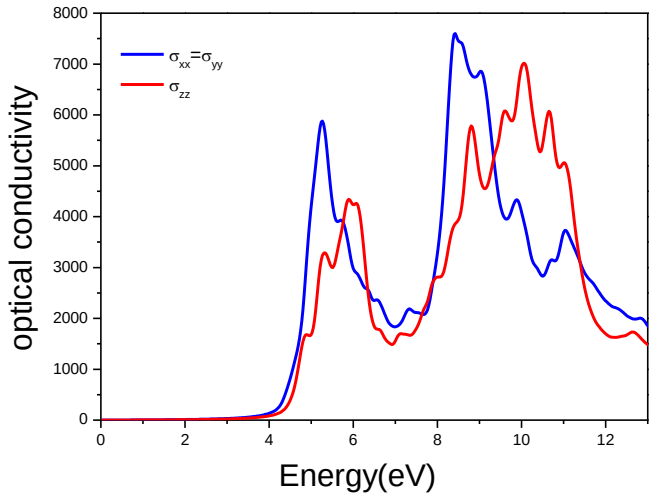


Fig. 10 Optical conductivity

should be clear and concise. The most important features and trends in the results should be described but should not interpreted in detail.

IV. CONCLUSION

WIEN2k, based on density functional theory, was used to analyze the electronic, structural, and optical properties of BNO.

PBE-GGA provided the best lattice constant . BNO displayed indirect bandgap

Energy bandgap 4.1 eV and is good with expriment 3.76 eV . Nb and O are Influenced the conduction band.

Optical properties, including absorption coefficient, refractive index, and reflectivity, showed anisotropy. The compound reflected UV light predominantly.

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Some Factors in Shanghai's Rise to the Top of the PISA Exams

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Abstract – The Ministry closely monitors the reports and data of international assessment and rating institutions and organizations and takes these data into account in policy-making processes. One of these international assessments is the PISA exams. The Program for International Student Assessment (PISA), one of these examinations, is conducted to assess the knowledge and skills of 15-year-old students in the fields of mathematical literacy, reading skills and science literacy and aims to improve education policies worldwide. According to the PISA 2022 results, the average scores of the participating countries in science are between 347 and 561 points. The average score of 81 countries is 447 and the average score of 37 OECD countries is 485. Turkey's average score in science is 476, which is above the average of the participating countries. With PISA 2022, Turkey's average science performance has reached its highest level since 2003. In addition to Turkey's positive progress, it is possible to make some evaluations to increase Turkey's success in the field of science literacy by critically evaluating the factors behind the success of China, one of the countries that has shown a remarkable success in PISA exams, especially in science literacy. The aim of this study is to examine the main reasons for China's success in PISA exams in international assessments rather than the fact that our country is making progress in PISA exams compared to previous years. In this study, the factors behind China's success were tried to be more understandable by examining the views of the people involved in the process. The general evaluation of the study reveals that some of the most important results are the assignment of teachers who are successful in science education to transfer their experiences to other schools, and the assignment of teachers who are experts in the field who are only responsible for the development of science curricula and the follow-up of the process.

Keywords – Science teaching, science literacy, PISA 2022, China, Turkey.

I. INTRODUCTION

Published in 1995, the Education Law is recognized as the fundamental law on which China's Education System is built. The highest authority related to education in China is the State Council. After the State Council, the Ministry of Education is recognized as the unit responsible for education administration. The Ministry of Education has responsibilities such as implementing laws and regulations, principles and policies related to education; formulating education policies, preparing and coordinating education development plans; ensuring coordination among all education-related units in the country; and guiding reforms in the education system [2].

The Chinese Education System consists of 12 years of education with a total duration of 6+3+3, the first nine years being compulsory education. The evaluation of the 12-year education process in terms of the lower levels of education is as follows.

Preschool Education Process: Due to the state policies implemented in China, families can have only one child. High academic expectations from children start during early childhood education. For children aged 3-6, preschool education is provided in kindergartens or preschool education classes and is not compulsory.

Primary and Secondary Education: Nine years of compulsory education includes both primary and secondary education. In many provinces of China, this compulsory education period is planned as 6 years of primary school and 3 years of secondary education. In some provinces, however, the 5+4 system is applied.

Upper Secondary Education: There are basically three types of secondary education institutions in China. These are defined as general high schools, vocational and technical high schools and "key" high schools where high-achieving students enroll.

Higher Education: Higher education in China is classified as universities, research institutes, specialized institutes, independent colleges, medical schools and colleges.

Vocational Education: Lower secondary vocational education, which is part of the nine-year compulsory education, trains workers, peasants and employees with basic vocational knowledge and specific skills. These schools are usually located in less economically developed rural areas. Training can last three or four years. Vocational training at upper secondary level can last two to four years. The length of training depends on whether the school accepts students with vocational training in lower secondary education or students from general lower secondary education. Graduates of these schools occupy important positions in production, services, technology and management. Vocational education at lower secondary level plays an important role in training a workforce with practical skills.

During compulsory education, students take a final or control exam at the end of each semester. After nine years of compulsory schooling, students in China take an entrance exam to continue on to upper secondary education. No matter what type of upper secondary school, everyone who wants to continue their education has to take this exam. Students are allowed to take the exams from the second year of upper secondary education. The highest score obtained counts. The content of the exam includes politics, Chinese, mathematics, foreign languages, physics, chemistry, biology, history and geography [4],[5].

Aims of compulsory education:

- To know their roles and responsibilities in the family, society, nation and to show interest in people's well-being,
- Understanding national identity and dedication to contribute to the nation and society,
- To develop the habit of independent reading,
- Participate actively and confidently in conversations in English and Chinese,
- Develop creative thinking and independent learning skills,
- Have basic and broad knowledge in eight key learning areas,
- Lead a healthy lifestyle and develop an interest in aesthetic and physical activities.

Teacher Training: To become a teacher in China, one can study at three types of schools. These are teacher training institutions of higher education, two-year colleges and four-year universities of education. Graduates of these teacher training institutions have to get a certificate in order to teach. This certificate is obtained in two stages. The first is to pass the National Mandarin Language Test. After this test, candidates take another test on pedagogy, psychology, teaching methods and skills. To demonstrate their teaching skills, as part of the exam, candidates are required to conduct a sample lesson.

Schools are the main place for the training of teachers. Once in office, teachers are required to receive systematic and continuous in-service training. Teachers are encouraged to obtain a bachelor's, master's or doctoral degree [2].

Factors behind Shanghai's rise to the top of the PISA results

This section discusses the factors that have influenced the success of China's education system. The views of some of the practitioners of the Chinese education system are given below [6].

Vivien Stewart

Who is Vivien Stewart?

Stewart was a senior advisor to the Asia Society for Education, where she served as vice president for education. While at Asia Society, she traveled frequently to China, meeting with education officials at all levels and visiting Chinese schools. Before joining Asia Society, Stewart directed children, youth and

education programs at the Carnegie Corporation of New York. Although she says she is retired, Stewart is in great demand around the world for meetings where comparative national education performance is a key topic.

Vivien Stewart's Views:

- China's Director of Education states that their educational success is due to their "Tiger Mom" in the eyes of westerners. However, this is not the reality and not all parents are involved. In China's education reform, the number of schools was first increased in the 1970s and 1980s, and quality was emphasized in the 1990s.
- In the 1990s, there was a huge gap between so-called key schools and other schools. To close this gap, successful schools were paired with unsuccessful schools. Principals of successful schools were allowed to manage more than one school in the district.
- When teachers start work, they know that there are 13 career steps that they can move up the ladder. There is no obligation to work in rural schools, but they are encouraged to work in such schools for careers.
- Beginning teachers are guided by a mentor teacher. Several observers can be seen in each classroom. Teachers choose a topic, do preliminary research on it and write a report after applying it in the classroom. Teachers do not spend a lot of time in class hours.

Minxuan Zhang

Who is Minxuan Zhan?

Zhang has served as Rector of Shanghai University. He is the Director of the Center for International Education Studies and Consultation, Ministry of Education of China and a scholar in the field of comparative education. He served as Director General of the Shanghai Academy of Educational Sciences. From 2004 to 2011, Zhang was Deputy Director-General of the Shanghai Municipal Education Committee, in which capacity he was instrumental in planning the educational reforms for which Shanghai has since become famous.

Minxuan Zhan's Views:

- Parents are focused on the need for their children to get a good education, regardless of their economic status.
- He states that Chinese people are very hardworking and are aware that only through hard work can they achieve good things.
- They think that national exams play a very important role in the success of students. It is emphasized that thanks to this exam, people from all walks of life compete equally and those who make enough effort are successful.
- The Open Door Policy is used to keep abreast of developments in the world and to encourage foreigners to study in China.
- With the "Reform of Curriculum and Teaching Approaches", which has been in its third phase from 1986 to the present, the process continues with continuous updating.
- Updating the teacher training system is an important part of improving the quality of education. The fact that teachers first study in a specialty department and then receive formation stands out as a remarkable practice in teacher training.
- Pairing of successful and unsuccessful schools is practiced. Teachers working in successful schools work in cooperation with the teachers in the matched schools.
- China ensures that financial resources are transferred from rich regions to disadvantaged regions with positive differences such as geographical and economic characteristics.
- Another noteworthy detail is the allocation of quotas for students from low-achieving schools to study in high-achieving schools.

Tom Corcoran

Who is Tom Corcoran?

Tom Corcoran is co-director of the Consortium for Policy Research in Education at Teachers College, Columbia University. Over the years, Mr. Corcoran has led numerous high-profile research, evaluation, and professional development projects in the United States and abroad with Marc Tucker Introduction. Mr. Corcoran has worked closely with the Shanghai Municipal Education Commission and this experience has provided him with the opportunity to learn a great deal about education in Shanghai prior to the implementation of the new reforms.

Tom Corcoran's Views:

- Corcoran's observation of a science class in China was that in order to find a solution to a problem, the teacher asks the students to think. Students are actively participating on an intellectual level. They characterize this as “heads working, not hands”.
- He mentions that there is a mechanism that supervises teachers 4-6 times a year.
- The traditional cultural view in China, and especially in Shanghai, is that learning and a strong work ethic are linked. These historical values are the foundation of the emerging modern society. These values underpin Shanghai's educational success. Students work hard during school and often after school. China has a one-child policy that focuses parents' attention on the development of their only child and has a profound impact on the interaction between families and children. There is a much more intense focus in China than in other countries on giving the child all the opportunities for growth that the family can provide. Second, the Shanghai system has important features that create a unique professional environment for teachers. While some of these features are common across China, there are some that are unique to Shanghai. The first is the apprenticeship model for beginning teachers, where new teachers are routinely apprenticed to master teachers in their schools. Recognition as a master teacher is an honor and teachers take their mentoring responsibilities very seriously. Second, teachers work together to develop lessons and, most importantly, the questions that are asked of students during lessons, designed to check for understanding. These questions are continuously developed, tested and refined by teachers working together. This has become a very sophisticated form of formative assessment that plays a crucial role in helping teachers monitor student understanding and adjust their teaching moment by moment in the light of their responses to these probing questions. In addition, early career teachers are frequently observed and receive a lot of feedback and help with their lesson plans.

II. CONCLUSION

It is understood that China's success in the field of science literacy in PISA exams is not accidental, but the result of an education system that has been carried out in a planned manner for many years. The process of planning and implementing education requires time. China's educational reform started by increasing the number of schools in the 1970s and 1980s, and laid the foundations for its current success by giving importance to quality in the 1990s [1],[2]. The fact that education programs are frequently changed in our country stands out as a disadvantage. That is to say, if we consider that a new program that we have just implemented is started to be implemented from the fourth grade of primary school, we can get results by graduating at least the eighth grades in order to get the outputs of the program. This corresponds to a period of at least 6 years. At the same time, for the program to be fully implemented, teacher and school physical conditions must also become suitable. It is also a fact that the next outcomes of the teacher who gains experience after the first five years of implementing the program will improve over time. Therefore, curricula need to be planned and developed very well, and after the implementation begins, continuous in-service training and follow-up of schools are required to ensure that the program is implemented as planned. Schools that have problems in the implementation phase can be ensured by assigning successful teachers to less successful schools, as China has done, and by implementing the science curriculum more successfully in that school. In this way, the achievement gap between schools will be minimized and equal opportunity will be provided to students.

The fact that beginning teachers in China are guided by a mentor teacher also stands out as a remarkable practice. Early career teachers are frequently observed and receive a lot of feedback and help with lesson

plans. Teachers are not required to spend a lot of time in class time, thus allowing them to spend more time on their own professional development.

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QBlade Kullanılarak NACA 1518 Uçak Kanadı Profiline Sahip Yatay Eksenli Rüzgar Türbin Tasarımı

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Özet – Dünya sanayileşme ve nüfus artışına bağlı olarak sürekli artan enerji ihtiyacını karşılamak için çeşitli enerji kaynaklarına başvurmaktadır. Fosil yakıtların sınırlı olması ve kullanımının çevresel etkileri, sürdürülebilir ve temiz enerji kaynaklarına olan ilgiyi artırmıştır. Rüzgar enerjisi, çevre dostu ve sürdürülebilir bir enerji kaynağı olarak büyük bir potansiyele sahiptir. Bu nedenle rüzgar enerjisini elektriğe dönüştüren sistemler olarak tanımlanan rüzgar türbinlerinin verimliliğini artırmaya yönelik çalışmalar her geçen gün artmaktadır. Rüzgar türbin kanadının aerodinamik özellikleri türbinden elde edilecek güç miktarını etkilediğinden dolayı türbinlerin verimliliğini artırmada kanat tasarımı ve optimizasyonu önemli bir faktördür. QBlade, bu süreçte rüzgar türbinlerinin aerodinamik performansını analiz ve optimize etmek için kullanılan bir programdır. Program rüzgar türbin kanat profillerinin tasarımı, analizi ve simülasyonu için kapsamlı araçlar sunmaktadır. Bu çalışmada QBlade programı kullanılarak 3 kanatlı küçük ölçekli bir yatay eksenli rüzgar türbininin tasarımı ve optimizasyonu yapılmıştır. 0.5 m rotor yarıçapına sahip yatay eksenli rüzgar türbin kanadı için NACA 1518 kanat profili seçilmiştir. Programda $1x10^5$ Reynolds sayısı için kanadın atak açısına (AoA) göre taşıma (C_L) ve sürükleme (C_D) katsayısı ve taşıma/sürükleme oranının (C_L/C_D) değişimi analiz edilmiştir. C_L/C_D' nin maksimum olduğu atak açısı 6.5° olarak belirlenmiştir. Türbin kanadı 10 eşit parçaya bölünerek kanat boyunca burulma açısının ve veter uzunluğunun değişimine ait veriler elde edilmiştir. Bu veriler BEM Teorisine dayalı olarak Schmitz denklemlerine göre optimize edilmiştir. Uç hız oranının (TSR) 4.6 olduğu durumda türbinin güç katsayısının maksimum olduğu değer $(C_P)_{max}$, 0.4517 bulunmuştur. Böylece bu çalışmada rüzgar türbini kanadı oluşturmak ve optimize etmek için gerekli adımlar sunulmuştur.

Anahtar Kelimeler – Rüzgar enerjisi, Yatay eksenli rüzgar türbini, Qblade, Kanat tasarımı, Optimizasyon

I. GİRİŞ

Günümüzde dünya genelindeki nüfus artışı, sanayileşmenin hızlanması ve teknolojik gelişmeler sebebiyle enerji ihtiyacı hızla artmaktadır [1]. Fosil yakıtlar (kömür, petrol, doğalgaz vb.) küresel ısınma ve iklim değişikliği gibi olumsuz etkilere neden olduğundan enerji ihtiyacını karşılamak için sürdürülebilir çevre kalitesini sağlayacak yenilenebilir enerji kaynaklarının kullanımına daha fazla öncelik verilmektedir. Bu bağlamda yenilenebilir enerji kaynakları arasında rüzgar enerjisi, temiz ve sürdürülebilir bir enerji kaynağı olarak ön plana çıkmaktadır.

Rüzgar türbinleri, rüzgarda bulunan kinetik enerjiyi öncelikle mekanik enerjiye ve sonrasında elektriğe dönüştüren sistemlerdir [2]. Rüzgar enerjisi dönüşüm sürecinde rüzgar türbin kanatları en önemli görevi yerine getirmektedir [3]. Bu nedenle rüzgar türbinlerinin verimliliği ve performansı büyük ölçüde kanat tasarımına bağlıdır. Kanat tasarımı ve optimizasyonu, rüzgarın kinetik enerjisinin en verimli şekilde mekanik enerjiye ve ardından elektrik enerjisine dönüştürülmesini sağlar.

Yatay eksenli rüzgar türbinlerinde kanat tasarımı, türbinin aerodinamik verimliliğini ve enerji üretim kapasitesini doğrudan etkilemektedir. Kanat tasarımının optimize edilmesi, rüzgarın kinetik enerjisinin elektrik enerjisine maksimum verimlilikte dönüştürülmesini sağlamaktadır. Bu süreçte, modern mühendislik yazılımları büyük bir rol oynamaktadır. QBlade, rüzgar türbin kanatlarının tasarımı ve analizi için kullanılan açık kaynaklı bir yazılımdır [4]. Bu yazılım, kullanıcıların kanat profillerini oluşturmasına, aerodinamik analizler yapmasına ve tasarımlarını optimize etmesine olanak tanımaktadır.

Literatürde QBlade programı kullanılarak rüzgar türbin kanatlarını optimize etmek için birçok çalışma yapılmıştır. Zidane ve Mahmood [5] QBlade programında NACA 4711 kanat profiline sahip küçük ölçekli yatay eksenli rüzgar türbin kanadının aerodinamik analizini ve tasarımını gerçekleştirmiştir. 155 cm uzunluğa sahip kanat 16 parçaya bölünerek kanadın güç faktörü, tork katsayısı, taşıma ve sürükleme katsayısı, kaldırma-sürükleme oranı gibi aerodinamik karakteristikleri belirlenmiştir. Ayrıca türbinin güç katsayısının (C_P) 0.4742 olduğu sonucuna varılmıştır.

Altmimi vd. [6] küçük ölçekli yatay eksenli rüzgar türbinini optimize etmek için QBlade programını kullanmıştır. Rüzgar türbininin kanat tasarımında SG-6041 kanat profili seçilerek BEM Teoremine göre programda kanadın kaldırma ve sürükleme katsayıları analiz edilmiştir. Çalışmada kanadı 10 eşit parçaya bölerek her bir parça için burulma ve veter uzunluğunun değişimi gösterilmiştir. Sonuç olarak 10 m/s ortalama rüzgar hızında 1 m kanat uzunluğuna sahip yatay eksenli rüzgar türbininin güç katsayısı (C_P) 0.4 olarak hesaplanmıştır.

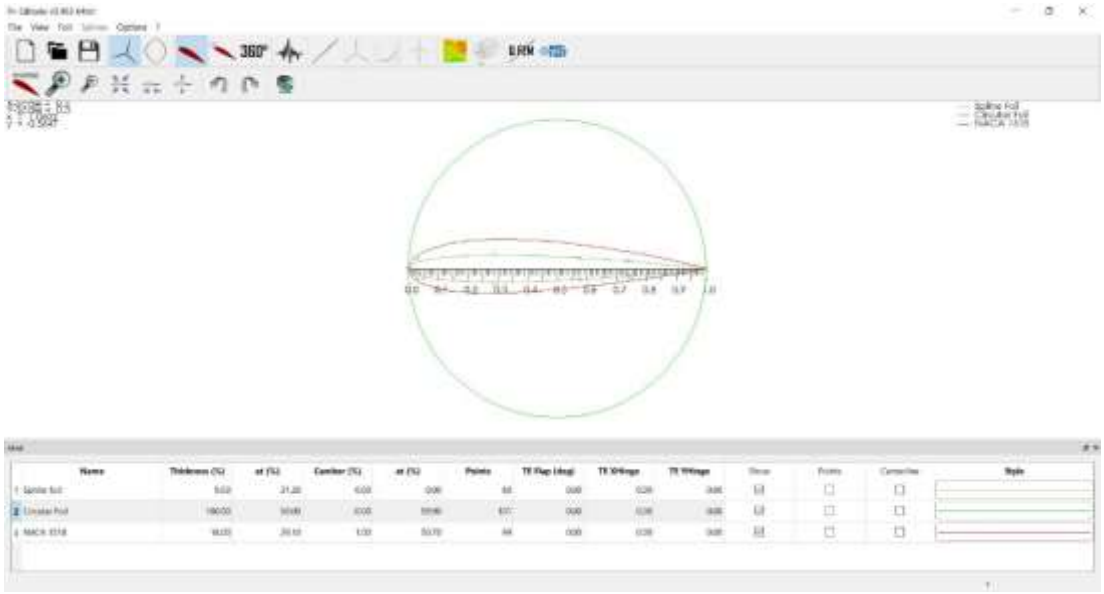
Alaskari vd. [7] BEM Teorisine dayalı QBlade programını kullanarak düşük rüzgar hızlarında çalışan yatay eksenli rüzgar türbininin tasarımını ve optimizasyonunu gerçekleştirmiştir. Çalışmada SG6043 kanat profili kullanılmış olup 1.17 m uzunluğa sahip kanat 10 parçaya bölünmüştür. Böylece burulma açısı ve veter uzunluğu gibi tasarım parametrelerinin rüzgar türbininin performansı üzerindeki etkisi incelenmiştir.

Bu çalışmada QBlade programında 0.5 m rotor yarıçapına sahip yatay eksenli bir rüzgar türbininin aerodinamik karakteristiklerinin belirlenerek optimum kanat tasarımının yapılması amaçlanmıştır.

II. MATERYAL VE YÖNTEM

QBlade programı rüzgar türbini kanat profillerinin aerodinamik performans analizini, tasarımını ve simülasyonunu gerçekleştirmek için kullanılmaktadır. Bu çalışmada rüzgar türbin kanadının tasarımı ve optimizasyonu QBlade programı üzerinden gerçekleştirilmiştir.

İlk olarak QBlade programında tasarımı gerçekleştirilecek olan 3 kanatlı yatay eksenli rüzgar türbini için kanat profili NACA 1518 seçilmiştir. Dairesel ve NACA 1518 kanat tipleri Şekil 1' de gösterildiği gibi oluşturulmuştur.



Şekil 1. Dairesel ve NACA 1518 kanat tipine ait görsel

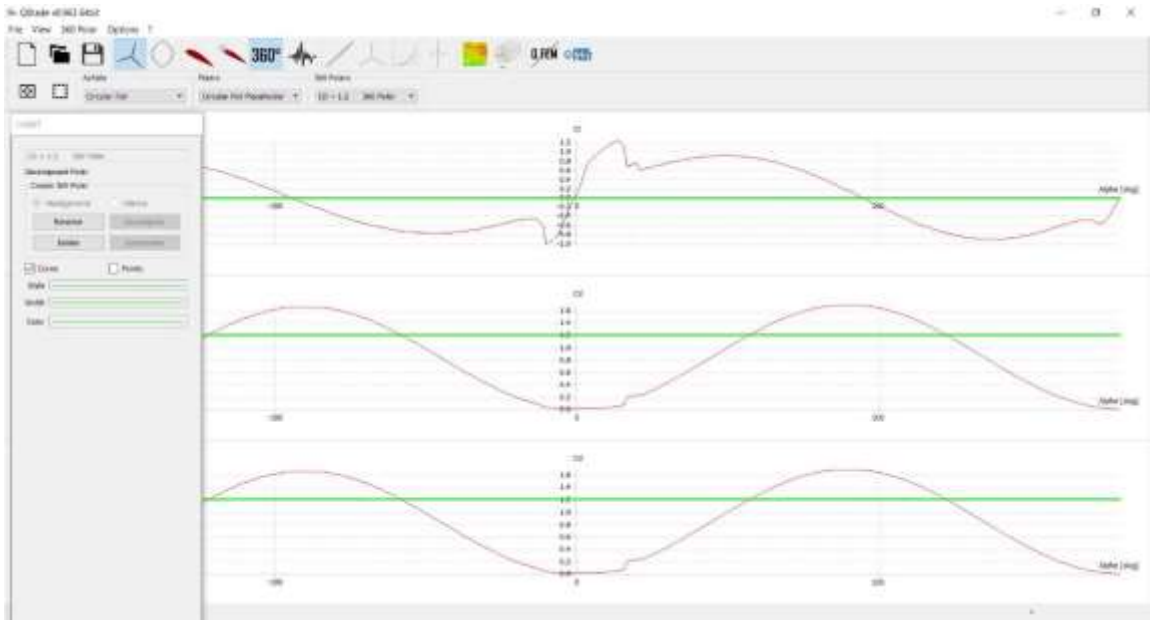
Daha sonra türbin kanadının aerodinamik karakteristikleri analiz edilerek kanadın atak açısına (AoA) göre taşıma (C_L) ve sürükleme (C_D) katsayısının ve taşıma / sürükleme oranının (C_L/C_D) değişimine ait veriler elde edilmiştir.

$$C_L = \frac{2F_L}{\rho * A * V^2} \quad (1)$$

$$C_D = \frac{2F_D}{\rho * A * V^2} \quad (2)$$

Denklem (1) ve (2) taşıma ve sürükleme katsayılarına ait formülleri ifade etmektedir. Denklemlerdeki C_L taşıma katsayısını, F_L taşıma kuvvetini, C_D sürükleme katsayını, F_D sürükleme kuvvetini, ρ havanın yoğunluğunu, A üst bakış alanını ve V serbest akış hızını temsil etmektedir.

Kanadın aerodinamik karakteristikleri belirlendikten sonra kanadın veter uzunluğuna benzer çapa sahip bir daire elde etmek için 360 derecelik kutupsal ekstrapolasyon kullanılarak bir daire ekstrapolasyon yapılmıştır. Şekil 2' de QBlade programında 360 derecelik kutupsal ekstrapolasyon işlemine ait görsel verilmiştir.



Şekil 2. 360 derecelik kutupsal ekstrapolasyon işlemine ait görsel

Bir sonraki aşamada rüzgar türbin kanadının tasarımına geçilmiştir. Tablo 1'de bu çalışmada tasarımı yapılan yatay eksenli rüzgar türbin kanatlarına ait tasarım parametrelerinin değerleri verilmiştir.

Tablo 1. Optimum NACA 1518 rüzgar türbini kanadı için kanat tasarım parametreleri

Tasarım Parametreleri	**Değerler**
Tasarım uç hız oranı, λ_D	5
Rotor yarıçapı, R	0.5 m
Kanat sayısı, B	3

Kanat tasarımı optimum güç üretim verimliliğine sahip etkili bir rüzgar türbininin elde edilmesinde önemlidir. Bu nedenle kanat geometrisi maksimum güç elde edilecek şekilde tasarlanmalıdır. Kanat eleman momentum (BEM) teorisi, rüzgar türbinleri ve pervaneler gibi döner makinelerin aerodinamik performansını analiz etmek için kullanılan bir yöntemdir.

BEM teorisi, özellikle rüzgar türbinlerinin kanatlarının tasarımı ve performans analizi için yaygın olarak kullanılmaktadır [6,7]. Bu teori, aerodinamik kuvvetlerin ve momentlerin hesaplanmasını sağlar ve rüzgar türbinlerinin enerji üretim verimliliğini artırmada önemli bir rol oynamaktadır [10].

Kanat eleman momentum teoreminde (BEM) elde edilen bağıntılarda gücü maksimum yapacak şekilde matematiksel hesaplamalar yapılarak optimum kanat geometrisi ölçülerini veren formüller elde edilir. Bu çalışmada türbin kanatları Schmitz denklemlerine göre optimize edilmiştir. Denklem (3) ve (4)'te Schmitz denklemleri verilmiştir:

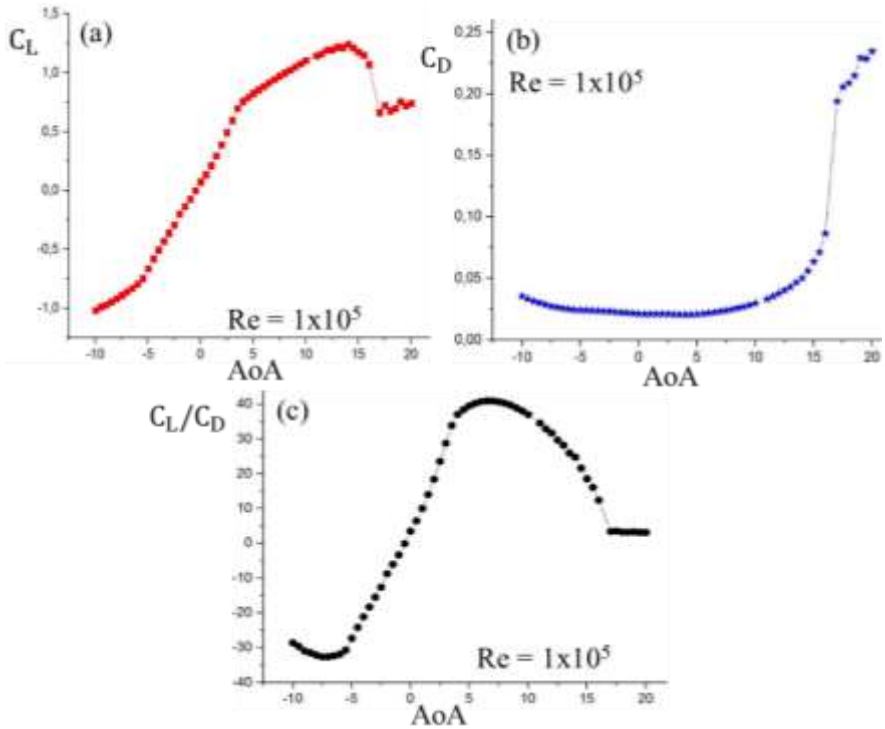
$$c(r) = \frac{16\pi r}{B(C_L)_D} sin^2 \left(\frac{1}{3} arctan \left(\frac{R}{r\lambda_D} \right) \right) \quad (3)$$

$$\beta(r) = \frac{2}{3} arctan \left(\frac{R}{r\lambda_D} \right) - \alpha_D \quad (4)$$

Bu denklemlerde kullanılan λ_D terimi tasarım uç hız oranını ifade etmektedir. Kanat geometrisi oluşturulurken kanadın şekli, kanat boyunun $c(r)$ kanat boyunca nasıl değişeceği ve bu kanatların rotor düzlemine hangi burulma $\beta(r)$ açısıyla yerleştirileceği dikkate alınmaktadır. Schmitz formülüne göre airfoil boyu $c(r)$ ve burulma açısı $\beta(r)$ hesaplanırken uçak kanadının tasarım kaldırma katsayısı $(C_L)_D$, tasarım hücum açısı α_D kullanılmaktadır. Kanat tasarımında kanat modelinin burulma ve veter uzunluklarını belirlemek için 0.5 m rotor yarıçapına sahip rüzgar türbin kanadı QBlade programında 10 eşit parçaya bölünerek her bölmedeki $c(r)$ ve $\beta(r)$ değerleri Schmitz denklemlerine göre optimize edilmiştir. Son olarak rüzgar türbininin performans analizi yapılarak türbinin aerodinamik verimliliğini ifade eden güç katsayısı (C_P) ve uç hız oranına (TSR) ait veriler elde edilmiştir.

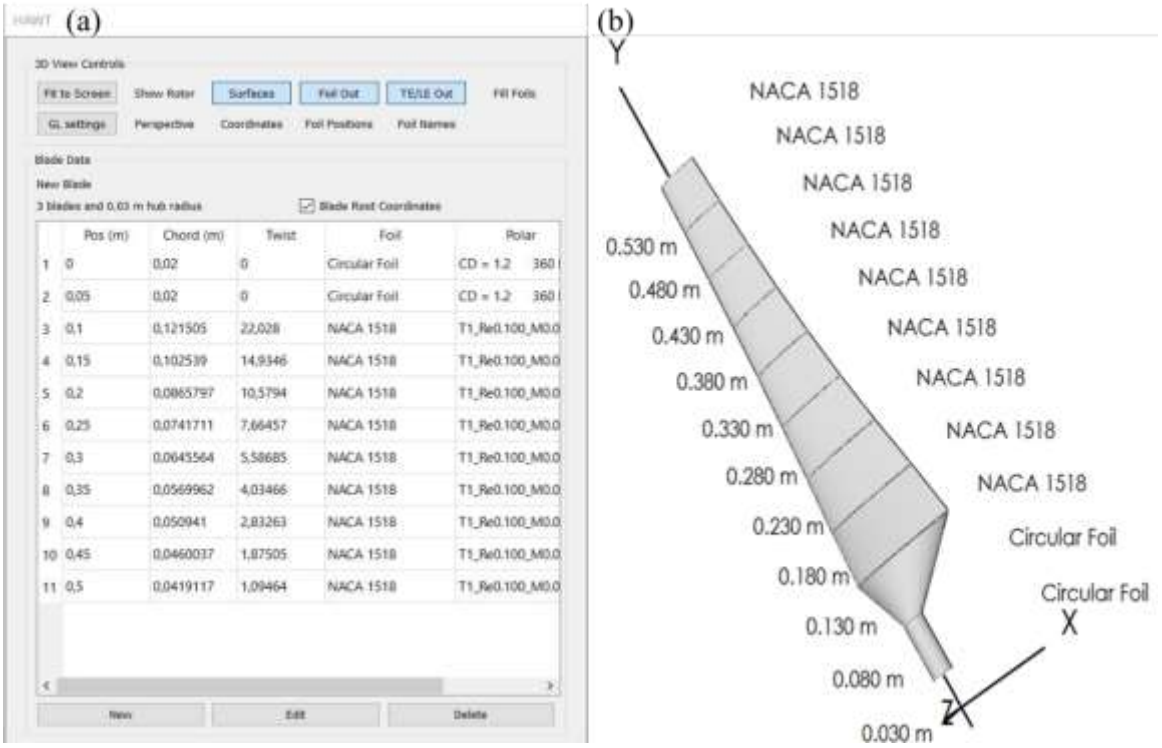
III. BULGULAR

Aerodinamik karakteristikleri belirlenen NACA 1518 kanat profili ve $1x10^5$ Reynolds sayısı için programda gerekli analizler yapılmıştır. Böylece kanadın atak açısına (AoA) göre taşıma (C_L) ve sürükleme (C_D) katsayısının ve taşıma / sürükleme oranının (C_L/C_D) değişimini veren grafikler çizilmiştir. Şekil 3 (a), (b) ve (c)' de sırasıyla bu grafikler verilmiştir. Şekil 3(a)'da görüldüğü üzere taşıma katsayısının maksimum değerinin $(C_L)_{max}$, 1.24 olduğu görülmüştür.



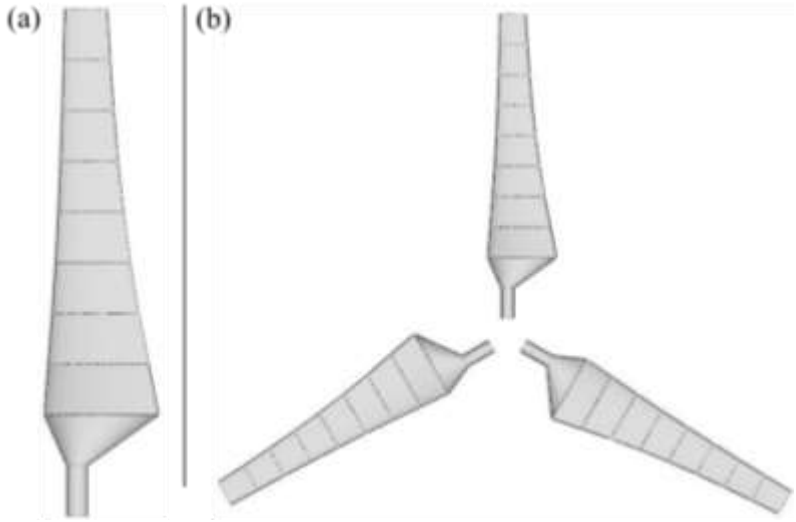
Şekil 3. (a) Atak açısına (AoA) göre taşıma katsayısının (C_L), (b) sürükleme katsayısının (C_D) ve (c) taşıma / sürükleme oranının (C_L/C_D) değişimi

Aerodinamik karakteristikleri belirlenen kanadın tasarımında, kanat modelinin burulma ve veter uzunluklarını belirlemek için 0.5 m rotor yarıçapına sahip rüzgar türbin kanadı QBlade programında 10 eşit parçaya bölünerek her bölmedeki $c(r)$ ve $\beta(r)$ değerleri Schmitz denklemlerine göre optimize edilmiştir.



Şekil 4. (a) NACA 1518 kanat profiline sahip optimum rüzgar türbini kanadı için c ve β değişimi ve (b) optimize edilmiş kanat tasarımı

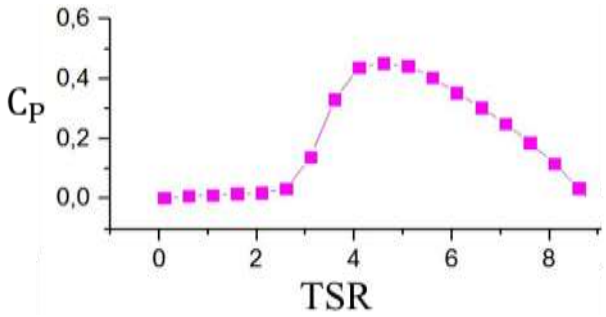
C_L/C_D' nin maksimum olduğu atak açısı 6.5° olarak belirlenmiş ve kanat eleman momentum teorisi (BEM) kullanılarak tasarım uç hız oranı (λ_D) 5 olan türbin kanadı optimize edilmiştir. Şekil 4 (a)' da NACA 1518 kanat profiline sahip optimum rüzgâr türbini kanadı için c ve β değişimine ait veriler ve (b)' de bu verilere göre optimize edilmiş kanat tasarımına ait görsel verilmiştir. Ayrıca Şekil 5 (a) ve (b)'de tasarımı ve optimizasyonu tamamlanan rüzgar türbinine ait görseller verilmiştir.



Şekil 5. (a) NACA 1518 kanat profiline sahip optimum rüzgar türbin kanadı ve (b) 3 kanatlı rotor tasarımı

Tasarlanan türbin kanadının uç hız oranına (TSR) bağlı olarak güç katsayısını (C_P) elde etmek için programda başlangıç ve bitiş uç hız oranları sırasıyla 0.1 ve 9 olarak belirlenmiştir. Ayrıca Şekil 6'da rüzgar

hızı 13 m/s alınarak C_P - TSR grafiği elde edilmiştir. Grafikte 4.6 uç hız oranında (TSR) türbinin maksimum güç katsayısının $(C_P)_{max}$ 0.4517 olduğu görülmüştür.



Şekil 6. Güç katsayısının (C_P) uç hız oranına (TSR) göre değişimi

IV. SONUÇLAR

Bu çalışmada, QBlade tasarım programı kullanılarak BEM teorisine dayalı olarak rotor kanadını optimize eden düşük rüzgar hızlarında çalışmak üzere 3 kanada sahip küçük ölçekli yatay eksenli bir rüzgar türbini tasarlanmıştır. Program içerisinden rüzgar türbini için NACA 1518 kanat profili seçilerek kanadın atak açısına göre C_L, C_D ve C_L/C_D analiz edilmiştir. Analizler $1x10^5$ Reynolds sayısına göre yapılmıştır. Aerodinamik karakteristikleri belirlenen türbin kanadı için $(C_L)_{max}$=1.24 bulunmuştur. Ayrıca C_L/C_D' nin maksimum olduğu atak açısı 6.5° olarak belirlenmiştir.

0.5 m rotor yarıçapına sahip rüzgar türbini için türbin kanadı 10 eşit parçaya bölünerek Schmitz denklemlerine göre optimizasyonu gerçekleştirilmiştir. Optimize edilmiş rüzgar türbin kanadı için kanat boyunca burulma açısının ve veter uzunluğunun değişimine ait veriler sunulmuştur.

Tasarımı yapılan yatay eksenli rüzgar türbininin verimliliğini değerlendirmek için türbinin uç hız oranına göre güç katsayısının değişimi incelenmiştir. 13 m/s rüzgar hızı için türbinin $(C_P)_{max}$=0.4517 bulunmuştur. TSR'nin 4.6 olduğu durumda türbinin güç katsayısının maksimum değere ulaştığı görülmüştür.

Sonuç olarak içerisinde aerodinamik analizler ve BEM simülasyonları bulunduran QBlade programı sayesinde kolayca rüzgar türbin kanatlarının aerodinamik analizleri ve türbin tasarımı yapılabilmektedir. Bu nedenle, QBlade programının rüzgar türbinlerinin kanatlarını tasarlamak ve optimize etmek için etkili programlardan biri olduğu görülmüştür.

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6 Different Equivalent Circuit model analysis of rGO/TiO_2/PEDOT nanocomposites for Supercapacitors

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Abstract **–** In this study, 6 different equivalent circuit model analysis of (R(CR), R(QR), $LR_1(C_1(R_2(C_2R_3)))$, $LR_1Q(CR_2)$, $LR_1(QR_2)$, LR(Q(R(CR)))) for rGO/TiO_2/PEDOT nanocomposites were examined to understand theoretical and experimental analysis of electrochemical impedance spectroscopic (EIS) data for supercapacitor evaluations. Supercapacitor devices were set up with a 2-electrode system on stainless steel electrode for rGO/TiO_2/PEDOT nanocomposites. The simulation programme of ZSimpWin 3,22 was evaluated for all EIS analysis. Moreover, the circuit parameters of (L, R_1, R_2, C, Q, etc.) in each circuit parameters were explained specifically for each circuit.

Keywords –Supercapacitor, reduced graphene oxide, TiO_2, equivalent circuit model, $LR_1(C_1(R_2(C_2R_3)))$

I. INTRODUCTION

Supercapacitors are divided by 3 categories, such as electrochemical double layer capacitance (EDLC), pseudocapacitance (PCs) and hybrid supercapacitors [1]. A supercapacitor study has previously been carried out for the rGO/TiO_2/PEDOT nanocomposite [2]. According to our previous results, rGO/PEDOT nanocomposite has the highest energy density and power density as E= 11.873 Wh/kg at 5 mA and P=8010 W/kg at 40 mA. Moreover, the highest energy densities in the ternary nanocomposites of $[rGO]_o/[TiO_2]_o/[EDOT]_o$= 1:1:1; 1:1:2 and 1:1:5 were calculated at 2 mA as, E=10.09 Wh/kg, 12.20 Wh/kg and 8.42 Wh/kg, respectively. It has been observed that the supercapacitors are superior ternary TiO_2-based nanocomposites in the literature in terms of power density and energy densities obtained from literature as given in **Table 1**.

Table 1. Energy, power and capacitance values of hybrid TiO_2-based nanocomposites.

TiO_2 based nanocomposites					
Nanocomposite	**Electrolyte**	**E / Whkg^{-1}**	**P / Wkg^{-1}**	**C_{sp}/ Fg^{-1}**	**Ref.**
rGO/TiO_2	1 M NaOH	6.22	1.87	202.50	[3]
rGO/TiO_2	1 M H_2SO_4	9.08	598	201.50	[4]
rGO/TiO_2	1 M H_2SO_4	16.50	199.50	455.30	[5]
rGO/TiO_2	1 M H_2SO_4	32.45	716.78	160	[6]
PANI/TiO_2	1 M H_2SO_4	27	200	540	[7]
TiO_2/PPy	1 M H_2SO_4	17.70	1257	614.70	[8]

Titanium dioxide (TiO_2) is a cheap, readily available, non-toxic, chemically and mechanically stable, and has a high economical value. Due to these physical and chemical properties, it is widely used as reinforcement in metallic matrices to increase the fracture resistance, micro-hardness and wear resistance of composites [9].

II. Materials and Method

In this study, 1-Butyl-3-methylimidazolium tetrafluoroboarete ionic liquid, stainless steel electrode, Kapton tape and *N*-Methyl-2-pyrrolidone material were used in the fabrication of supercapacitor devices.

A. Used Devices

In this study, rGO/TiO_2/PEDOT nanocomposite was synthesized as ternary nanocomposite. Electrochemical performance measurements were carried out using EIS method using IVIUMSTAT device and equivalent circuit model analysis, programme ZSimpWin 3,22..

III. Results & Discussion

A. Circuit Models of RGO/TiO_2 and rGO/TiO_2/PEDOT Nanocomposites

EIS of GO/PEDOT and rGO/TiO_2/PEDOT nanocomposites with $[rGO]_o$=$[TiO_2]_o$=$[PEDOT]_o$= 1:1:1; 1:2:1 and 1:5:1 ratios using equivalent circuit models ZSimpWin 3.22 programme *R*(*CR*) of the best fitting circuit model of rGO/PEDOT and rGO/TiO_2/PEDOT nanocomposites with $[rGO]_o$=$[TiO_2]_o$=$[PEDOT]_o$= 1:1:1; 1:2:1 and 1:5:1. The plots obtained as a results of the equivalent circuit applied to nanocomposites are given in Fig.1. R1 is the solution resistance of the equivalent circuit model [10]. While C_{dl} represents the double layer capacitance [11], R_2 represents the charge transfer resistance, that is, the electron exchange in the electrode and electrolyte [12].

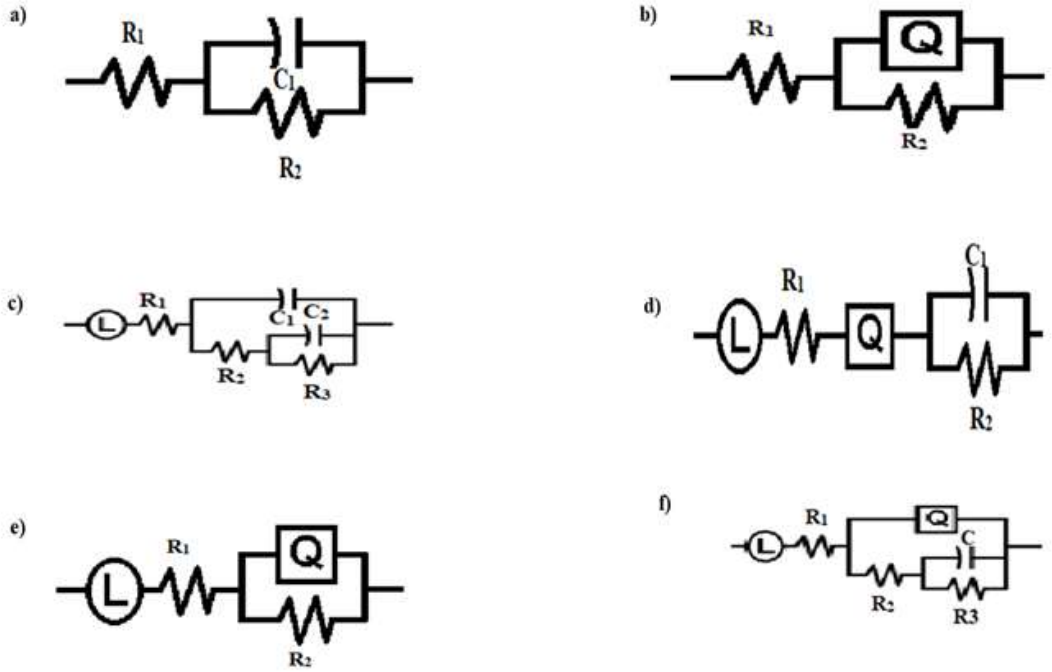

Fig.1. Equivalent circuit models of rGO/TiO_2, $[rGO]_o/[TiO_2]_o/[EDOT]_o$ =1/1/1, 1/2/1, 1/5/1 a) R(CR), b) R(QR), c) $LR_1(C_1(R_2(C_2R_3)))$, d) $LR_1Q(CR_2)$, e) $LR_1(QR_2)$, f) LR(Q(R(CR))).

B. **Equivalent circuit model analysis of rGO/ TiO_2 Nanocomposites**

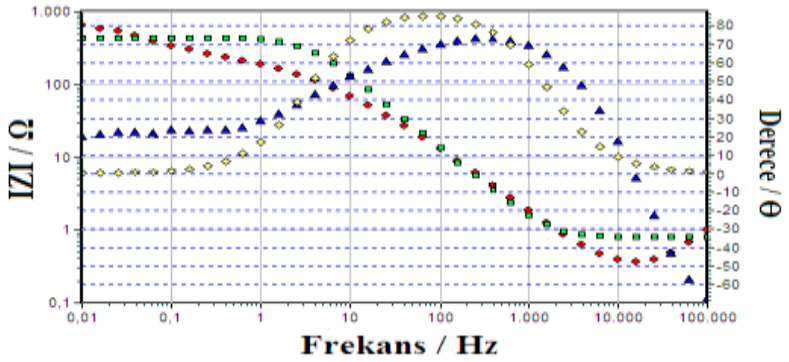

Fig.2. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o$ =1:1 nanocomposite.

Table.2. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o$ =1:1 nanocomposite. R(CR) circuit model results.

Eq. circuit parameters	**R_1/Ω**	**R_2/Ω**	**C / F**
$[rGO]_o/[TiO_2]_o$ =1:1	0.805	444.2	1.156×10^{-4}

C. **Equivalent Circuit Model analysis of $[rGO]_o/[TiO_2]_o$/[EDOT] Nanocomposites**

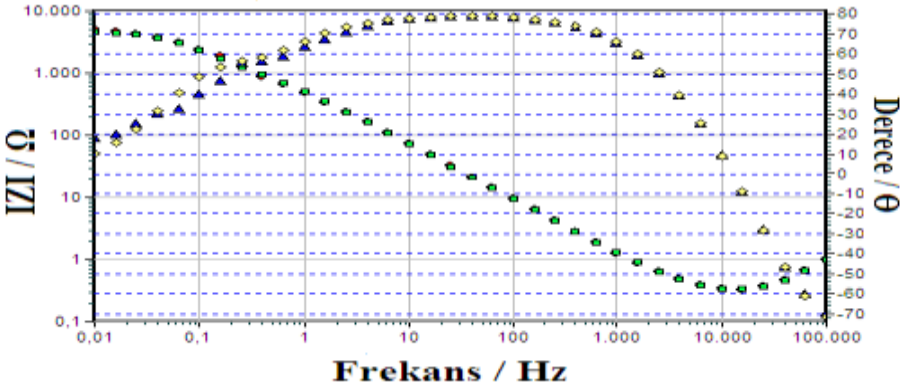

Fig.2. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:1:1 nanocomposite. Equivalent circuit model of LR(Q(R(CR))) was used.

Table 3. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$ =1:1:1 nanocomposite. LR(Q(R(CR))) circuit model results.

Eq. circuit parameters	**R_1/Ω**	**R_2/Ω**	**R_3/Ω**	**CPE/ Y^o [S, sec^n]**	**Freg.power,n [0 <n> 1]**	**L/Henry**	**C/F**
$[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:1:1	0.3112	1966	2922	3.356×10^{-4}	0.8937	1.514×10^{-6}	5×10^{-4}

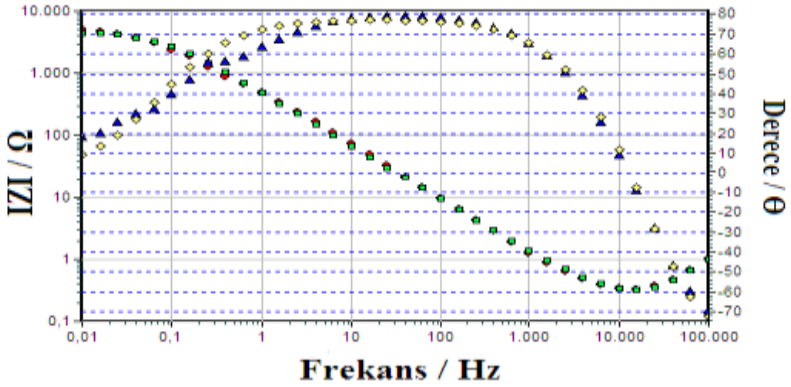

Fig.3. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:1:1 nanocomposite. Equivalent circuit model of $LR_1(QR_2)$ was used.

Table 4. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$ =1:1:1 nanocomposite. $LR_1(QR_2)$ circuit model results.

Eq. circuit parameters	R_1/Ω	R_2/Ω	CPE/ Yo [S,sec^n]	Freg power,n [0 <n> 1]	L/Henry
$[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:1:1	0.299	4778	4.56×10^{-4}	0.866	1.56×10^{-8}

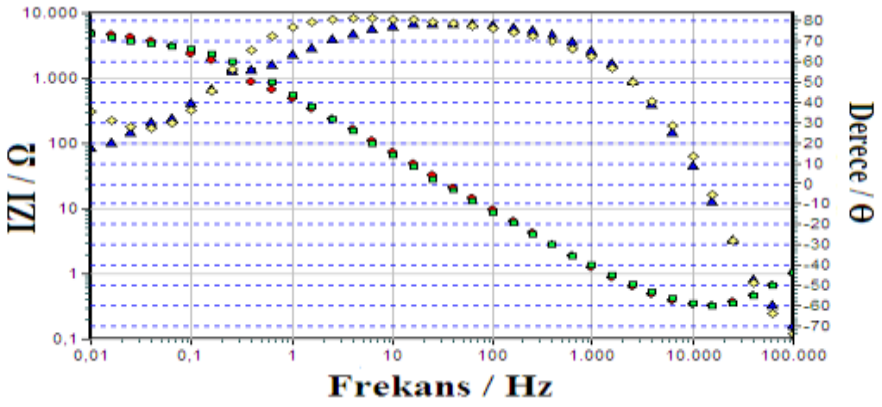

Fig.4. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:1:1 nanocomposite. Equivalent circuit model of $LR_1Q(CR_2)$ was used.

Table 5. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$ =1:1:1 nanocomposite. $LR_1Q(CR_2)$ circuit model results.

Eq. circuit parameters	**R_1/Ω**	**R_2/Ω**	**CPE/ Yo [S,sec^n]**	**Fre. power,n [0 <n> 1]**	**L/Henry**	**C/F**
$[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:1:1	0.272	2688	2.40×10^{-3}	0.716	1.62×10^{-6}	3.36×10^{-4}

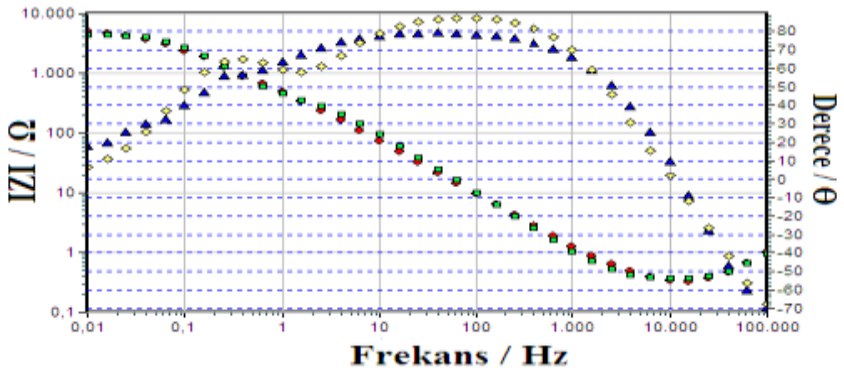

Fig.5. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:1:1 nanocomposite. Equivalent circuit model of LR(C(R(CR))) was used.

Table 6. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$ =1:1:1 nanocomposite. LR(C(R(CR))) circuit model results

Eq. circuit parameters	**R_1/Ω**	**R_2/Ω**	**R_3/Ω**	**L/Henry**	**C/F**	**C_2/ F**
$[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:1:1	0.364	511.1	3973	1.40×10^{-6}	3.56×10^{-4}	1.60×10^{-4}

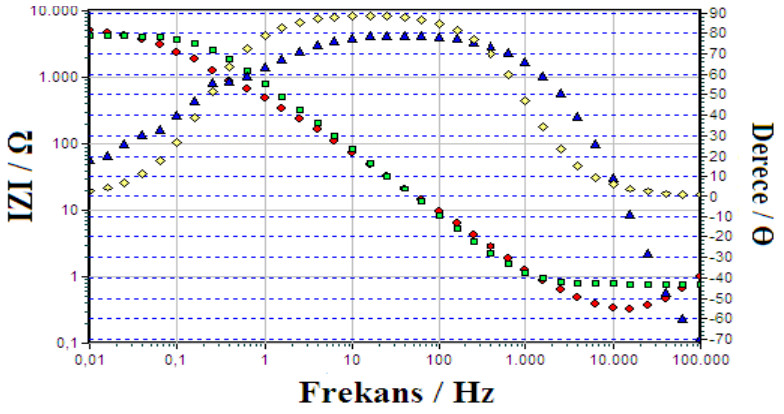

Fig.6. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:1:1 nanocomposite. Equivalent circuit model of R(CR) was used.

Table 7. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$ =1:1:1 nanocomposite. R(CR) circuit model results

Eq. circuit parameters	**R_1/Ω**	**R_2/Ω**	**C/F**
$[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:1:1	0.7696	4198	1.191×10^{-4}

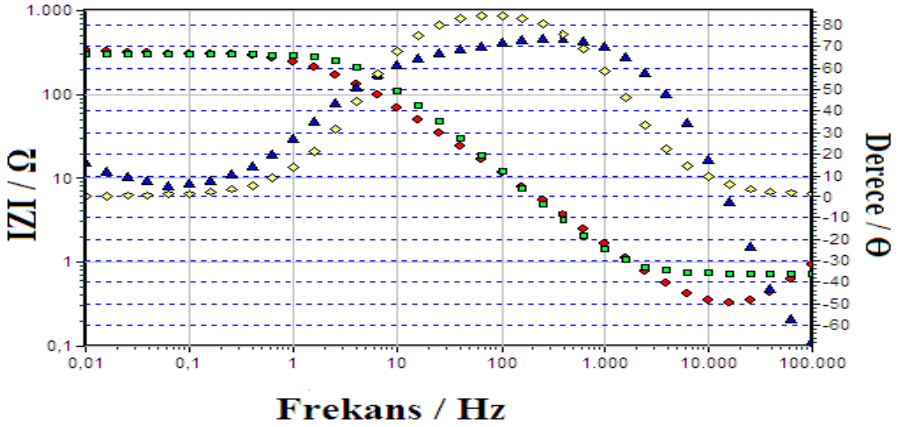

Fig.7. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:2:1 nanocomposite. Equivalent circuit model of R(CR) was used.

Table 8. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$ =1:2:1 nanocomposite. R(CR) circuit model results

Eq. circuit parameters	**R_1/Ω**	**R_2/Ω**	**C / F**
$[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:2:1	0.732	301	$1.31\text{x}10^{-4}$

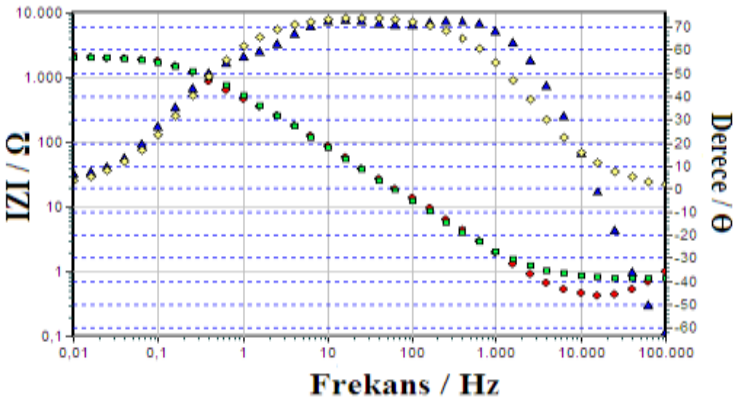

Fig.8. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:5:1 nanocomposite. Equivalent circuit model of R(QR) was used.

Table 9. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$ =1:5:1 nanocomposite. R(QR) circuit model results.

Eq. circuit parameters	**R_1/Ω**	**R_2/Ω**	**CPE/ Y^o [S,sec^n]**
$[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:5:1	0.769	2148	0.845

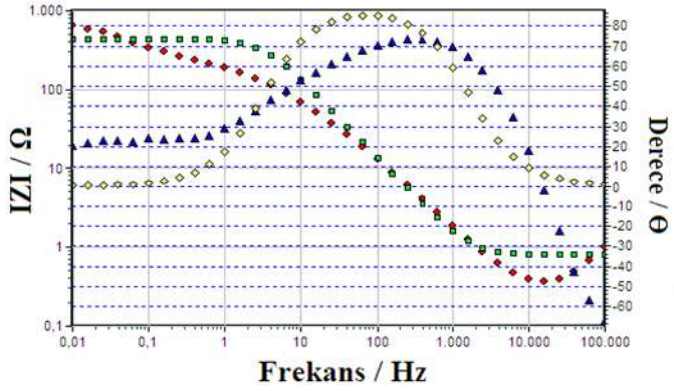

Fig.9. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:5:1 nanocomposite. Equivalent circuit model of R(QR) was used.

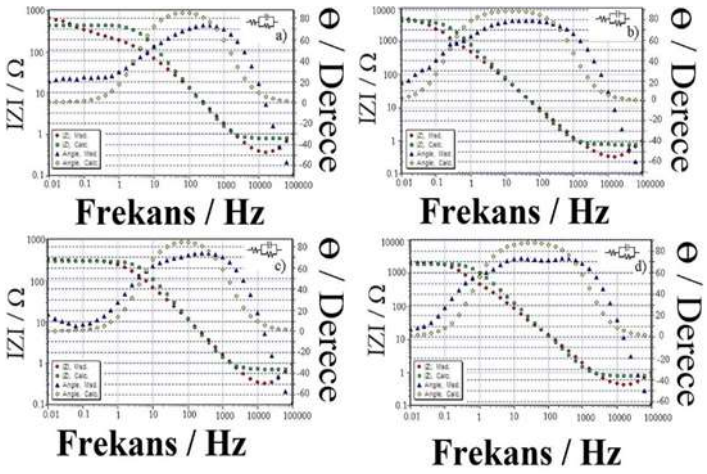

Fig.10. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:5:1 nanocomposite. a)$[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:0:1, b) $[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:1:1, c)$[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:2:1, d) $[rGO]_o/[TiO_2]_o/[EDOT]_o$=1:5:1.

Table 10. Bode-magnitude-Bode phase plots of $[rGO]_o/[TiO_2]_o/[EDOT]_o$ = 1:1:1; 1:2:1 and 1:5:1 nanocomposite. R(CR) circuit model result.

Parameters	**rGO/PEDOT**	**$[rGO]_o/[TiO_2]_o/[EDOT]_o$=**		
		1:1:1	**1:2:1**	**1:5:1**
R_1 / Ω	0.805	0.769	0.732	0.80
C / F	1.16×10^{-4}	1.91×10^{-4}	1.31×10^{-4}	1.24×10^{-4}
R_2 /Ω	444.2	4198	301	1923

CONCLUSION

The results obtained after applying the equivalent circuit model are given in Table 1 to Table 11. As a result, equivalent circuit model studies of rGO/TiO_2/PEDOT was given using the EIS data of the nanocomposites using ZSimpWin 3.22. 6 different equivalent circuit model was given in this study. It was carried out in the circuit programme. In addition, an equivalent circuit model analysis of R(CR) was presented at different initial feed ratios of $[rGO]_o/[TiO_2]_o/[EDOT]_o$= 1:1:1, 1:1:3, 1:1:5. The lowest charge transfer resistance (R_{ct}) was obtained as R_{ct}= 301 Ω for equivalent circuit models of $[rGO]_o/[TiO_2]_o/[EDOT]_o$= 1:2:1. If the R_{ct} is low, the capacitance of the supercapacitor should be higher value.

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Effective communication as a function of the quality of electronic education

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Abstract – In this paper, the possibilities of active communication will be investigated from the aspect of the impact on the quality of electronic teaching in the light of the recent mass application of electronic teaching during the pandemic of the COVID 19 virus. The consequences of inadequate communication often leave disastrous consequences in society, but despite this, very few scientific works deal with research communication process in education. In this direction, this paper, based on a studious theoretical evaluation of the relevant literature, will analyze various aspects of communication between teachers, on the one hand, and pupils and students, on the other hand, which in the process of electronic education affect the efficiency of knowledge transfer and the quality of educational work. By reviewing the latest literature and conducted research in practice, the paper will investigate the way in which active communication affects the quality of knowledge of students in online classes.

The descriptive method and the method of comparative analysis were used in the work. Data were collected from relevant literature, recent research by domestic and foreign authors, from domestic and international databases. For the purposes of the work, the research was conducted in educational institutions of primary, secondary and higher education with the aim of analyzing various aspects of effective communication in education. The purpose of the research is reflected in a better understanding of the place, role and importance of communication in education at all levels of education in general, as well as in providing useful recommendations for teaching practice, which could improve existing educational processes and educational outcomes.

Keywords – Education, Communication, E-learning's, teaching quality.

I. INTRODUCTION

Education is of great importance for society, primarily because the modern period made school education a social issue and made it one of the key factors of social progress and individual development [4]. Different definitions of education can be found in the theory, but the most common is the one that defines education as a process of acquiring knowledge, skills and habits [2]. This is followed by the opinion of local authors, who point out that from the position of objects to whom knowledge is offered and given, the student has come to the position of acquiring knowledge on his own and working maximally on developing his abilities [19]. However, one of the still insufficiently researched areas is certainly active, effective communication of participants in the teaching process with a special emphasis on electronic education[5]. In this sense, some authors emphasize that the modern school tries to liberate the process of education by bringing the two most important factors of that process into the subjective position - the student and the teacher [2]. We are witnessing the realization of the predictions of numerous scientists, who deal with issues of the future,

that the new scientific and technological revolution will lead human society into the information era where science and knowledge will be the basic resources of all paths of further development [1]. The Internet, in turn, has evolved even faster than any other previous medium [14]. Precisely because of the importance of the Internet, most European and world countries include the process of its informatization in the priority tasks of education reforms [18]. The results of existing research indicate that there is still not a sufficient number of experts in the field of communication in electronic teaching [6]. In this sense, according to the latest research of the Republic Institute of Statistics, on the use of information and communication technologies, among individuals in 2023 over 91% percent of people between the ages of 16 and 74 use the Internet several times during the day, a part uses electronic education services , then about 51% of internet users used e-commerce services, i.e. bought or ordered goods or services via the internet (RZS, 2024) [17]

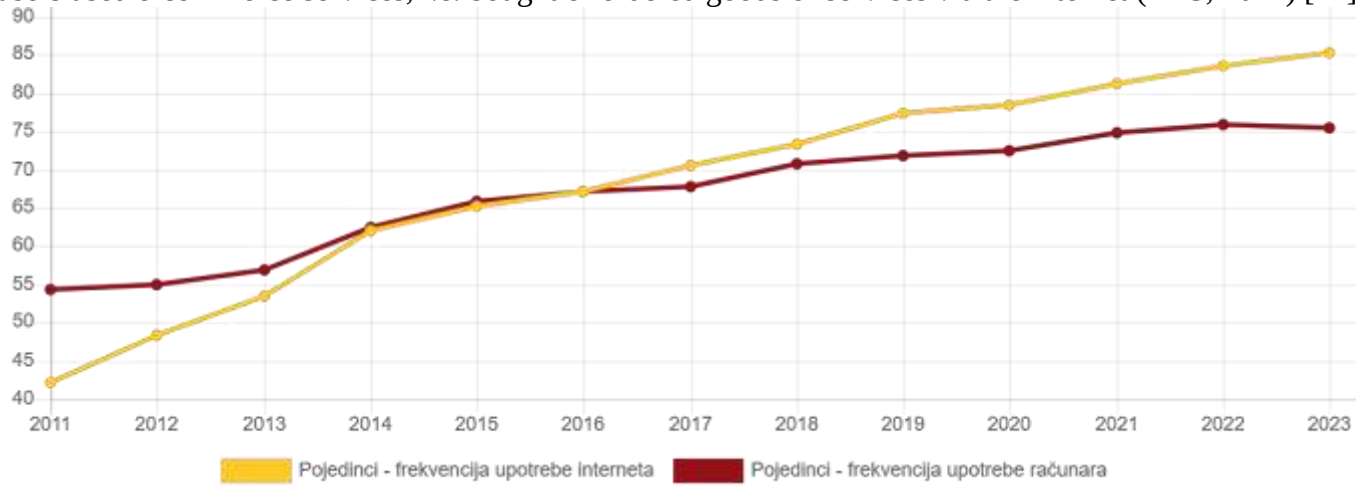


Fig. 1 Presentation of the frequency of computer and Internet use in Serbia, 2011-2023 [17]

As shown in the previous figure 1, the frequency of computer and Internet use in the observed period (2011-2023) in Serbia is constantly increasing. The future exponential development of the Internet will include multifunctional devices, which will satisfy various fields of application, including the field of electronic teaching. In this sense, well-known authors conclude that modern technologies have had an impact on the entire human community, bringing various benefits both for private life and business performance [13.] One of the more significant and still insufficiently explored possibilities of applying modern technologies is education [7] . In this sense, some authors emphasize that the concept of permanent education affirms the value of the human factor in a qualitative sense and new technologies derived from functionally established and developed science with the organized action of the free market [18]. In the review of the relevant literature, it is pointed out that "The goal of introducing computers into teaching is to increase the efficiency of the teaching process, that is, to master the teaching material more successfully in a shorter period of time, than in usual teaching" [3]. In order to achieve the aforementioned goals in accordance with the outlined educational outcomes, it is inevitable that there is effective communication between the participants in the educational process. The results of the research indicate an increasing use of ICT or educational software in education. In this direction, eminent authors define educational software as a term obtained by combining the terms course and software or, in the simplest terms, software designed for educational purposes [18]. Innovation requires the right time and place to be used, otherwise we may have the right innovation at the wrong time or in the wrong form [12]. In practice, experience shows that despite the application of sophisticated technologies in teaching, success is not guaranteed and that it is necessary for teachers to be digitally literate as well as to master communication skills as a prerequisite for quality teaching. In this direction, some experts emphasize that current efforts to expand computing in schools will not be successful in the long term without new teachers, who are well prepared to "combine pedagogical principles with computer science content to improve the learning experience for their students" [20]. It is obvious that with the adequate application of educational technologies, the presentation of materials can be very diverse and interesting [8]. Pupils and students can communicate with the computer through written text, orally, using sketches, animations, pictures and graphs. As a result, communication

becomes more interesting, which has a very favorable effect on the end result, that is, on the quality of education [11]. It is noticeable that part of the experts in this field deals with the application of ICT in the educational process, however, some authors emphasize that, in order to fully address the topic of the application of information and communication technologies in the improvement of higher education, in addition to the large number of advantages it brings, it is necessary to mention the disadvantages that are also present, as in every system [1]. In addition to the above, practical experience indicates that it is necessary to pay special attention to the process of communication in electronic teaching [9].

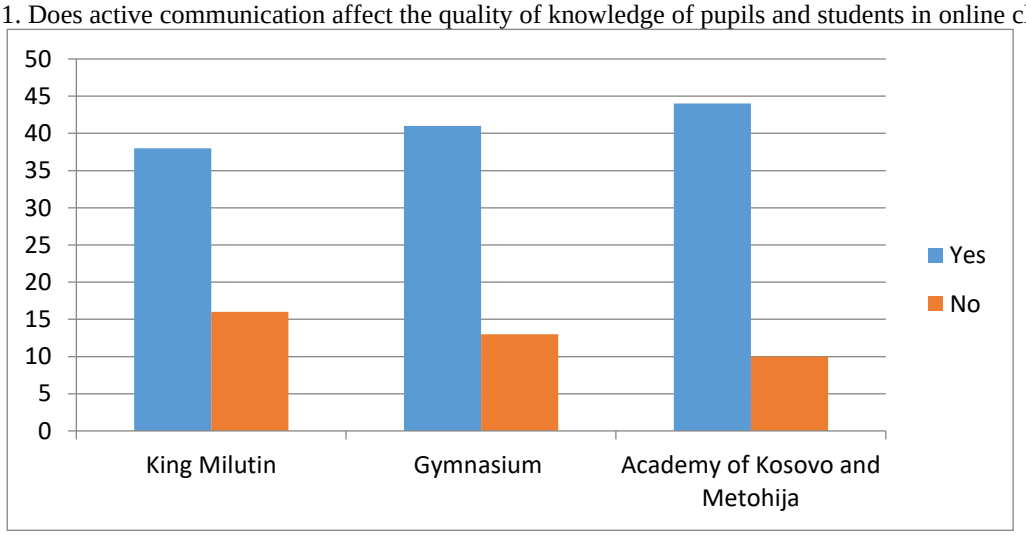
II. Materials and Method

In the work, which has a multidisciplinary approach, a descriptive method was used, which includes description, analysis and drawing conclusions, and corresponds to the subject of this research and the method of comparative analysis. In addition, standard methods of statistical processing will be used for data processing, and in general it can be said that the work is based on a combination of quantitative and qualitative methods. The quantitative part of the research includes a survey conducted among teachers, pupils and students. The qualitative part includes interviews with teachers, with the help of which a deeper insight into their attitudes and experiences with the process of communication in electronic teaching would be obtained. For the purposes of the work, a survey was conducted through a questionnaire, and in addition, data collected from relevant literature, recent research by domestic and foreign authors, as well as from domestic and international databases publicly available on the Internet.

III. Results

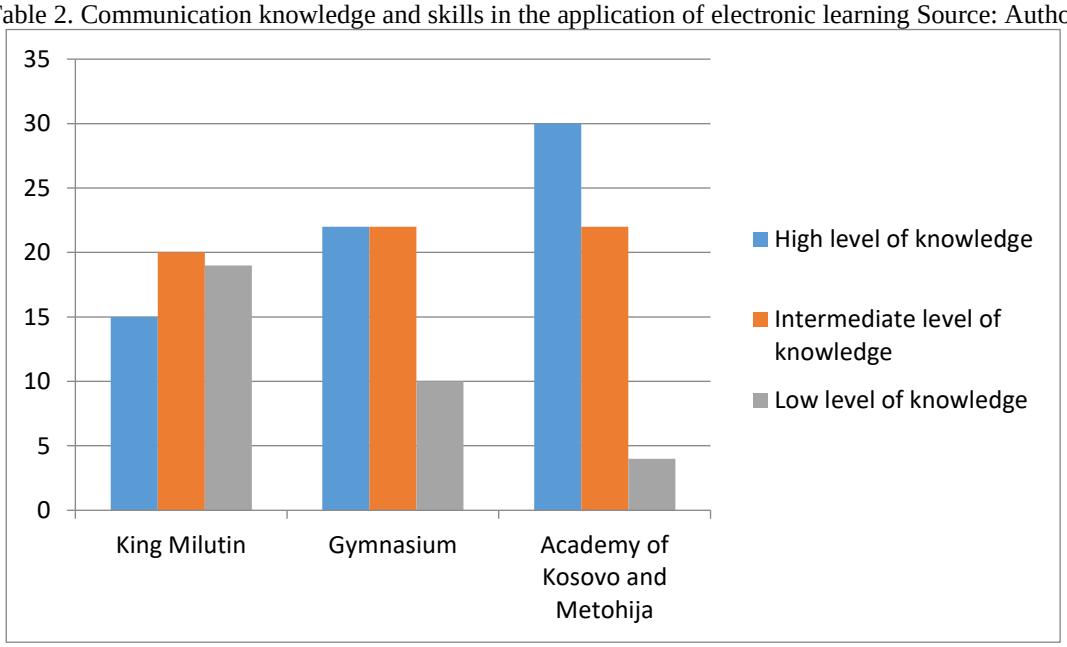
The research results contribute to determining the views of teachers, pupils and students on the impact of effective communication in the application of electronic platforms in education. The research sample consists of 54 teachers and professors in elementary schools in O.Š. "Kralj Milutin-Gračanica", then at the Gymnasium and the Academy of Kosovo and Metohija. The following table presents the results of the impact of active communication on the quality of students' knowledge in online classes.

Table 1. Does active communication affect the quality of knowledge of pupils and students in online classes



The results show that at all levels of education, a significant influence of functional communication on the success of pupils and students is noticeable, with the answers indicating that in higher education this importance is more visible by the surveyed participants. One of the key factors in the success of knowledge acquisition and the durability of knowledge are the communication skills and didactic and IT knowledge of teachers [10]. In this sense, the following Table 2 presents the responses of the surveyed participants to the question of the relationship between the level of knowledge and communication skills in the application of electronic learning.

Table 2. Communication knowledge and skills in the application of electronic learning Source: Author



From the previous table, it is obvious that teachers in higher education possess a high level of knowledge and communication skills compared to the surveyed participants in primary and secondary education. The unprecedented finding is related to the way of teaching and the constant and permanent scientific training and professional development of teachers in higher education at scientific gatherings, international scientific conferences and the like, in contrast to teachers in primary and secondary education, where, although continuous professional development of teachers is prescribed and defined by the acts of the Ministry of Education, however, the results of this research indicate that there is still significant room for additional improvements in communication knowledge and skills of lecturers.

IV. DISCUSSION

The results of the conducted research indicate a significant influence of effective communication in teaching, providing answers to questions concerning whether teachers in primary, secondary and higher education use some of the forms of effective communication in teaching, as well as the degree of satisfaction achieved by its application in educational educational work and the level of professional competence of teachers for the implementation of electronic teaching. Based on the results of the research, the conclusion is that, in relation to the traditional form of teaching, electronic learning in teaching additionally motivates students, provides a greater amount of information and easier renewal and confirmation of the material, thus making teaching more interesting, dynamic and successful. However, the results of theoretical considerations, which confirm experiences in practice, say that the application of electronic learning implies adequate communication skills and information literacy of students and teachers [15]. The research results confirmed that the practice of developing digital literacy in teaching is not sufficiently established, although there is a practice of using digital technologies in teaching processes and for learning purposes. The results confirmed that teachers use some forms of electronic teaching, that they are satisfied with its use, but that they are not sufficiently trained in its use, as well as that, in addition to pedagogical and didactic knowledge and work experience, they need additional training in the field of communication skills. In this sense, it is very important that in the process of the educational system, a part of the educational program, which refers to knowledge and communication skills, as well as the application of information technologies in educational work, is realized. The results of the research indicate that lecturers should be qualified to implement educational projects in communication skills and the area of application of information technologies in educational work, to diagnose and evaluate knowledge using information technologies, to encourage independent learning, as well as to continue independent professional development. Today, pupils or students, using ICT, independently access information, which

increases their activity in the learning process [21]. Pupils and students receive information from multiple sources, independently analyze, draw conclusions, arrive at knowledge that is no longer at the level of reproduction, but is able to apply that knowledge in practice [16]. The results of the research show that students, in the case when the application of ICT in teaching is adequate and with good communication by the teacher, have the feeling that the acquired knowledge is related to real life, as well as that the theory is connected to practice, which increases durability. and acquisition of knowledge.

V. CONCLUSION

Active communication encourages learning, supports diversity and empathy, and enables collaboration between school, family and community, in order to ensure quality education for each participant in the educational process. For the successful use of tools, methods and techniques of electronic learning, a good knowledge of educational technology is inevitable, along with a necessary knowledge of didactics and methodology of the subject taught by the teacher. In addition to the above, one of the key factors in the success of electronic teaching is good communication among all participants in the educational process. It is known that modern teaching implies the application of new information technologies, so accordingly with the development of technology it can be said that teaching takes on a more attractive form compared to the traditional form of teaching. In this sense, this development must be accompanied by the need for additional education of the persons who create such teaching content. Namely, it is obvious that new forms of work require greater effort to create, which implies mastering the handling of different software, i.e. tools, as well as constant permanent professional development, in this sense, experience in practice says that a well-done preparation of an electronic class is a prerequisite for successful teaching. In addition to the above, the very advantage of using computers in teaching is reflected in easier learning and faster mastering of the material, a more creative way of learning, whereby the acquired knowledge motivates for continuous learning, advancement and research for a longer period of time. In this sense, it is imperative to conclude that the teaching staff must improve and improve their communication knowledge, skills and abilities for the application of information technology in teaching through continuous professional development programs. Experiences in practice show that the integration of ICT in the educational process entails the question of teacher competence and expertise, and among other things, communication knowledge and skills. With the effective use of ICT in teaching, we now have interactive communication between students and teachers, students and their colleagues, as well as students and students and teaching content. The informational communication knowledge and skills of the teacher, who plans the teaching process among other things, who chooses the teaching content and determines the educational process are of great importance and fundamentally affect the durability of the acquired knowledge and therefore the quality of education.

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Toz Metalurjisi Yöntemi ile Üretilen Fe-C-Nb-V-Cu Mikroalaşım Çeliğinin MQL Destekli İşlenmesinde Kesme Parametrelerinin Yüzey Pürüzlülüğü Üzerine Etkisinin Analizi

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Özet **–**Bu çalışmada, toz metalurjisi yöntemi ile üretilen Fe-C-Nb-V-Cu mikroalaşım çeliğinin frezelenmesinde yüzey pürüzlülüğü üzerinde kesme parametrelerinin etkileri deneysel olarak araştırılmıştır. Frezeleme deneyleri CNC dik işleme tezgâhında kuru ve MQL soğutma şartlarında gerçekleştirilmiştir. Bu deneyler soğutma şartı ve kesme parametrelerinin farklı seviyeleri dikkate alınarak Taguchi L18 dizinine göre tasarlanmıştır. Bu çalışmanın sonuçları, kuru işleme şartına göre MQL destekli işleme şartında yüzey pürüzlülüğü değerinin yaklaşık olarak %30,79 daha düşük olduğunu ve en düşük yüzey pürüzlülüğü değerinin MQL destekli işleme şartında 270 m/dak kesme hızı ve 0,06 mm/diş ilerleme miktarında yapılan deneyler sonucunda 0,490 µm olarak elde edildiğini göstermiştir.

Anahtar Kelimeler – Toz Metalürjisi, Mikroalaşım Çeliği, İşlenebilirlilik, Frezeleme, MQL

I. GİRİŞ

Mikroalaşımlı çelikler, çeşitli endüstriyel uygulamalarda yüksek performans ve dayanıklılık sağlamak için farklı mikroalaşım elementleri içeren çeşitli özel bir çelik grubunu ifade etmektedir. Başlıca alaşım elementleri arasında Nb, V, Ti, Al, Mo ve B bulunmaktadır [1]. Uygun çelik bileşimi ve termomekanik işlemler ile bu mikroalaşım elementlerinin potansiyel çökelme sertleşmesi ve tane inceltme etkileri ile çeliklerin mekanik özellikleri iyileşmektedir [2]. Mikroalaşımlı çelikler sahip oldukları, yüksek dayanım aşınma direnci, iyi kaynaklanabilirlik, ısı ve korozyon direnci gibi özelliklerinden dolayı otomotiv endüstrisinde yaygın olarak kullanılmaktadır [3]. Özellikle araç gövdesi ve şasi yapılarında, yüksek mukavemet ve hafiflik gerektiren bölgelerde tercih edilmektedirler [4]. Dahası, inşaat, enerji ve denizcilik endüstrilerindeki yapısal uygulamalarda kullanılmaktadır [5].

Mikroalaşımlı çeliklerin üretim aşamalarının zorluğu ve maliyeti toz metalürjisiyle bu çeliklerin üretilmesi için yeni alaşım sistemlerinin geliştirilmesine yol açmıştır. Toz metalürjisinin en büyük avantajlarından bir tanesi istenilen kimyasal bileşimde toz metal çelik üretiminin kolay bir şekilde gerçekleştirilebilmesidir [6]. Bu yöntemle üretilen parçalar, diğer yöntemlerle üretilen parçalara göre daha az pürüzlü bir yüzeye sahiptir ve çoğu zaman ikincil işlem gerektirmemektedir [7]. Tamamen kontrol edilebilir bileşen ve düşük birim maliyet, toz metalurjisini üretim endüstrisinde benzersiz bir üretim yöntemi haline getirmektedir. Bu yöntem ile sert metaller, takım çelikleri, kendinden yağlamalı burçlar, sürtünme elemanları, elektrik kontak malzemeleri, grafit fırçalar ve mıknatıslar arzulanan bileşimde üretile bilinmektedir [6, 8]. Literatürde toz metalurjisi yöntemiyle mikroalaşımlı çeliklerin üretimi ve mekanik özelliklerinin karakterizasyonu üzerine yapılan çalışmalar değerlendirildiğinde, Taştemur ve arkadaşları, toz metalurjisi ile üretilen Fe-0.35C mikroalaşımlı çeliğin yoğunluğu ve sertliği üzerinde Nb alaşım elementi eklentisinin ve termomekanik işlemin etkilerini araştırmışlardır [9]. Sonuç olarak, deformasyon

oranındaki artış ile gözenekli yapının azaldığını ve buna bağlı olarak yoğunluğun arttığını ve Nb alaşım elementi eklentisi ile sertlik değerinin arttığını bildirmişlerdir. Kandavel ve arkadaşları, Yapay Sinir Ağı (YSA) kullanarak titanyum (Ti) ve tungsten (W) ilavesinin toz metalurjisi (P/M) Fe-%1C çeliğinin tribolojik davranışı üzerindeki etkilerini araştırmışlardır [10]. Ti ve W ilavesinin aşınma direncini artırdığını ve YSA aracılığıyla P/M alaşımlı çeliklerin aşınma davranışının tahmin edilebilineceğini bildirmişlerdir. Farklı bir çalışmalarında ise sinterlenmiş Fe-C-Cu-Mo P/M alaşımlı çeliklerin EN 31 karşı yüzey malzemesine karşı aşınma davranışını analiz etmişlerdir [11]. Çalışmanın sonuçlar Cu ve Mo ilavesinin aşınma direncini artırdığını göstermiştir. Özdemirler ve diğerleri de sinterleme sıcaklığının NbC katkılı PM çeliklerinin mikroyapısı ve mekanik özellikleri üzerindeki etkisini araştırmıştır [12]. NbC'nin çökelmesinin tane büyümesini sınırladığını ve bunun da mukavemette önemli bir iyileşmeye neden olduğunu bildirmişlerdir.

Yukarıda bahsedilen literatür taramasından, PM yöntemiyle çelik üretimi, mikroyapının karakterizasyonu ve mekanik özelliklerin iyileştirilmesi üzerine birçok çalışmanın olduğu ancak PM çeliklerinin işlenebilirliği üzerine çalışmaların kısıtlı olduğu görülmüştür. Otomotiv, inşaat, enerji ve denizcilik gibi endüstriyel alanlarda çoğu ürüne son şekli talaşlı imalat işlemleriyle verildiği göz önüne alındığında, mühendislik malzemelerinin kullanıma hazır hale getirilmesi için çoğunlukla talaşlı imalat işlemlerine maruz kalmaktadır. Bu yüzden bu çalışmada Fe-C-Nb-V-Cu bileşiminde üretilen PM mikroalaşımlı çeliğinin frezelenmesinde yüzey kalitesi üzerinde kesme parametrelerinin etkisi araştırılmıştır.

II. MATERYAL VE YÖNTEM

Toz metalurjisi yöntemi ile Fe-C-Nb-V-Cu çeliğinin üretiminde Aldrich ve Höganas'tan temin metal tozları kullanılmıştır. Grafit, Fe, Nb, V ve Cu metal tozlarının saflıkları sırasıyla %96,5, %99,9, %99,8, %99,5 ve %99'dur. Bu metal tozları Fe0.25C0.075Nb0.075V0.5Cu bileşimini oluşturacak şekilde hassasça tartılmış ve TURBULA T2F cihazında 1 saat boyunca bilye olmadan karıştırılmıştır. Karıştırılan tozlar, hidrolik basınç altında 750 MPa basınç altında ASTM E8/E8M'ye göre çekme test numunesine tek yönlü olarak preslenmiştir. Elde edilen numune %95 nitrojen ve %5 hidrojen gazı sirkülasyonuna sahip seramik tüp fırında 1400 ℃'de sinterleme işlemine tabi tutulmuştur. Bu işlemde numune 5 °C/dk hızla sinterleme sıcaklığına ısıtıldı, bu sıcaklıkta bir saat bekletildi ve daha sonra 5 °C/dk soğutma hızıyla ortam sıcaklığına soğutuldu. Şekil 1'de toz metalurjisi ile elde edilen numunenin üretim aşamaları görülmektedir. Deney numunesinin sertlik ölçümü, SHIMADZU sertlik ölçüm cihazında HV0,5 (500g) yük altında on farklı ölçümün ortalama değeri alınarak gerçekleştirilmiştir. Toz metalurjisi yöntemi ile üretilen Fe-C-Nb-V-Cu mikroalaşım çeliğinin işleme deneylerinde, Walter kesici takım firması tarafından WKP35S kalitesinde ve SDMT06T204-F57 formunda üretilen kesici takımlar kullanılmıştır. Bu kesici takımlar, Walter marka M4132-Ø25 takım tutucuya rijit bir şekilde bağlanmıştır. Deneylerde kullanılan kesme parametreleri ve seviyeleri Tablo 1'de verilmiştir. Kesme parametrelerinin belirlenmesinde üretici takım firmasının önerileri ve literatürde 17-4 PH çeliğinin işlenebilirliği üzerine yapılan çalışmalar dikkate alınarak belirlenmiştir.

Şekil 1. Toz metalurjisi yöntemi ile Fe-C-Nb-V-Cu çeliğinin üretim aşaması

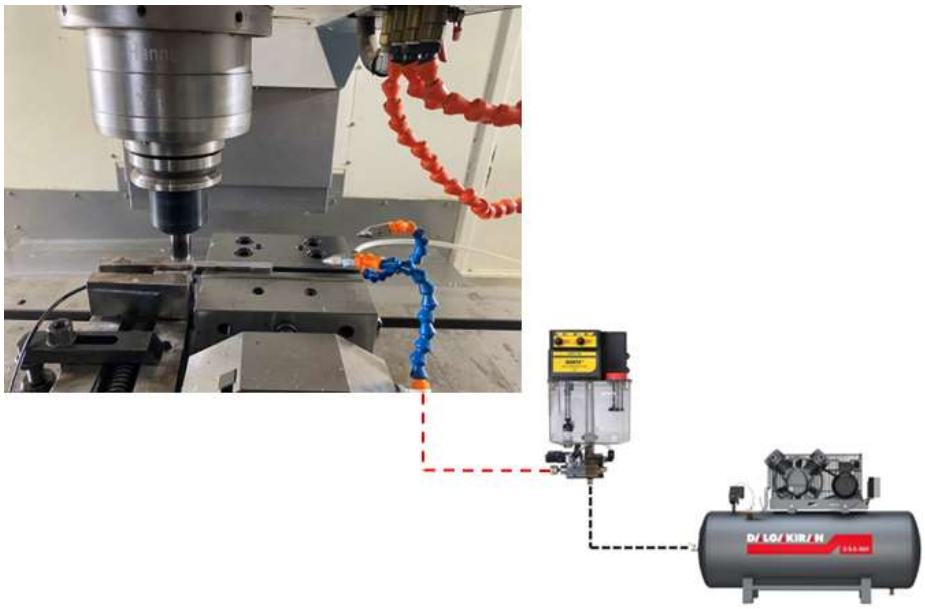
Deneylerde soğutucu akışkan olarak bio-stabil yarı sentetik metal işleme sıvısı kullanılmıştır. Kesme sıvısının işleme alanına iletilmesinde Werte Mikro STN 15 model MQL (Minimum Miktarda Yağlama)

sistemi kullanılmıştır. Frezeleme deneyleri, MQL sistemi 6 bar püskürtme basıncında ve 0,028 ml/sn debide olacak şekilde gerçekleştirilmiştir. Kesme sıvısının işleme alanına iletilmesinde 2 mm çapa sahip çift nozul kesici takıma 30˚ açı yapacak şekilde konumlandırılarak kullanılmıştır. Şekil 2'de MQL soğutma sistemi ile frezeleme deneylerinin şematik görüntüsü verilmiştir.

Tablo 1. Kesme parametreleri ve seviyeleri

Sembol	Kesme Parametreleri	I	II	III
Ort	İşleme Şartı	Kuru	MQL	
t	Talaş derinliği (mm)	0,6		
f	İlerleme miktrı (mm/diş)	0,06	0,12	0,18
Vc	Kesme hızı (m/dak)	90	180	270

Her bir frezeleme deneyi sonrası oluşan işlenmiş yüzeyler üzerinde yüzey pürüzlülüğü ölçümlerinde Mahr Perthometer M1 cihazı kullanılmıştır. Ölçümler öncesi mastar aracılığıyla yüzey pürüzlülüğü cihazının kalibrasyonu sağlanmıştır. Pürüzlülük ölçümlerinde örnekleme uzunluğu (λ) 0,8 mm ve ölçme uzunluğu (L) 5,6 mm seçilmiştir. Ortalama yüzey pürüzlülük (Ra) değerleri, frezelenmiş yüzeyler üzerinde işleme yönünde üç farklı noktadan ölçüm yapılarak elde edilen değerlerin aritmetik ortalaması alınarak hesaplanmıştır.



Şekil 2. Frezeleme deney düzeneği

Toz metalurjisi yöntemi ile üretilen Fe-C-Nb-V-Cu mikroalaşım çeliğinin frezelenmesinde yüzey pürüzlülüğü üzerinde kesme parametrelerinin etkisini belirlemek için Taguchi metodu uygulanmıştır. Deney tasarımı Taguchi L18 dizinine göre yapılmıştır. Frezeleme deneylerinde elde edilen yüzey pürüzlülüğü değerlerine S/N gürültü ve varyans (ANOVA) analizlerine tabi tutulmuştur. S/N sinyal-gürültü oranı analizi; yüzey pürüzlülüğü için Kuru ve MQL işleme şartları ile kesme parametrelerinin optimum seviyelerinin tanımlamak için kullanılmıştır. Yüzey pürüzlülüğü için Eş. 2.1'deki "en küçük en iyi eşitliği" yaklaşımı, kullanılarak S/N oranları belirlenmiştir. Ardından Yüzey pürüzlülüğü üzerinde girdi parametrelerinin etki seviyelerini belirmek için Anova analizi yapılmıştır.

$$n = \frac{S}{N} = -10 \log\left(\frac{1}{n}\sum_{i=1}^{n} y_i^2\right) \quad (2.1)$$

3. DENEY SONUÇLARI VE TARTIŞMA

3.1. S/N ORANLARININ ANALİZİ

Toz metalurjisi yöntemi ile üretilen Fe-C-Nb-V-Cu mikroalaşım çeliğinin MQL destekli frezelenmesinde yüzey pürüzlülüğü üzerinde kesme parametrelerinin etkisi araştırılmıştır. Frezeleme şartlarının ideal seviyelerinin belirlenmesinde S/N analizinden yararlanılmıştır. Deneysel ölçümler sonucunda elde edilen yüzey pürüzlülüğü değerleri (Ra) ve her bir frezeleme şartı için bu değerlere karşılık gelen S/N değerleri Tablo 2'de yer almaktadır. Yüzey pürüzlülüğü değerlerinin aritmetik ortalaması ve ortalama S/N oranı değerleri sırasıyla 1,515 μm ve 2,821 dB olarak hesaplanmıştır.

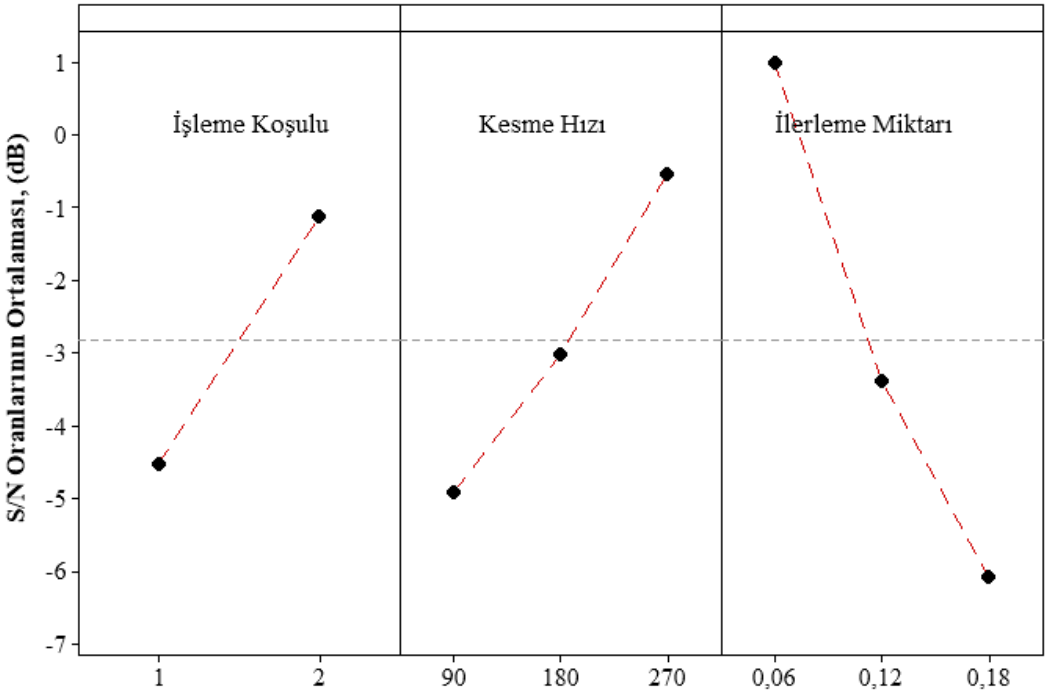
Tablo 2. Deney kombinasyonu ve sonuçlar.

Test No	İşleme Koşulu	Kesme Hızı	İlerleme Miktarı	Yüzey Pürüzlülüğü	S/N Oranları
1	Kuru İşleme Şartı	90	0,06	1,445	-3,197
2	Kuru İşleme Şartı	90	0,12	2,185	-6,789
3	Kuru İşleme Şartı	90	0,18	2,745	-8,770
4	Kuru İşleme Şartı	180	0,06	1,120	-0,984
5	Kuru İşleme Şartı	180	0,12	1,840	-5,296
6	Kuru İşleme Şartı	180	0,18	2,385	-7,549
7	Kuru İşleme Şartı	270	0,06	0,805	1,884
8	Kuru İşleme Şartı	270	0,12	1,520	-3,636
9	Kuru İşleme Şartı	270	0,18	2,078	-6,352
10	MQL İşleme Şartı	90	0,06	1,055	-0,465
11	MQL İşleme Şartı	90	0,12	1,569	-3,912
12	MQL İşleme Şartı	90	0,18	2,090	-6,402
13	MQL İşleme Şartı	180	0,06	0,745	2,556
14	MQL İşleme Şartı	180	0,12	1,234	-1,826
15	MQL İşleme Şartı	180	0,18	1,780	-5,008
16	MQL İşleme Şartı	270	0,06	0,490	6,196
17	MQL İşleme Şartı	270	0,12	0,870	1,209
18	MQL İşleme Şartı	270	0,18	1,325	-2,444

Tablo 3. Yüzey pürüzlüğü için S/N analiz sonucu.

	Kesme Parametreleri		
	İşleme Koşulu	**Kesme Hızı**	**İlerleme Miktarı**
Ra			
1	-4,5215	-4,9229	**0,9984**
2	**-1,1219**	-3,0181	-3,3752
3		**-0,5241**	-6,0882
Delta	3,3996	4,3989	7,0866

Tablo 3 deneysel ölçümler ile elde edilen yüzey pürüzlülüğü değerleri için S/N oranlarının yanıt tablosunu, Şekil 3'te kesme parametrelerinin seviye değerlerini grafik formda göstermektedir. Sonuç olarak, en düşük yüzey pürüzlülüğü değerinin elde edildiği optimum frezeleme parametresi kombinasyonu A2B3C1 olarak belirlenmiştir. Başka bir deyişle, en düşük yüzey pürüzlülüğü değeri için MQL destekli işleme, 270 m/dak kesme hızı ve 0,06 mm/diş ilerleme miktarı ideal kesme parametreleri seviyeleri olarak belirlenmiştir. Bu parametrelerde gerçekleştirilen delme deneyleri sonucunda ortalama yüzey pürüzlülüğü değeri 0,490 µm olarak ölçülmüştür.

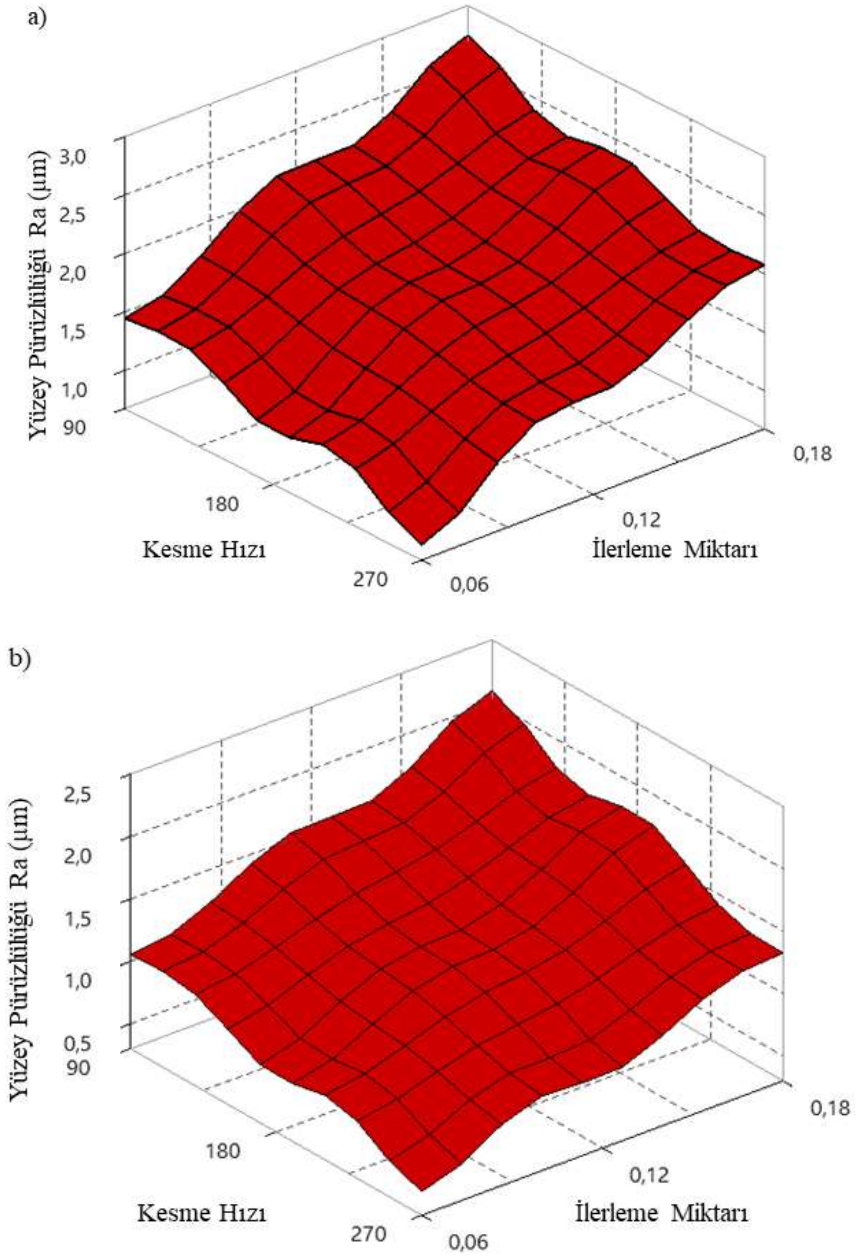


Şekil 3. Ra için S/N oranlarına göre kesme parametrelerinin dağılımı.

3.2. Deney Sonuçlarının Değerlendirilmesi

Toz metalurjisi yöntemi ile üretilen Fe-C-Nb-V-Cu mikroalaşım çeliğin frezeleme deneyleri, kuru ve MQL destekli işleme şartlarında farklı kesme hızı ve ilerleme miktarlarında gerçekleştirilmiştir. Şekil 4 a) kuru b) MQL destekli işleme şartlarında gerçekleştirilen delme deneylerinde ölçülen ortalama yüzey pürüzlülüğü değerleri üzerinde kesme parametrelerinin etkilerini göstermektedir. Şekil 4 incelendiğinde, iki işleme koşulu için kesme hızındaki artışla yüzey pürüzlülüğü değerinin azaldığı ancak ilerleme miktarındaki artış ile arttığı gözlenmiştir. İşleme koşulunun yüzey pürüzlülüğü değeri üzerinde etkili bir rol oynadığı açıkça görülmektedir. MQL destekli işleme şartında ölçülen yüzey pürüzlülüğü değerlerinin kuru işleme şartında ölçülen yüzey pürüzlülüğü değerlerinden daha düşüktür. Bütün ölçümlerin ortalamaları dikkate alındığında, kuru işleme şartına göre MQL destekli işleme şartında elde edilen yüzey pürüzlülüğü değerlerinin sırasıyla %30,79 daha az olduğu tespit edilmiştir. Kesme bölgesine soğutucu akışkanın iletilmesi ile yağlama fonksiyonunun artmasının bir sonucu olarak kesici takım-talaş ara yüzeyinde sürtünmenin azalması yüzey

pürüzlülüğü değerleri üzerinde olumlu bir etkiye neden olmuştur [13]. Öndin ve arkadaşları, bu durumu MQL tekniğinde kullanılan uçucu yağlayıcıların takım ve iş parçası arasındaki sürtünmeyi azaltarak daha iyi bir film tabaka oluşturması (penetrasyonu) ile açıklamışlardır [14].



Şekil 4. Kesme hızı ve ilerleme miktarına göre yüzey pürüzlülüğü değerlerinin dağılımı.

En düşük yüzey pürüzlülüğü değeri MQL destekli işleme şartında 270 m/dak kesme hızında 0,06 mm/diş ilerleme miktarında 0,490 µm olarak ölçülmüştür.

3.3. VARYANS ANALİZİ (ANOVA)

Yüzey pürüzlülüğü değerleri üzerinde işleme koşulu ve kesme parametrelerinin etkinliğini analiz etmek için Anova uygulanmıştır. Tablo 4'te Anova sonuçları yer almaktadır. Sonuç olarak, yüzey pürüzlülüğü

üzerinde İşleme koşulu, kesme hızı ve (f) ilerleme miktarı için etki oranları sırasıyla %20,76 %20,22 ve %57,5 olarak belirlenmiştir. Yüzey pürüzlülüğünü etkileyen en önemli parametre %57,5 katkı oranı ile ilerleme miktarı olarak belirlenmiştir.

Tablo 4. Ra için varyans analizi sonuçları.

Faktörler	Serbestlik Derecesi (DoF)	Kareler Toplamı (SS)	Kareler Ortalaması (MS)	F Değeri	P Değeri	Katkı Oranı (%)
İşleme koşulu	1	1,36951	1,36951	164,5	0,000	20,76
Kesme hızı	2	1,33403	0,66701	80,12	0,000	20,22
İlerleme miktarı	2	3,79287	1,89643	227,19	0,000	57,50
Hata	12	0,09991	0,00833			1,51
Total	17	6,59631				1000

4. SONUÇLAR

Bu çalışmada, Toz metalurjisi yöntemi ile üretilen Fe-C-Nb-V-Cu mikroalaşım çeliğinin frezelenmesinde, kuru ve MQL destekli işleme şartlarının ve kesme parametrelerinin yüzey pürüzlülüğü üzerindeki etkileri araştırılmıştır. Yapılan deneysel çalışmanın sonuçları aşağıda verilmiştir;

S/N analiz sonuçlarına göre en düşük yüzey pürüzlülüğü değeri için MQL destekli işleme, 270 m/dak kesme hızı ve 0,06 mm/diş ilerleme miktarı ideal kesme parametreleri seviyeleri olarak belirlenmiştir. Bu parametrelerde gerçekleştirilen delme deneyleri sonucunda ortalama yüzey pürüzlülüğü değeri 0,490 µm olarak ölçülmüştür.

Fe-C-Nb-V-Cu mikroalaşım çeliğinin MQL destekli işleme şartında frezelenmesinde yüzey pürüzlülüğü değerinin azaldığı görülmüştür. Kuru işleme şartına göre MQL destekli işleme şartında yüzey pürüzlülüğü değerinin yaklaşık olarak %30,79 daha düşük olduğu belirlenmiştir.

Varyans (ANOVA) analiz sonucu, Toz metalurjisi yöntemi ile üretilen Fe-C-Nb-V-Cu mikroalaşım çeliğinin frezeleme deneyleri sonucunda elde edilen yüzey pürüzlülüğü değerini etkileyen en önemli parametrenin %57,5 katkı oranı ile ilerleme miktarı olduğunu göstermektedir.

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Hafifletilmiş Şanzıman Dişlileri ile İçten Yanmalı Motor Performansının İyileştirilmesi: Topoloji Optimizasyonu ve Gerilme Analizi

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Özet – Bu çalışmada, içten yanmalı motorlarda kullanılan şanzıman dişlilerinin topoloji optimizasyonu ve malzeme değişimi yoluyla performans iyileştirmesi ve çevresel etki azaltımı hedeflenmiştir. Toyota Corolla model bir aracın 6 ileri manuel şanzımanı üzerinde gerçekleştirilen araştırmada, geleneksel dökme demir yerine alüminyum 6061-T6 alaşımı kullanılarak topoloji optimizasyonu uygulanmıştır. Solidworks 2022 ve Ansys 2019 yazılımları kullanılarak yapılan 3B modelleme ve sonlu elemanlar analizleri sonucunda, şanzıman dişlilerinin toplam ağırlığında %67'lik bir azalma sağlanmıştır. Optimize edilmiş dişlilerdeki maksimum Von Mises gerilme değerleri, alüminyum alaşımının akma dayanımının önemli ölçüde altında kalmıştır. Sonuçlar, optimize edilmiş şanzıman tasarımının araç performansını ve yakıt verimliliğini artırma, dolayısıyla karbon emisyonlarını azaltma potansiyeline sahip olduğunu göstermektedir. Bu çalışma, otomotiv endüstrisinde daha hafif ve daha verimli araçların geliştirilmesine yönelik önemli bir adımı temsil etmektedir.

Anahtar Kelimeler – Topoloji optimizasyonu, şanzıman tasarımı, enerji verimliliği, içten yanmalı motorlar, çevresel etki azaltımı.

I. GİRİŞ

İçten yanmalı motorlar, modern ulaşım ve endüstriyel sistemlerin temelini oluşturmaya devam etmektedir. Bununla birlikte, artan çevresel kaygılar ve sıkılaşan emisyon düzenlemeleri, bu motorların verimliliğini artırma ve çevresel etkilerini azaltma ihtiyacını ön plana çıkarmıştır [1]. Bu bağlamda, şanzıman sistemleri, motorun ürettiği gücü tekerleklere iletmede kritik bir rol oynamakta ve enerji verimliliği üzerinde önemli bir etkiye sahip olmaktadır [2].

Şanzıman dişlileri, güç aktarma sistemlerinin temel bileşenleridir ve performans, dayanıklılık ve verimlilik açısından önemli bir rol oynarlar. Geleneksel tasarım yöntemleri, genellikle aşırı mühendislik uygulamalarına yol açmakta, bu da gereksiz ağırlık artışına ve dolayısıyla yakıt tüketiminde artışa neden olmaktadır [3]. Bu nedenle, şanzıman dişlilerinin optimizasyonu, içten yanmalı motorların genel verimliliğini artırmada kritik bir adım haline gelmiştir.

Son yıllarda, topoloji optimizasyonu ve gelişmiş gerilme analizi teknikleri, mühendislik tasarımında önemli ilerlemeler sağlamıştır [4, 5]. Bu yöntemler, malzeme dağılımını optimize ederek ve yapısal bütünlüğü korurken ağırlığı minimize ederek, daha verimli ve hafif bileşenler tasarlamaya olanak tanımaktadır.

İçten yanmalı motorların verimliliği ve emisyonları üzerine yapılan çalışmalar, son yıllarda önemli ölçüde artmıştır. Zhao ve ark. [6], motor tasarımındaki ilerlemelerin emisyon azaltımı üzerindeki etkilerini incelemiş ve güç aktarma sistemlerinin optimizasyonunun önemini vurgulamışlardır. Şanzıman sistemleri özelinde, Li ve ark. [7] otomatik şanzımanların enerji verimliliği üzerine kapsamlı bir araştırma yapmış ve

dişli tasarımının kritik rolünü ortaya koymuşlardır. Ahmed ve ark. [8], dişli geometrisinin optimizasyonunun yakıt tüketimi üzerindeki olumlu etkilerini göstermiştir.

Topoloji optimizasyonu alanında, Bendsøe ve Sigmund [9] yapısal optimizasyon için temel prensipleri ortaya koymuştur. Zhu ve ark. [10], topoloji optimizasyonunun otomotiv bileşenlerinde uygulanmasını incelemiş ve ağırlık azaltımında elde edilen önemli kazanımları raporlamışlardır. Gerilme analizi konusunda, Karakoc ve ark. [11], sonlu elemanlar yöntemini kullanarak dişli sistemlerinde gerilme dağılımını incelemiş ve optimizasyon için kritik alanları belirlemiştir.

Mevcut literatür, şanzıman dişlilerinin optimizasyonunun içten yanmalı motorların verimliliğini artırmada önemli bir potansiyele sahip olduğunu açıkça ortaya koymaktadır. Wang ve ark. [12] tarafından yapılan kapsamlı bir meta-analiz, optimize edilmiş dişli tasarımlarının yakıt verimliliğinde ortalama %3-5'lik bir artış sağlayabileceğini göstermiştir. Bununla birlikte, mevcut çalışmaların çoğu, topoloji optimizasyonu ve gerilme analizini ayrı ayrı ele almaktadır [13, 14]. Bu iki yöntemin entegrasyonu, potansiyel olarak daha hafif, daha dayanıklı ve daha verimli dişli tasarımlarına yol açabilir. Ancak, bu entegrasyonun karmaşıklığı ve hesaplama yoğunluğu, şimdiye kadar kapsamlı çalışmaların yapılmasını engellemiştir [15].

Bu çalışmada, topoloji optimizasyonu ve gerilme analizinin bütünleşik uygulanmasındaki araştırma boşluğu ele alınmaktadır. Amaç, içten yanmalı motorlar için şanzıman dişlilerinin optimizasyonunda yeni bir metodoloji geliştirmektir. Bu yaklaşım, dişli tasarımlarının performansını, dayanıklılığını ve enerji verimliliğini iyileştirmeyi hedeflemektedir. Optimize edilmiş dişlilerin, araç ağırlığını azaltarak yakıt tüketimini ve karbon emisyonlarını düşürmesi beklenmektedir. Ayrıca, malzeme kullanımının azaltılmasıyla üretim sürecinin çevresel etkilerinin de minimize edilmesi amaçlanmaktadır. Sonuç olarak, bu araştırma hem araç kullanımı hem de üretim aşamasında çevresel etkilerin azaltılmasına yönelik veriler sunmayı hedeflemektedir.

II. YÖNTEM

Bu çalışmada, içten yanmalı motorlarda kullanılan şanzıman dişlilerinin optimizasyonu için sistematik bir yaklaşım benimsenmiştir. Araştırma yöntemi, fiziksel ölçüm, 3B modelleme, sonlu elemanlar analizi ve malzeme optimizasyonu gibi çeşitli mühendislik tekniklerini içermektedir.

A. Fiziksel Ölçüm ve 3B Modelleme

Toyota Corolla model bir aracın (1.6 litre benzinli motor, 6 ileri manuel şanzıman) şanzımanı sökülerek tüm bileşenlerin boyutları ve kütleleri hassas ölçüm aletleriyle ölçülmüştür. Elde edilen veriler kullanılarak Solidworks 2022 yazılımında şanzıman bileşenlerinin 3B modelleri oluşturulmuştur.

B. Malzeme Seçimi

Çalışmada iki farklı malzeme karşılaştırılmıştır:

1. Geleneksel dökme demir
2. Hafif alüminyum 6061-T6 alaşımı

C. 2.3 Sonlu Elemanlar Analizi ve Topoloji Optimizasyonu

Oluşturulan 3B modeller Ansys 2019 yazılımına aktarılarak her bir dişli ve mil için ayrı ayrı yapısal analizler gerçekleştirilmiş, ardından topoloji optimizasyonu uygulanmıştır. Analizlerde dişlilere 180 Nm'lik moment uygulanmıştır.

D. Performans ve Çevresel Etki Değerlendirmesi

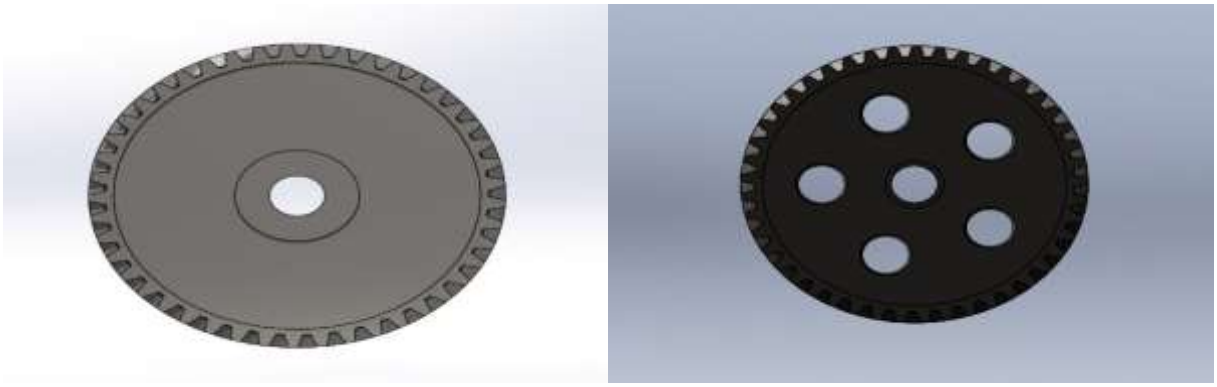
Optimize edilmiş alüminyum dişlilerin performansı, dayanıklılığı ve çevresel etkileri, orijinal dökme demir dişlilerle karşılaştırılmıştır. Gerilme dağılımı, deformasyon miktarı ve yorulma dayanımı gibi parametreler analiz edilmiş, ayrıca malzeme değişimi ve ağırlık azaltımının yakıt tüketimi ve emisyon üzerindeki etkileri değerlendirilmiştir.

III. BULGULAR

Bu bölümde, şanzıman dişlilerinde uygulanan topoloji optimizasyonu ve malzeme değişiminin etkileri, gerçekleştirilen analiz sonuçlarına dayanarak sunulmaktadır.

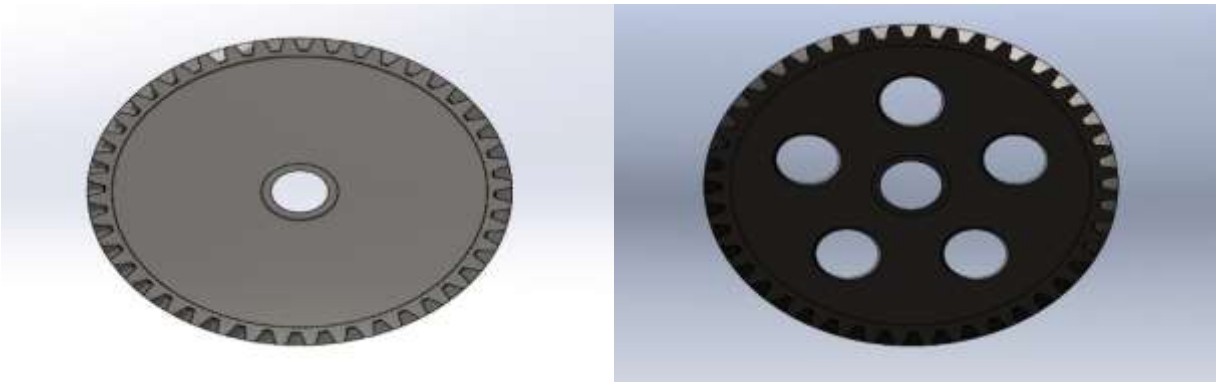
A. Geometrik Optimizasyon ve Ağırlık Analizi

Topoloji optimizasyonu ve malzeme değişimi sonucunda, şanzıman dişlilerinin geometrilerinde ve ağırlıklarında önemli değişiklikler gözlemlenmiştir. Şekil 1-6, her bir vites dişlisinin orijinal ve optimize edilmiş hallerini göstermektedir.

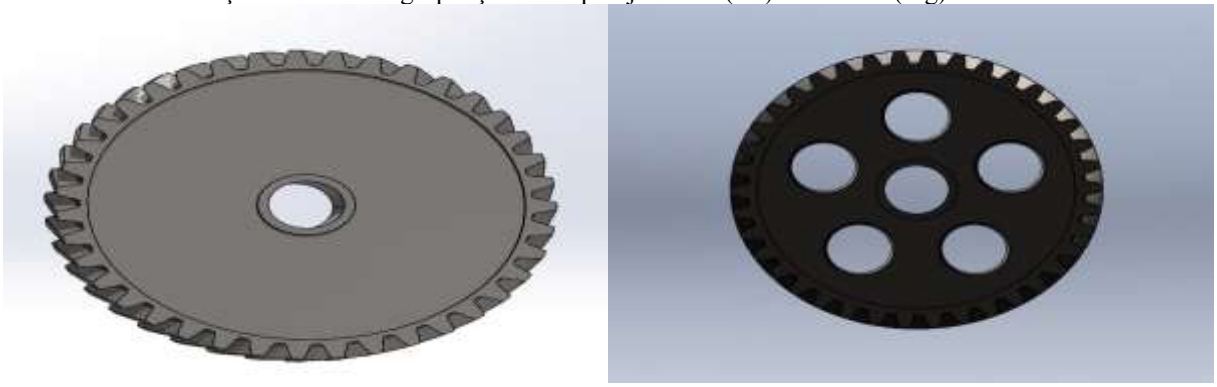


Şekil 1. 1. Vites grup dişlisinin topoloji öncesi (sol) ve sonrası (sağ) hali

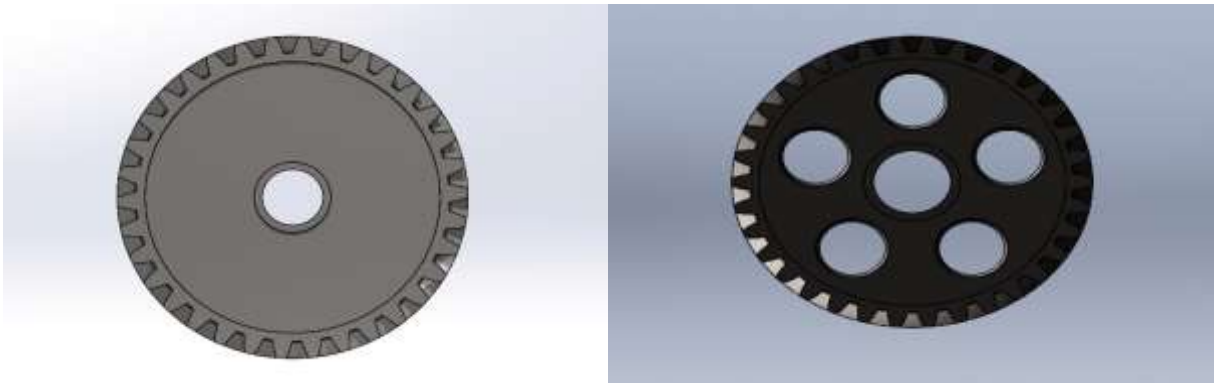
Şekil 1'de görüldüğü üzere, 1. vites dişlisinde uygulanan optimizasyon, dişli gövdesinde stratejik boşluklar oluşturarak ağırlığı önemli ölçüde azaltmıştır. Benzer optimizasyon stratejileri diğer vites dişlilerine de uygulanmıştır (Şekil 2).



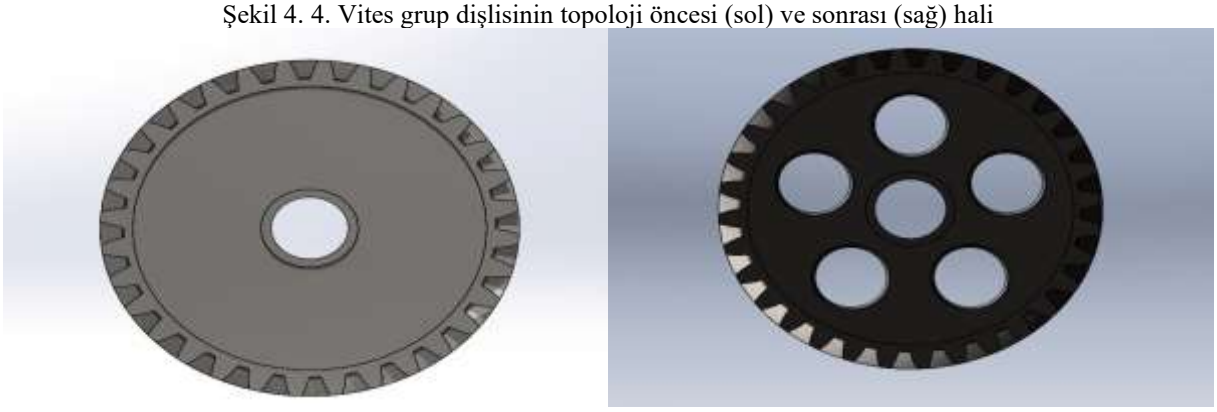
Şekil 2. 2. Vites grup dişlisinin topoloji öncesi (sol) ve sonrası (sağ) hali



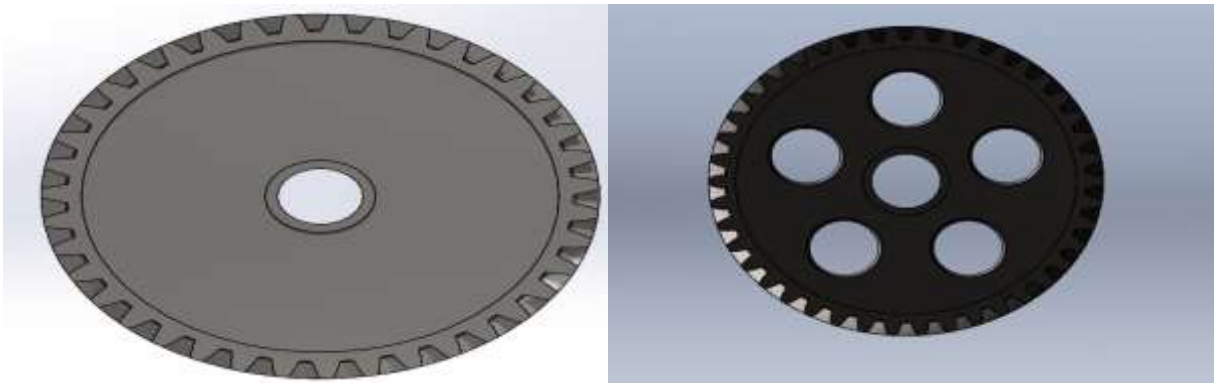
Şekil 3. 3. Vites grup dişlisinin topoloji öncesi (sol) ve sonrası (sağ) hali



Şekil 4. 4. Vites grup dişlisinin topoloji öncesi (sol) ve sonrası (sağ) hali



Şekil 5. 5. Vites grup dişlisinin topoloji öncesi (sol) ve sonrası (sağ) hali



Şekil 6. 6. Vites grup dişlisinin topoloji öncesi (sol) ve sonrası (sağ) hali

Tablo 1, optimizasyon ve malzeme değişimi sonrasında elde edilen ağırlık azalmalarını detaylı bir şekilde göstermektedir.

Tablo 1. Şanzıman Dişlilerinde Optimizasyon ve Malzeme Değişimi Sonrası Elde Edilen Ağırlık Azalmaları

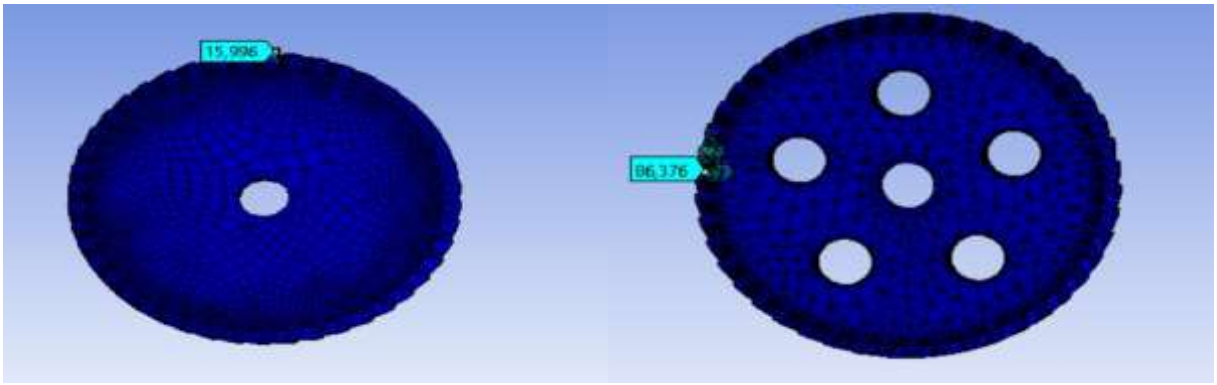
Dişli Türü	Dökme Demir (İlk Hali)	Dökme Demir (Optimize)	Alüminyum (Optimize)
1. Vites Dişlisi	1.53 kg	1.38 kg	0.520 kg
2. Vites Dişlisi	1.46 kg	1.38 kg	0.480 kg
3. Vites Dişlisi	1.14 kg	1.27 kg	0.480 kg
4. Vites Dişlisi	0.870 kg	0.743 kg	0.280 kg
5. Vites Dişlisi	0.758 kg	0.646 kg	0.245 kg
6. Vites Dişlisi	1.14 kg	0.950 kg	0.363 kg
Toplam Ağırlık	**6.898 kg**	**5.939 kg**	**2.248 kg**

Tablo 1'den görüldüğü üzere, topoloji optimizasyonu ve malzeme değişimi sonucunda toplam ağırlıkta %67 oranında bir azalma sağlanmıştır. Bu azalma, araç performansı ve yakıt verimliliği üzerinde potansiyel olarak olumlu bir etki yaratabilir.

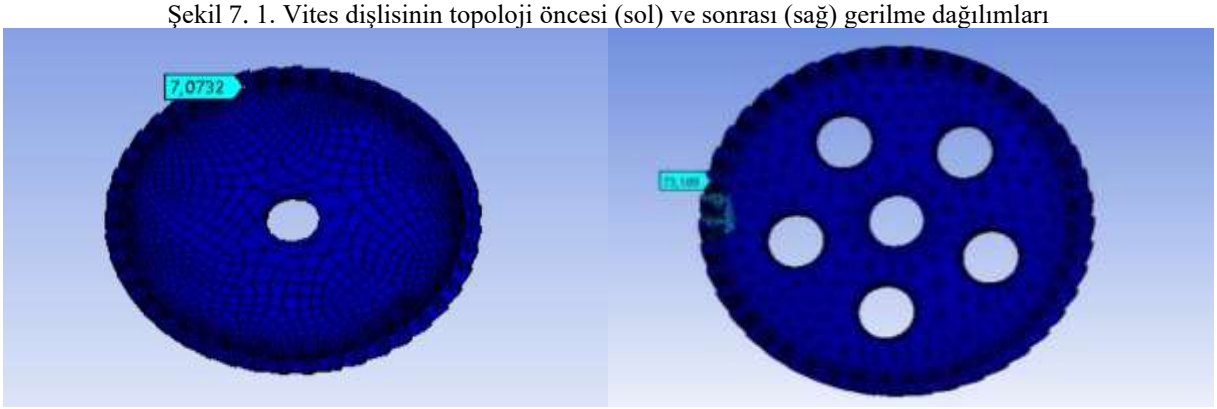
B. Gerilme Analizi

Optimize edilmiş dişlilerin yapısal bütünlüğünü değerlendirmek amacıyla, her bir vites dişlisi için kapsamlı gerilme analizleri gerçekleştirilmiştir. Ansys yazılımı kullanılarak yapılan analizlerde, dişlilere 180 Nm'lik bir moment uygulanmıştır. Şekil 7-12, her bir vites dişlisi için topoloji öncesi ve sonrası Von Mises gerilme dağılımlarını göstermektedir. Genel olarak, tüm optimize edilmiş dişlilerde gerilme değerlerinde bir artış gözlemlenmektedir. Ancak, gerilme dağılımının daha homojen hale geldiği ve kritik bölgelerde yoğunlaştığı görülmektedir.

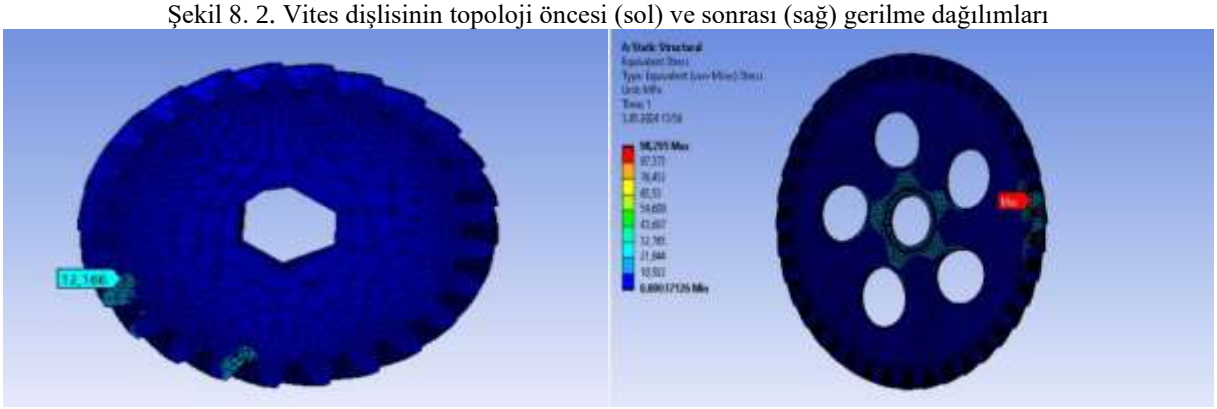
Örnek olarak, Şekil 7'de görüldüğü üzere, optimize edilmiş 1. vites dişlisinde maksimum Von Mises gerilmesi 86.376 MPa'ya yükselmiştir. Bu artışa rağmen, gerilme değeri alüminyum 6061-T6 alaşımının akma dayanımının (270 MPa) önemli ölçüde altında kalmıştır. Bu durum, diğer tüm dişliler için de benzer şekilde gözlemlenmiştir.



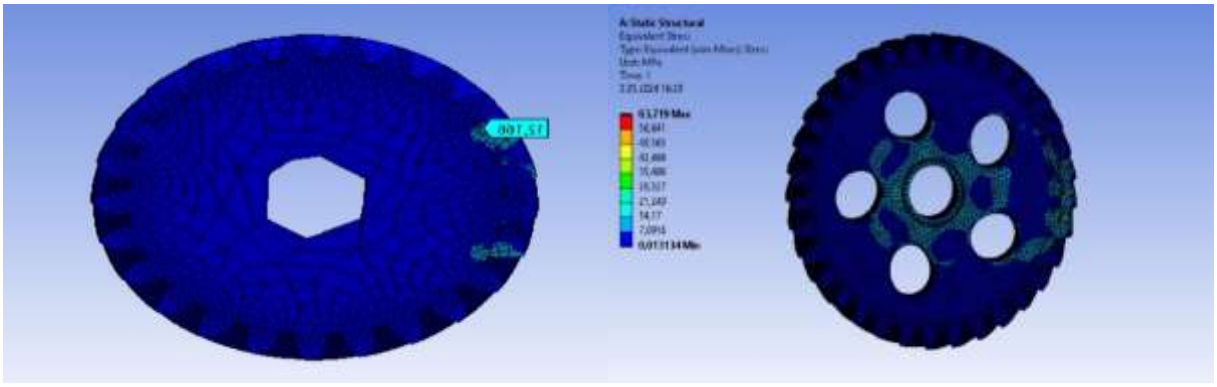
Şekil 7. 1. Vites dişlisinin topoloji öncesi (sol) ve sonrası (sağ) gerilme dağılımları



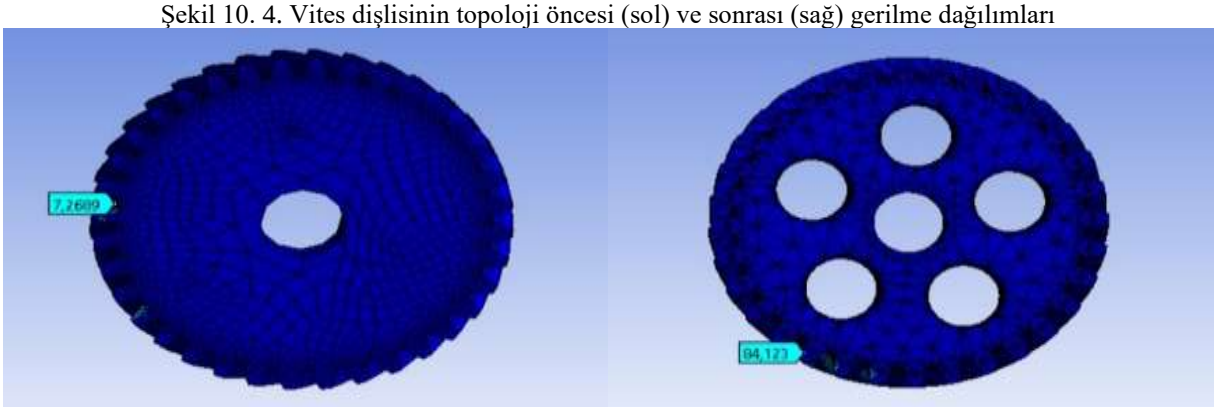
Şekil 8. 2. Vites dişlisinin topoloji öncesi (sol) ve sonrası (sağ) gerilme dağılımları



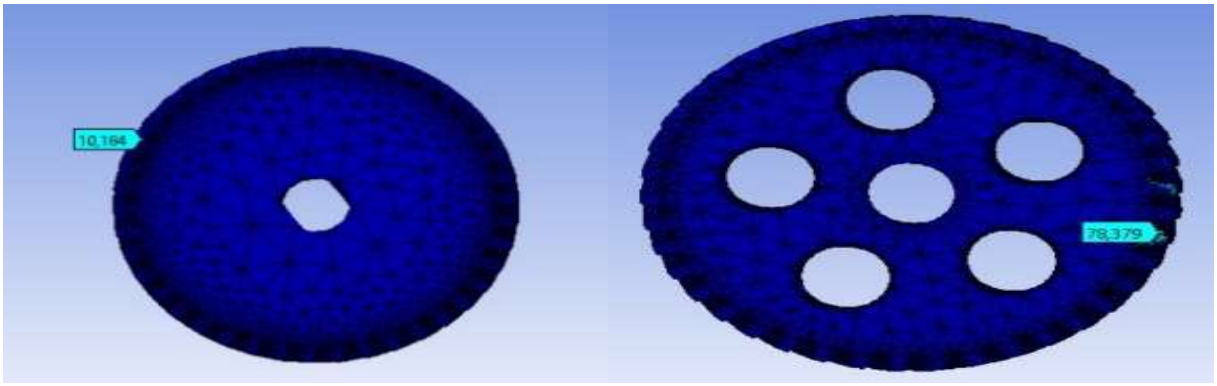
Şekil 9. 3.Vites dişlisinin topoloji öncesi (sol) ve sonrası (sağ) gerilme dağılımları



Şekil 10. 4. Vites dişlisinin topoloji öncesi (sol) ve sonrası (sağ) gerilme dağılımları



Şekil 11. 5. Vites dişlisinin topoloji öncesi (sol) ve sonrası (sağ) gerilme dağılımları



Şekil 12. 6. Vites dişlisinin topoloji öncesi (sol) ve sonrası (sağ) gerilme dağılımları

1-6. Vites Dişlilerinin Optimize Öncesi ve Sonrası Gerilme ve Kütle Değerleri Tablo 2'de sunulmuştur. Buna göre altı farklı vites dişlisinin topoloji optimizasyonu ve malzeme değişimi öncesi ve sonrasındaki kütle ve Von Mises gerilme değerlerini karşılaştırmalı olarak sunmaktadır. Tablodaki veriler, optimizasyon sürecinin etkilerini net bir şekilde ortaya koymaktadır.

Kütle Değişimi:

- Tüm vites dişlilerinde önemli bir kütle azalması gözlemlenmiştir.
- En büyük kütle azalması 1. vites dişlisinde gerçekleşmiş olup, 1.53 kg'dan 0.520 kg'a düşmüştür (yaklaşık %66 azalma).
- En küçük kütle azalması ise 5. vites dişlisinde görülmüş, 0.758 kg'dan 0.245 kg'a inmiştir (yaklaşık %68 azalma).
- Ortalama olarak, dişlilerin kütlelerinde yaklaşık %67'lik bir azalma sağlanmıştır.

Gerilme Değişimi:

- Optimize edilmiş tüm dişlilerde Von Mises gerilme değerlerinde artış gözlemlenmiştir.
- En büyük gerilme artışı 5. vites dişlisinde olup, 7.269 MPa'dan 84.123 MPa'ya yükselmiştir (yaklaşık 11.6 kat artış).

- En küçük gerilme artışı 4. vites dişlisinde görülmüş, 12.166 MPa'dan 63.719 MPa'ya çıkmıştır (yaklaşık 5.2 kat artış).
- Optimize edilmiş dişlilerdeki en yüksek gerilme değeri 1. vites dişlisinde 86.376 MPa olarak ölçülmüştür.

Tablo 2. 1-6.vites dişlilerinin optimize öncesi ve sonrası gerilme ve kütle değerleri

Veri	1. Vites	2. Vites	3. Vites	4. Vites	5. Vites	6. Vites
Optimize Edilmeden Önceki Kütle	1.53 kg	1.46 kg	0.758 kg	0.870 kg	0.758 kg	1.14 kg
Optimize Edildikten Sonraki Kütle	0.520 kg	0.480 kg	0.245 kg	0.280 kg	0.245 kg	0.363 kg
Optimize Edilmeden Önceki Von Misses Gerilmesi	15.906 MPa	7.0732 MPa	7.269 MPa	12.166 MPa	7.269 MPa	10.184 MPa
Optimize Edildikten Sonraki Von Misses Gerilmesi	86.376 MPa	73.189 MPa	84.123 MPa	63,719 MPa	84.123 MPa	78.379 MPa

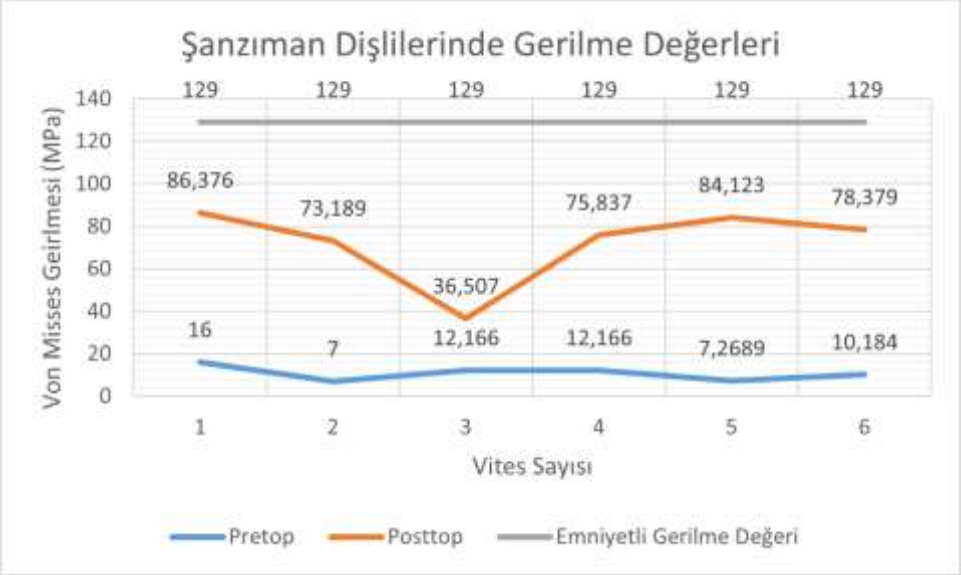
Topoloji optimizasyonu ve malzeme değişimi, şanzıman dişlilerinde dikkate değer sonuçlar ortaya koymuştur. Tüm dişlilerde gözlemlenen önemli kütle azalması, araç toplam ağırlığında ciddi bir düşüş potansiyeli sunmakta, bu da yakıt verimliliğini artırma ve emisyonları azaltma imkanı sağlamaktadır. Optimize edilmiş dişlilerde gerilme değerlerindeki artış, malzeme miktarının azaltılması ve yükün daha küçük bir alana dağılması nedeniyle beklenen bir sonuç olmasına rağmen, en yüksek gerilme değeri (86.376 MPa) bile alüminyum 6061-T6 alaşımının akma dayanımının (270 MPa) önemli ölçüde altında kalarak, dişlilerin hala güvenli çalışma sınırları içinde olduğunu göstermektedir. Optimizasyon süreci, her dişli için farklı etkiler göstermiş, örneğin 4. vites dişlisi en az gerilme artışı ile en fazla kütle azalması sağlayan dişlilerden biri olarak öne çıkmıştır. Tüm optimize edilmiş dişlilerde gerilme değerleri artmasına rağmen, en yüksek gerilme değerinin bile malzemenin akma dayanımının yaklaşık üçte biri kadar olması, tasarımda yeterli bir güvenlik faktörünün korunduğunu kanıtlamaktadır. Sonuç olarak, bu çalışma topoloji optimizasyonu ve malzeme değişiminin şanzıman dişlilerinin ağırlığını önemli ölçüde azaltırken gerekli mukavemet özelliklerini koruyabildiğini göstermekte ve bu sonuçlar, otomotiv endüstrisinde daha hafif ve daha verimli araçların geliştirilmesine yönelik önemli bir adımı temsil etmektedir.

C. Gerilme Değişimlerinin Analizi

Şekil 13'te gösterilen gerilme değişimleri incelendiğinde, optimize edilmiş tüm dişlilerde gerilme değerlerinde belirgin bir artış gözlemlenmiştir. En yüksek gerilme değeri 1. vites dişlisinde (86.376 MPa), en düşük gerilme değeri ise 3. vites dişlisinde (36.507 MPa) ölçülmüştür. Gerilme artış oranları vites numarasına göre değişkenlik göstermekte, 3 kat ile 11.5 kat arasında değişmektedir. Önemli bir nokta, tüm optimize edilmiş dişlilerin gerilme değerlerinin, emniyetli gerilme sınırı olan 129 MPa'nın altında kalmasıdır.

Bu sonuçlar, topoloji optimizasyonu ve malzeme değişiminin şanzıman dişlilerinin gerilme değerlerini artırdığını, ancak bu artışın güvenli sınırlar içinde kaldığını göstermektedir. Optimize edilmiş tüm dişlilerin maksimum gerilme değerleri, emniyetli gerilme değerinin altında kalmıştır, bu da yeni tasarımların güvenilirliğini ve dayanıklılığını kanıtlamaktadır.

Şekil 13, çalışmanın temel hedeflerinden biri olan ağırlık azaltımının, malzemenin mekanik özellikleri üzerinde önemli bir olumsuz etki yaratmadan başarıyla gerçekleştirildiğini görsel olarak ortaya koymaktadır. Bu sonuçlar, otomotiv endüstrisinde daha hafif ve daha verimli araçların geliştirilmesine yönelik önemli bir adımı temsil etmekte ve gelecekteki araştırmalar için umut verici bir temel oluşturmaktadır.



Şekil 13. Dişlilerde oluşan gerilim değerlerinin değişimi

IV. SONUÇ VE ÖNERİLER

Bu çalışmada, şanzıman dişlilerinde topoloji optimizasyonu ve malzeme değişiminin etkilerini incelenmiş ve aşağıdaki sonuçlara ulaşılmıştır:

- Topoloji optimizasyonu ve alüminyum malzeme kullanımı, şanzıman dişlilerinin toplam ağırlığında %67'lik bir azalma sağlamıştır. Bu önemli ağırlık azalması, araç performansını ve yakıt verimliliğini artırma potansiyeline sahiptir.
- Optimize edilmiş alüminyum dişlilerde gerilme değerleri artış göstermesine rağmen, bu değerler malzemenin akma dayanımının altında kalmıştır. Bu durum, optimize edilmiş dişlilerin güvenli çalışma sınırları içinde olduğunu göstermektedir.
- Ağırlık azalması, araçların toplam ağırlığını düşürerek yakıt tüketimini ve buna bağlı karbon emisyonlarını azaltma potansiyeline sahiptir. Otomobil toplam ağırlığındaki her %10'luk azalmanın %5-10 oranında yakıt tasarrufu sağladığı göz önüne alındığında, elde edilen ağırlık azalmasının yakıt tüketimi ve emisyonlar üzerinde önemli bir etkisi olacağı öngörülmektedir [16].
- Alüminyumun geri dönüştürülebilirliği, şanzıman üretiminin çevresel etkilerini azaltma potansiyeli sunmaktadır. Alüminyumun ham maddeden üretim için gerekli enerjinin sadece %5'i kadar bir enerjiyle tekrar ergitilebilmesi, yaşam döngüsü boyunca enerji tasarrufu sağlamaktadır [17].
- Çalışmada kullanılan her 1 kg çeliğin 500 gr alüminyumla yer değiştirmesi, aracın tüm kullanım ömrü için toplam 10 kg daha az emisyona sebep olacağı hesaplanmıştır. Bu bağlamda, optimize edilmiş şanzıman dişlilerinin araç başına emisyon azaltımına önemli katkı sağlayacağı öngörülmektedir [18].
- Malzeme kullanımındaki azalma, doğal kaynakların korunmasına ve üretim sürecindeki atık miktarının azaltılmasına katkıda bulunmaktadır.

Bu sonuçlar ışığında, çalışmanın bulgularını daha da ileriye taşımak ve pratik uygulamalarını geliştirmek için aşağıdaki çalışmaların yapılması önerilmektedir.

- Optimize edilmiş dişlilerin uzun vadeli dayanıklılığını değerlendirmek için yorulma testleri yapılmalıdır.
- Farklı sürüş koşulları altında optimize edilmiş şanzımanın performansını ve yakıt tüketimi üzerindeki etkisini değerlendirmek için saha testleri gerçekleştirilmelidir.
- Optimize edilmiş şanzımanın üretim maliyetleri, ekonomik fizibilitesi ve yaşam döngüsü analizi üzerine detaylı bir çalışma yapılmalıdır. Bu analiz, üretim, kullanım ve geri dönüşüm aşamalarındaki çevresel etkileri kapsamalıdır.

- Alüminyum dişlilerin aşınma direnci ve yağlama gereksinimleri üzerine daha fazla araştırma yapılmalıdır. Bu, optimize edilmiş şanzımanın uzun vadeli çevresel etkilerini anlamak için önemlidir.
- Optimize edilmiş şanzımanın farklı araç modellerine uygulanabilirliği incelenmelidir. Bu, teknolojinin yaygınlaştırılması ve genel emisyon azaltımı potansiyelinin değerlendirilmesi açısından önemlidir.
- Şanzıman optimizasyonunun elektrikli ve hibrit araçlara uygulanabilirliği araştırılmalıdır. Bu, gelecekteki ulaşım teknolojilerinde de enerji verimliliğini artırma potansiyeli sunabilir.
- Optimize edilmiş şanzımanın üretim sürecinin çevresel etkilerini minimize etmek için temiz üretim teknolojileri ve yenilenebilir enerji kaynaklarının kullanımı araştırılmalıdır.
- Şanzıman dişlilerinin geri dönüşüm süreçleri optimize edilmeli ve bir döngüsel ekonomi modeli geliştirilmelidir.

Bu çalışma, içten yanmalı motorlu araçların verimliliğini artırmak ve çevresel etkilerini azaltmak için şanzıman tasarımında yenilikçi bir yaklaşım sunmaktadır. Elde edilen sonuçlar, otomotiv sektöründe sürdürülebilirlik hedeflerine ulaşmada önemli bir adım teşkil etmektedir. Gelecekteki araştırmalar, bu yaklaşımın pratik uygulamalarını, uzun vadeli etkilerini ve daha geniş ölçekte uygulanabilirliğini değerlendirmeye odaklanmalıdır.

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Karbon Fiyatlandırılmasının Isı Pompalarının Birim Maliyetine Etkisi

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Özet **–** Yenilenebilir enerji kaynakları küresel enerji pazarındaki etkisi giderek artmaktadır. Enerji güvenliğini sağlamak ve sürdürülebilirliği artırmak açısından kritik bir rol oynayan yenilenebilir enerji kaynakları, aynı zamanda karbon salınımını azaltma konusunda da büyük bir potansiyele sahiptir. Temel olarak binaların iklimlendirilmesi için kullanılan farklı tip ısı pompaları yenilenebilir enerjinin doğrudan kullanımı açısından önemli etkiye sahiptir. Bu çalışmada, farklı güçteki ısı pompalarının yılda 2000 saat çalıştığı varsayılarak birim maliyetleri hesaplanmıştır. Ayrıca farklı karbon fiyat senaryoları altında birim maliyetlerdeki değişim incelenmiştir. Karbon fiyatlandırması arttıkça daha az enerji harcayıp daha az karbon salınımı yapan düşük kapasiteli cihazların birim maliyetinin daha düşük olduğu görülmüştür. Bu gelişme, yatırımcılar ve enerji şirketleri için yenilenebilir enerji projelerini daha çekici hale getirmektedir. Karbon fiyatlandırma politikası ile ısı pompalarının birim maliyetinde kısmi bir artış olsa bile karbon salınımı yüksek diğer fosil yakıtların maliyetleri daha yüksek oranda artacağı için ısı pompaları gibi daha temiz enerji türlerinin cazibesi ekonomik olarak da artacaktır. Ayrıca, çevresel etkilerin azaltılması ve sürdürülebilir enerji üretimi hedeflerine ulaşma yolunda önemli bir adım olarak değerlendirilmektedir.

Anahtar Kelimeler – Isı pompası, karbon fiyatlandırması, emisyon, maliyet analizi, sürdürülebilirlik

I. GİRİŞ

Petrol ve fosil yakıt enerji kaynaklarının gitgide artan kullanımları, fiyatlarındaki ani dalgalanma, yoğun bir şekilde tüketilmesi, yenilenebilir ve maliyet açısından uygun yeşil, alternatif ve sürdürülebilir enerji bulma ve kullanma eğilimlerinin artmasına neden olmuştur.

Isı pompaları, endüstriyel sektörlerde yaygın olarak kullanılan doğal ısı kaynaklarından, havadan, topraktan ve sudan faydalanarak etkin bir şekilde çalışmaktadır. Bu sistemler, enerji tasarrufu sağlama, atık ısıyı değerlendirme, güvenilirlik, düşük bakım maliyetleri, uzun ömür, düşük yüklerde yüksek verimlilik ve çevre dostu olma gibi bir dizi avantaj sunarlar. Düşük sıcaklıkta bulunan yenilenebilir enerji kaynakları, örneğin hava, su, jeotermal sular, deniz suyu, göller ve güneş enerjisi gibi kaynaklar, ısı pompası sistemlerinde kullanılabilmektedir. Ancak, bu avantajlara rağmen, henüz geniş çapta benimsenmemişlerdir ve hedeflenen pazar payına ulaşamamışlardır. Türkiye'nin bu kaynaklardan zengin olması, ısı pompaları için önemli bir avantaj sunmaktadır.

Kaya (2009), yaptığı çalışmada ısı pompası sisteminin kondenser sıcaklığına karşı kombi sistemini ekonomik olarak karşılaştırmıştır. Kondenser sıcaklığı 60°C'de birim maliyet toplamı 0.007449 $/kWh iken 180°C'de ise 0.05553 $/kWh, kombi sisteminin birim maliyeti ise yaklaşık olarak 0,020$/kWh olduğu hesaplanmıştır. Yapılan çalışmada ısı pompası sistemi 100°C kondenser sıcaklığında doğalgaz kullanılan kombi sistemiyle aynı maliyettedir. Daha yüksek sıcaklıklarda kombi daha avantajlıdır, daha düşük sıcaklıklarda ise ısı pompası sistemi avantajlı olduğu belirtilmiştir.

Kuş ve Çomaklı (2015) çalışmada, farklı ısı pompası sistemleri için Net Bugünkü Değer ve Geri Ödeme Süresi Metodunu kullanılarak ekonomik analiz yapmıştırlar. Isıtma tesir katsayısının buharlaştırıcı kaynak akışkan sıcaklığındaki değişimine bağlı olarak incelenme yapmıştırlar. Havadan suya ısı pompası sisteminde en yüksek yıllık elektrik maliyeti, sudan havaya ısı pompası sisteminde ise en düşük yıllık elektrik maliyeti hesaplamıştırlar.

Coşman (2013), yaptığı çalışmada, fore kazıklara entegre edilen ısı pompası uygulaması ve bu sistemin ekonomik analizini yapmıştır. Isı pompası ve klasik sistem için yıllık enerji maliyetleri hesaplanmıştır. Isı pompası için yıllık toplam maliyet 209.810 €, klasik sistem için ise 320.245,1 € olarak bulunmuştur. Klasik sistem, birim ısıtma enerjisi açısından %35 daha pahalı ve geri ödeme süresi 1,1 yıl olduğunu hesaplamıştır.

Zozan (2009) tarafından yapılan çalışmada, Antalya ili için güneş enerjisi kaynaklı ısı pompası destekli ısıtma sisteminin termodinamik ve termoekonomik analizi yapılmıştır. Isıtma sezonu boyunca ortalama olarak ekserji kaybının kolektörde 1050€, depoda 9344€, akümülasyon tankında 4633€, ısı pompasında 11529€ ve kazanda 2820€ olarak gerçekleştiği belirlenmiştir. Tesisin toplam ortalama ekserji kaybı 20 kW ve bu kaybın senelik maliyeti 293755€ olarak hesaplanmıştır. Yapılan analizde, önerilen sistemin kullanılmasıyla ciddi yakıt tasarrufu sağladığını, ancak artan elektrik tüketimiyle birlikte ilk yatırım maliyetlerinin yüksek olduğunu göstermiştir. Bu nedenle, sistem bugünkü koşullarda uygun bulunmadığı belirtilmiştir.

Serpen ve Palabıyık (2006) tarafından yapılan bu çalışmada, konutların lpg, jeotermal ısı pompası ve güneş enerjisi ile ısıtılmasının ekonomik analizi yapılmıştır. Alternatif sistemlerin ekonomik yönü "ömür boyu maliyet" ve LCC (life cycle costing) yöntemi kullanılarak incelenmiştir. LCC (Sosyal Maliyet ve Klima Dahil) maliyeti sırasıyla doğalgaz için 23.597 $, ısı pompası kullanımı için 30.261 $, LPG yakıt kullanımı için 35.992 $, güneş enerjisi ile 38.341 $ olarak hesaplanmıştır. Çalışmanın sonucunda, kısa dönemde doğal gazla ısıtmanın en ekonomik sistem olduğu belirlenmiştir.

Lu ve ark. (2017), Avustralya, Melbourne'deki bir konut için SEPD programı içindeki farklı tasarıma sahip toprak kaynaklı ısı pompası sistemi ile hava kaynaklı ısı pompası sisteminin

performanslarının karşılaştırmalı analizini yapmıştırlar. Bu analizde, sistemlerinin maliyetleri çeşitli ekonomik göstergeler kullanılarak diğer geleneksel ısıtma/soğutma yöntemleriyle karşılaştırılmıştır. Yapılan analiz sonucunda, tasarım ömrü 40 yıl boyunca yıllık 592$'lık eşdeğer bir kazanç sağlayan toprak kaynaklı ısı pompası sistemi kurmanın daha avantajlı olduğu ortaya konmuştur.

Rad ve ark. (2013), Kanada, Toronto Milton Şehri'nde gerçek bir evde güneş enerjisi kollektörlerini kullanarak hibrit toprak kaynaklı ısı pompası sistemlerinin uygulanabilirliğini incelemiştirler. Genel sistem ekonomik uygulanabilirliği, 20 yıllık bir yaşam döngüsü maliyet analiziyle değerlendirilmiştir. Yapılan analizde, geleneksel toprak kaynaklı ısı pompası sistemine kıyasla düşük bir ekonomik fayda olduğu gösterilmiştir. 20 yıllık yaşam döngüsü maliyet analizine dayalı olarak önerilen hibrit sistemin net bugünkü değerinin, geleneksel toprak kaynaklı ısı pompası sistemlerine göre %3,7-%7,6 (veya 1500 ila 3430 Kanada doları) arasında daha düşük olduğu tahmin edilmiştir. Bu farkın güneş destekli sistemin daha az sondaj ve boru maliyetinden kaynaklandığı belirtilmiştir.

Blum ve ark. (2011), Almanya'daki dikey toprak kaynaklı ısı pompası sistemlerinin tekno-ekonomik, mekânsal analizini ve iklim koşulları ile mekânsal korelasyonu, güney Almanya'da yürütülen bir sübvansiyon programı kullanılarak değerlendirilerek yapmıştırlar. Önerilen sistem için ortalama toprak kaynaklı ısı pompası sisteminin, ısıtma talebi 11 ± 3 kW ve ısıtma alanı yaklaşık 190 ± 57 m2 olan bir evde kurulmuştur. Sistem genellikle sıcak su ve ısınma amaçlı kullanılmaktadır. İki sondaj kuyusuna ısı eşanjörü kurulumu yapılmıştır ve bunlar ayrı ayrı 95 ± 34 m derinliğe ve toplamda 180 ± 90 m uzunluğa sahip çift U-borulardan oluşmaktadır. Çalışma sonucunda, Almanya'da toprak kaynaklı ısı pompası sisteminin ortalama maliyeti yaklaşık 23.500 € ± 6.800 € olarak hesaplanmıştır. Bu maliyetin %51'i toprak ısı değiştiricisini yerleştirmek için yapılan sondaj işlemleri için, geriye kalan %49'un ise ısı pompası cihazı için olduğu tespit edilmiştir.

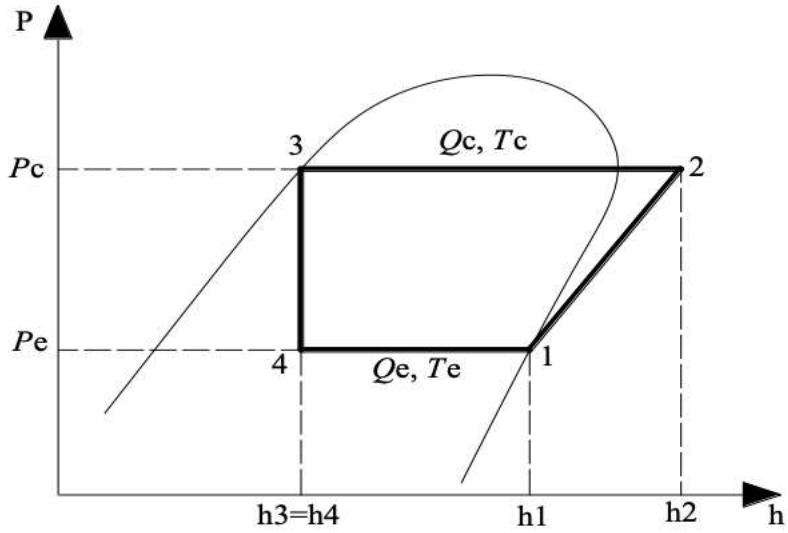
Atılgan ve ark. (2023), yaptıkları çalışmada Konya ilinin rüzgâr hızı verileri incelenmiş, gelecek dönemler için rüzgâr hızı tahminleri yapılmış ve bu tahminler doğrultusunda elektrik üretim miktarlarını hesaplamıştırlar. 3 farklı rüzgâr türbininin ekonomik açıdan değerlendirilip, birim maliyetlerini karşılaştırmıştırlar. Rüzgâr hızı verileri mevsimsel olarak değiştiği için tahmin yönetimi olarak mevsimsel ARIMA modelini kullanmıştırlar. Karbon fiyatlaması dikkate alındığında, rüzgâr türbinlerinin boyutuna bağlı olarak birim maliyetlerde %9,4 ile %16 arasında azalma tespit edilmiştir.

Bu çalışmada üç farklı kaynaklı ısı pompaları için 2000 saat çalışma saatine karşılık, sistemin birim maliyeti hesaplanmış, farklı karbon fiyatı senaryolarına göre ısı pompalarının birim maliyet analizi yapılmıştır. Yapılan analizle karbon fiyatlandırmasının farklı güçlerdeki ısı pompalarının maliyetlerine etkisi incelenmiştir.

II. MATERYAL VE YÖNTEM

A. Isı Pompası Çalışma Prensibi

Düşük sıcaklıktaki bir ortamdan yüksek sıcaklıktaki başka bir ortama ısıl enerji aktaran makinelere soğutma makinesi denir. Isıtma ya da soğutma yapmak amacıyla, ısının bir yerden başka bir yere transfer edilmesini sağlayan makinelere ise ısı pompası denir. Soğutma makineleri ve ısı pompaları aynı çevrimi gerçekleştirirler. En yaygın kullanılan sistemlerden biri buhar sıkıştırmalı soğutma (BSS) çevrimleridir. Bu çevrimlerde, bir miktar soğutucu akışkan sırasıyla yoğuşturulup buharlaştırılır. Şekil 1'de buhar sıkıştırmalı sistemin p-h diyagramı görülmektedir.



Şekil 1. Buhar Sıkıştırmalı Sistemin P-H Diyagramı

Şekil 1'de görüldüğü gibi çevrim sırasındaki yoğuşma ile buharlaşma işlemleri sırasındaki basınçlara sırasıyla yoğuşma basıncı (P_c), buharlaşma basıncı (P_e), sıcaklıklara ise yoğuşma sıcaklığı (T_c), buharlaşma sıcaklığı (T_e) denir. BSS çevriminde sürekli akışın olduğu elemanlar mevcuttur. Bir girişli ve bir çıkışlı sürekli akışlı açık sistem için enerjinin korunumu (birim kütle için TD 1. yasası) Denklem 1 ile ifade edilir.

$$q - W = \Delta h + \Delta E_k + \Delta E_p \quad (1)$$

Burada q ve w sırasıyla birim kütle için ısı geçişi ve işi; ΔE_p ve ΔE_k ise sırasıyla potansiyel ve kinetik enerjileri ifade etmektedirler. BSS'de dolaşan soğutucu akışkanın potansiyel ve kinetik enerji değişimleri, iş ve ısı geçişi değerlerine göre çok düşük olduğundan ihmal edilebilir. Bu durumda, sürekli akışlı açık sistemin birim kütle için enerjinin korunumu Denklem 2 ile ifade edilir.

$$q - W = h_{out} - h_{in} \quad (2)$$

Şekil 1'den de anlaşıldığı üzere, kompresörde adyabatik olarak (q=0) dışarıdan iş alınmaktadır. Bu durum için Denklem 2 yeniden düzenlenerek kompresörün çektiği enerji,

$$W_k = \dot{m}(h_2 - h_1) \quad (3)$$

W_k, Denklem 3 ile hesaplanabilmektedir. Bu denklemde, sistemde dolaşan soğutucu akışkan debisini ($\dot{m}$), akışkanın kompresör giriş entalpi değeri (h_1) ve çıkış entalpi (h_2) değeridir.

Yoğuşturucu ve buharlaştırıcıda iş etkileşimi yoktur ($W = 0$). Bu durumda yoğuşturucudan dış ortama atılan enerji Q_c ve buharlaştırıcıda çekilen enerji miktarı, Q_e, Denklem 4 ve Denklem 5 ile hesaplanabilir.

$$Q_c = \dot{m}(h_2 - h_3) \quad (4)$$

$$Q_e = \dot{m}(h_1 - h_4) \quad (5)$$

Denklem 4'te yoğuşturucu çıkışındaki akışkanın entalpisi (h_3) ve buharlaştırıcı girişindeki akışkanın entalpisi (h_4)ile gösterilmiştir.

BSS'nin soğutma performans katsayısı, COP, buharlaştırıcıda çekilen enerjinin kompresörde harcanan enerjiye oranıdır ve Denklem 6 ile gösterilmiştir.

$$COP = \frac{Q_e}{W_{cp}} \quad (6)$$

Isı pompası ünitesinin ısıtma performans katsayısı COP_{hp} Denklem 7 ile sistemin ısıtma performans katsayısı COP_{sys} Denklem 8 ile hesaplanır.

$$COP_{Ip} = \frac{Q_e}{W_{cp}} \quad (7)$$

$$COP_{SIS} = \frac{Q_e}{W_k + W_{p1} + W_{p2}} \quad (8)$$

Denklem 8'de, kompresörün şebekeden çektiği güç (W_k), dolaşım pompasının şebekeden çektiği güç (W_{p1}) sisteme bağlanan güç analizörü ile ölçülmüştür.

Yoğuşturucudan havaya transfer olan ısı miktarı (Q_c), Denklem 9 ile hesaplanır.

$$Q_c = \dot{m} c_p (T_{out} - T_{in}) \quad (9)$$

Denklem 9'da havanın debisini ($\dot{m}$) (kg/s), havanın özgül ısısını (c_p) (kj/kgC), havanın buharlaştırıcıdan çıkış sıcaklığını (T_{out}) (C), havanın buharlaştırıcıya giriş sıcaklığını (T_{in}) (C) ile gösterilmektedir.

Toprak ısı değiştiricisi içerisinde dolaştırılan su-antifriz karışımı tarafından topraktan çekilen ısı miktarı (QTID) Denklem 10 ile hesaplanmaktadır.

$$Q_{GHE} = \dot{m}_{mix} c_{p,mix} (T_{mix,out} - T_{mix,in}) \quad (10)$$

B. Karbon Fiyatlandırması Hesaplaması

Mühendislik projeleri ve yatırımlarının ekonomik analizinde en sık kullanılan yöntem, net bugünkü değer (NBD) metodudur. Bu metot, gelecekteki tüm nakit akışlarını şimdiki değere indirgeyerek alternatif yatırımları karşılaştırır ve en ekonomik olanı seçmeyi sağlar. Eğer alternatifler arasında maliyet karşılaştırması yapılıyorsa, toplam masrafların şimdiki değerinin en düşük olduğu seçenek tercih edilir. Net bugünkü değer yöntemiyle, yatırım yapılacak projenin nakit akışları, paranın zaman değeri dikkate alınarak değerlenir. Bu değerleme işleminde, işletmenin yatırımdan beklediği getiri oranı göz önünde bulundurulur. Yapılan yatırım harcamaları nakit çıkışı gerektirdiği için negatif, kazançlar ise pozitif alınır. Sonuç olarak, net bugünkü değer negatifse yatırım projesi gerçekleştirilmez; ancak pozitif bir sonuç, yatırımın yapılabilir olduğunu gösterir. Isı pompalarında birim yatırım maliyeti formülü kullanılarak net bugünkü değer metoduna göre hesaplanır.

Birim maliyet, net bugünkü değerin toplam üretim miktarına oranı ile hesaplanır, denklem 11'de gösterilmiştir.

Birim Maliyet = Net Bugünkü Değer /Toplam Üretim (11)

Net bugünkü değer hesaplanırken, İlk yatırım maliyeti ile, elektrik tüketim maliyetinin toplamıdır.

$$NBD = I_0 + \sum_{t=0}^{T} \frac{C_t}{(1+r)^t} \quad (12)$$

Denklem 12'de I_0, ilk yatırım maliyetini, C_t, Elektrik maliyetini, r, faiz oranını, T, cihazın yaşam ömrünü temsil etmektedir. Hesaplamalar yapılırken cihazın yaşam ömrü 30 yıl olarak kabul edilmiştir. Elektriğin birim fiyatı 0,058 Euro/kWh olarak alınmıştır.

$$C_t = \frac{2}{35} \frac{E}{COP} \quad (13)$$

Tablo 1'de farklı tip kaynağa sahip ısı pompaları için ilk yatırım maliyeti, verim değerleri (COP) ve CO_2 salınım miktarları verilmiştir.

Tablo 1. Isı Pompaları Verileri

Kaynak Tipi	Güç				
	5 kW	**8 kW**	**10 kW**	**12kW**	**16kW**
Hava Kaynaklı Isı Pompası					
Fiyat (Euro)	1700	2500	2700	3600	3900
COP (Verim)	5	4,65	4,69	4,78	4,85
CO_2 ton/MWh	3,13	5,32	5,77	6,06	8,35
Toprak ve Su Kaynaklı Isı Pompaları					
COP (Verim)	4,47	4,67	4,6	4,57	4,4
CO_2 MWh	2,66	3,19	3,73	3,55	3,55
Fiyat (Euro)	8200	8400	8900	9100	9500

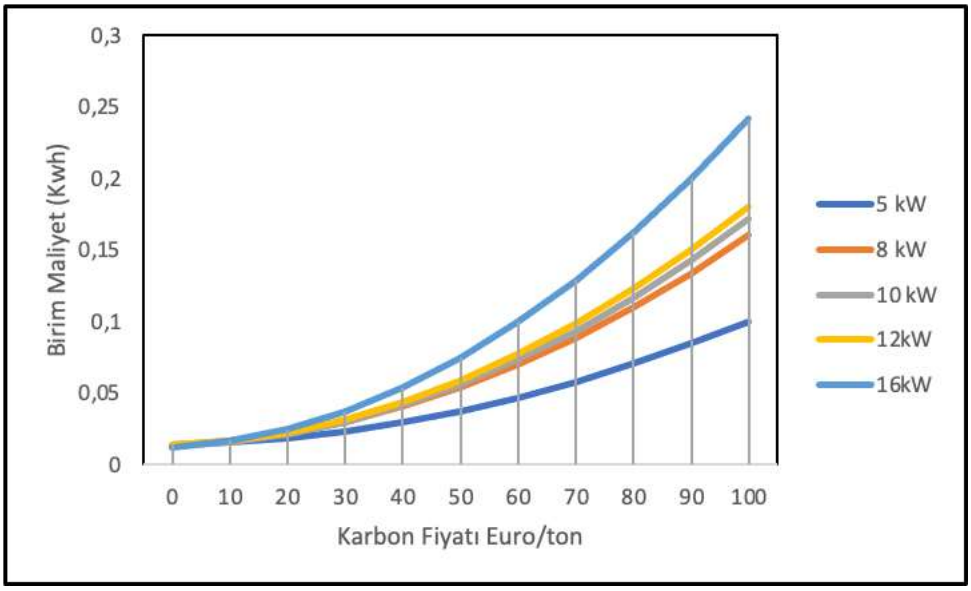
III. BULGULAR

Seçilen ısı pompalarının yılda 2000 saat çalıştığı varsayılarak birim maliyetleri hesaplanmıştır. Ayrıca farklı karbon fiyat senaryoları altında birim maliyetlerdeki değişim incelenmiştir. Tablo 2'de farklı karbon fiyatlarının farklı güçlerdeki ısı pompalarının maliyet değişimi verilmiştir.

Tablo 2. Karbon Fiyatlandırmasının birim maliyete etkisi

Karbon	5 kW	8 kW	10 kW	12kW	16kW
0	0,014	0,014	0,0125	0,0135	0,012
10	0,015565	0,01666	0,015385	0,01653	0,016175
20	0,018695	0,02198	0,021155	0,02259	0,024525
30	0,02339	0,02996	0,02981	0,03168	0,03705
40	0,02965	0,0406	0,04135	0,0438	0,05375
50	0,037475	0,0539	0,055775	0,05895	0,074625
60	0,046865	0,06986	0,073085	0,07713	0,099675
70	0,05782	0,08848	0,09328	0,09834	0,1289
80	0,07034	0,10976	0,11636	0,12258	0,1623
90	0,084425	0,1337	0,142325	0,14985	0,199875
100	0,100075	0,1603	0,171175	0,18015	0,241625

Karbon fiyatlandırmasının birim maliyetteki değişimi Şekil 2'de verilmiştir. Herhangi bir karbon fiyatlaması uygulanmadığında, birim maliyet en düşük 16 kW gücündeki ısı pompasında, en yüksek maliyet ise en düşük güçlerdeki 5 ve 8 kW'lık ısı pompalarında görülmüştür. Karbon fiyatı 10 Euro olduğunda ise en düşük maliyet en düşük güçteki 5 kW'lık ısı pompasında hesaplanmıştır. Karbon fiyatının en yüksek olduğu durumda ise en yüksek maliyet 16 kWlık ısı pompasında, en düşük maliyet ise 5kW'lık ısı pompasında tespit edilmiştir.



Şekil 2. Birim Maliyet-Karbon Fiyatı

Karbon fiyatlanması olmadığı durumda en yüksek kapasiteli olan 16 kW'lık ısı pompalarının birim maliyeti en düşük olduğu görülmüştür. Karbon fiyatlandırması arttıkça daha az enerji harcayıp daha az karbon salınımı yapan düşük kapasiteli 5kW'lık ısı pompasının birim maliyetinin daha düşük olduğu görülmüştür.

III. SONUÇLAR

Sürdürülebilirlik açısından ekonomik, çevresel ve sosyal faktörlerin birlikte değerlendirilmesi gereklidir. Yenilenebilir enerji kaynakları, enerjide dışa bağımlılığın etkileri göz önüne alındığında büyük önem taşımaktadır. Son yıllarda hızla artan yenilenebilir enerji kurulu gücü bu önemi vurgulamaktadır. Ancak, bu yenilenebilir enerji kaynakları mevsimsel koşullara bağlı olduğundan çeşitli kısıtlamalara sahiptir. Dolayısıyla, mevcut sınırlı kaynaklarla, yenilenebilir enerjiye yapılan yatırımlardan en yüksek verim elde edilebilmesi için doğru planlama ve ekonomik analiz gerekmektedir. Bu durum, enerjinin tüm yönlerini detaylı bir şekilde ele alacak şekilde mevcut çalışmaların geliştirilmesini gereklidir.

Bu çalışmada hava, su ve toprak kaynaklı ısı pompaları karbon fiyatlandırması temelli birim maliyet hesaplanmıştır. Karbon fiyatlarının yükselmesiyle birlikte, düşük kapasiteli cihazların birim maliyetlerinde düşüş gözlemlenmiştir, zira bu cihazlar daha az enerji tüketip daha az karbon salınımı yapmaktadır. Yenilenebilir enerji projelerinin çekiciliğinin artması, yatırımcılar ve enerji şirketleri için cazip bir alan sunmanın yanı sıra çevresel etkilerin azaltılması ve sürdürülebilir enerji üretimi hedeflerine ulaşmada önemli bir adımdır.

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Plastik Sanatlarda Maksimalist Yaklaşımlar

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Özet – Maksimalizm, plastik sanatlarda önemli bir estetik akım olarak tanımlanmaktadır. Bu akım, sanat eserlerinde görsel yoğunluk, karmaşıklık ve büyük ölçekli ifadelerle öne çıkmaktadır. Renklerin, desenlerin ve formların yoğun kullanımı, maksimalizmin temel özelliklerinden sayılabilir. Maksimalizmin temelleri, 20. yüzyılın ikinci yarısında ortaya çıkan Pop Art ve Minimalizm gibi akımlarla atılmıştır. Pop Art, tüketim kültürü ve popüler imgelerle bağlantılı olarak sanatı yeniden şekillendirirken, Minimalizm sade ve soyut formlarla sanatı basitleştirmeyi hedeflemiştir. Maksimalizm ise, bu iki akımın karşıtı olarak görsel yoğunluğu ve karmaşıklığı vurgulamaktadır. Maksimalizmin sanat dünyasındaki rolü, sanatçıların ifade biçimlerini ve estetik tercihlerini derinlemesine etkilemiş, sanat dünyasında çeşitliliği ve yeniliği teşvik etmiştir. Sanatçılar, büyük ölçekli eserlerin, canlı renk paletlerinin ve karmaşık desenlerin yoğun kullanımıyla izleyicinin dikkatini çekerler. Aynı zamanda, mekânın fiziksel sınırlarını zorlayarak ve çoklu katmanlar ekleyerek izleyiciye derin bir deneyim sunmayı hedeflemektedir. Maksimalizmin izleyici üzerindeki etkisi, duygusal ve bilişsel tepkilerin yanı sıra etkileşimli veya pasif bir deneyim sağlama şeklinde farklılık gösterebilir. Maksimalist eserler, izleyicide çeşitli duygusal ve düşünsel tepkiler uyandırarak sanatın gücünü vurgularlar. Sanatçıların maksimalizme yaklaşımı ise kişisel deneyimlere ve estetik tercihlere dayanır, toplumsal ve kültürel bağlamla ilişkilidir. Bu çalışmanın amacı, maksimalizm görsel sanatlardaki evrimini ve etkisini irdelemektir. Detaylı bir literatür tarama yöntemi izlenen çalışmada sanat dünyasında çeşitliliğe teşvik eden bu göz alıcı akımın, izleyicide derin duygusal ve bilişsel etkiler bırakışını da vurgusunun ortaya konması hedeflenmiştir., Bu çalışma, maksimalizmin sanatın çeşitli alanlarındaki rolünü daha iyi anlamak ve bu estetik akımın potansiyelini keşfetmek için gelecekte yapılacak araştırmalara önemli bir fırsat sunabilir.

Anahtar Kelimeler – Maksimalizm, Plastik Sanatlar, Estetik Akım, Pop Art, Minimalizm

I. GİRİŞ

Maksimalizm, görsel sanatlar alanında belirgin bir estetik akım olarak tanımlanmaktadır (Geczy & Botz-Bornstein, 2018). Bu akım, sanat eserlerindeki görsel yoğunluk, karmaşıklık ve büyük ölçekli ifadelerle öne çıkar. Maksimalizm, renklerin, desenlerin ve formların yoğun kullanımıyla kendini gösterirken, izleyici üzerinde etkileyici bir izlenim bırakmayı hedefler (Foster, 1996). Maksimalizmin sanat dünyasındaki kökenleri, 20. yüzyılın ikinci yarısında ortaya çıkan Pop Art ve Minimalizm gibi akımlarla yakından ilişkilidir (Livingstone, 1990). Pop Art, tüketim kültürü ve popüler imgelerle bağlantılı olarak sanatı yeniden şekillendirirken, Minimalizm sade ve soyut formlarla sanatı basitleştirmeyi hedefler (Stiles & Selz, 1996). Maksimalizm ise bu iki akımın karşıtı olarak görsel yoğunluğu ve karmaşıklığı vurgular. Bu makalede, maksimalizmin görsel sanatlardaki rolünü inceleyeceğiz. İlk olarak, maksimalizmin sanat tarihindeki evrimine ve kökenlerine odaklanacağız. Pop Art ve Minimalizm gibi önemli akımların etkisi altında nasıl şekillendiğini ve sanat dünyasındaki yerini nasıl kazandığını irdeleyeceğiz (Tarantino, 2017). Ardından, maksimalizmin görsel sanatlardaki tekniklerini ve kullanımını detaylı bir şekilde ele alacağız. Maksimalizmin görsel sanatlardaki etkisini

anlamak için, öncelikle büyük ölçekli eserlerin, canlı renk paletlerinin ve karmaşık desenlerin nasıl kullanıldığını inceleyeceğiz (Mavridorakis, 2019). Ayrıca, maksimalist sanatçıların mekanın fiziksel sınırlarını zorlayarak ve çoklu katmanlar ekleyerek nasıl bir derinlik ve karmaşıklık oluşturduklarını göreceğiz. Son olarak, maksimalizmin izleyici üzerindeki etkisini ve çağdaş sanat dünyasındaki yeri üzerine düşüneceğiz. Maksimalist eserlerin izleyicide nasıl duygusal ve bilişsel tepkiler uyandırdığını, etkileşimli veya pasif bir deneyim sunarak nasıl farklı bir etkileşim sağladığını inceleyeceğiz (Rupin, 2013). Ayrıca, sanatçıların maksimalizme yaklaşımını ve bu estetik anlayışın gelecekteki araştırmalar için potansiyel etkilerini de tartışacağız. Bu makale, maksimalizmin görsel sanatlardaki evrimini ve etkisini anlamak için bir temel sağlamayı amaçlamaktadır. Maksimalizmin, sanatın çeşitli alanlarında nasıl bir rol oynadığını ve gelecekteki araştırmalar için hangi potansiyelleri taşıdığını anlamak, sanat dünyasındaki tartışmalara yeni bir bakış açısı getirebilir (Geczy & Botz-Bornstein, 2018).

2. MAKSİMALİZM VE SANATIN İLİŞKİSİ

Maksimalizm, sanatın çeşitli alanlarında kökenlerine kadar uzanan bir estetik anlayışıdır (Geczy & Botz-Bornstein, 2018). Maksimalizmin sanat eserlerindeki varlığı, genellikle büyük ölçekli eserlerde, canlı renklerin ve karmaşık desenlerin yoğun kullanımıyla kendini gösterir (Foster, 1996) (Görsel-1). Özellikle, 20. yüzyılın ikinci yarısında popülerlik kazanan maksimalizm, sanatçıların ifade biçimlerini ve estetik tercihlerini derinlemesine etkilemiştir (Rubin, 2013).

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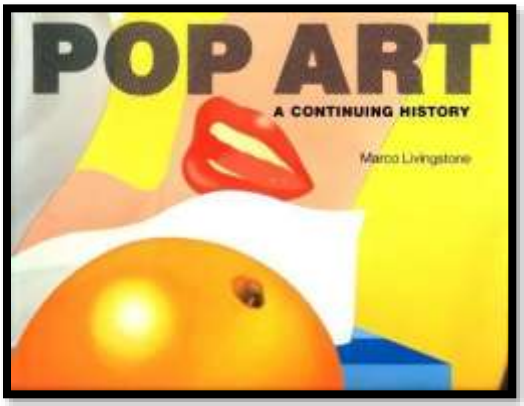
Maksimalizmin sanat dünyasındaki kökenlerine bakıldığında, 1960'ların Pop Art ve Minimalizm akımlarının etkisi açıkça görülür (Livingstone, 1990) (Görsel-2). Pop Art'ın tüketim kültürüne ve popüler imgelere dayalı olarak sanatı yeniden şekillendirmesi, maksimalist sanatın temelini atmıştır. Minimalizm'in sade ve soyut formlarıyla karşıtlık oluşturan maksimalizm, sanatın görsel yoğunluğunu ve karmaşıklığını vurgulamıştır (Stiles & Selz, 1996).



Görsel 2. Livingstone, M. Pop Art: A Continuing History (1990). https://m.media-amazon.com/images/I/51wvVVhX5IL.jpg

Bu bölümde, maksimalizmin sanat tarihindeki evrimi üzerine odaklanacağız. Özellikle, maksimalist sanat eserlerinin analizi ve yorumuyla bu estetik anlayışın sanat dünyasındaki yeri daha iyi anlaşılacaktır (Tarantino, 2017). Ayrıca, çağdaş tartışmaların ışığında maksimalizmin günümüz sanat pratiği üzerindeki etkileri ele alınacaktır (Mavridorakis, 2019).

3. GÖRSEL SANATLARDAKİ MAKSİMALİST TEKNİKLER

Renklerin, desenlerin ve formların maksimalist kullanımı sanat eserlerinde belirgin bir özelliktir (Geczy & Botz-Bornstein, 2018) (Görsel-3).

Görsel 3. Geczy, A., & Botz-Bornstein, T. (Eds.). Maksimalist Art (2018).
https://img.artam.com/storage/images/articles/1951/115705/warhol-basquiat-is-birliginin-zirvesi.jpg

Maksimalist sanatçılar, genellikle canlı ve çarpıcı renk paletleriyle çalışarak izleyicinin dikkatini çekmeyi amaçlarlar (Rubin, 2013) (Görsel-4). Aynı zamanda, karmaşık desenlerin ve detayların yoğun kullanımıyla maksimalist eserler, görsel zenginliği ve estetik çeşitliliği vurgularlar (Foster, 1996).

Görsel 4. Rubin, J. H. Psychedelic: Optical and Visionary Art since the 1960s. (2013).
https://glasstire.com/wp-content/uploads/2012/02/psychedelic.jpg?x88956

Büyük ölçekli eserlerin ve mekanın işgali de maksimalist sanatın önemli bir özelliğidir (Livingstone, 1990). Maksimalist sanatçılar genellikle büyük duvar resimleri, enstalasyonlar ve heykeller gibi hacimli eserler üreterek mekanın fiziksel sınırlarını zorlarlar (Tarantino, 2017). Bu şekilde, maksimalist eserlerin izleyici ile etkileşimi artar ve sanatın fiziksel varlığını güçlendirirler.

Çoklu katmanlar ve karmaşık kompozisyonlar da maksimalizmin görsel sanatlardaki etkileri arasındadır (Stiles & Selz, 1996). Maksimalist eserler genellikle birden fazla katmanı içerir ve izleyiciye derinlikli bir

deneyim sunarlar (Mavridorakis, 2019). Bu katmanlar, eserin anlamını zenginleştirir ve izleyicinin eseri farklı açılardan keşfetmesine olanak tanır.

4. MAKSİMALİZMİN İZLEYİCİ ÜZERİNDEKİ ETKİSİ

Maksimalist sanat eserleri, izleyicide çeşitli duygusal ve bilişsel tepkiler uyandırabilir (Rubin, 2013). Büyük ölçekli ve görsel olarak etkileyici eserler, izleyicinin duygusal bir deneyim yaşamasına yol açabilir ve onları şaşırtabilir (Geczy & Botz-Bornstein, 2018). Ayrıca, karmaşık kompozisyonlar ve detaylar izleyicinin düşünme ve anlamlandırma sürecini teşvik edebilir (Foster, 1996).

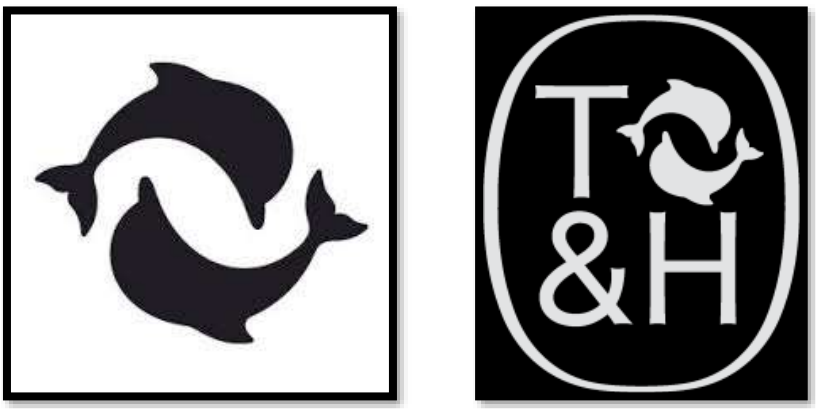
İzleyicinin maksimalist eserlerle etkileşimi, eserin etkileşimli veya pasif bir deneyim olmasına bağlı olarak değişebilir (Tarantino, 2017). Bazı eserler, izleyicinin fiziksel olarak etrafında dolaşmasını veya belirli bir açıdan bakmasını gerektirirken, diğerleri sadece görsel bir deneyim sunarlar (Livingstone, 1990). Bu şekilde, maksimalist eserlerin izleyici üzerindeki etkisi, eserin tasarımına ve sunumuna bağlı olarak değişir.

5. SANATÇILARIN MAKSİMALİZME YAKLAŞIMI

Maksimalist sanatçılar, çalışma süreçlerinde ve yaratıcı kararlarında genellikle özgürlükçü bir yaklaşım benimserler (Mavridorakis, 2019) (Görsel-5). Bu sanatçılar, geleneksel sınırları zorlayarak ve kuralları ihlal ederek kendilerini ifade etme özgürlüğü ararlar (Rubin, 2013). Maksimalizmin, sanatçıların ifade biçimleri ve estetik tercihleri üzerinde bu özgürlükçü etkisi, sanat dünyasında çeşitliliği ve yeniliği teşvik eder.

Görsel 5.Mavridorakis, V. Maximalism and the 21st Century Aesthetics (2019).
https://syspree.com/wp-content/uploads/2024/03/Maximalism-in-Graphic-Design-%E2%80%93-The-Art-of-Maximalism-in-Graphic-Design.jpg

Sanatçıların maksimalist estetik anlayışları, genellikle kişisel deneyimlerine ve estetik tercihlerine dayanır (Stiles & Selz, 1996). Bazı sanatçılar, karmaşık ve detaylı eserler üreterek izleyicide derin düşünceler uyandırmayı amaçlarken, diğerleri daha minimalist bir yaklaşım benimseyerek basit ve soyut formlarla çalışmayı tercih ederler (Geczy & Botz-Bornstein, 2018) (Görsel-6-7). Bu farklı yaklaşımlar, sanat dünyasında çeşitliliği ve çok yönlülüğü teşvik eder.



Görsel 6. Geczy & Botz-Bornstein, 2018

https://res.cloudinary.com/zoominfo-com/image/upload/w_140,h_140,c_fit/thamesandhudson.com
Görsel 7. Geczy & Botz-Bornstein, 2018
https://thamesandhudson.com.au/wp-content/uploads/THA-cartouche-grey.png

Sanatçıların maksimalist estetik anlayışlarına eleştirel bir bakış, sanatın sosyal ve kültürel bağlamıyla da ilişkilidir (Tarantino, 2017). Maksimalist eserler, genellikle toplumsal normlara ve kültürel değerlere meydan okuyarak ve onları sorgulayarak izleyiciyi düşünmeye teşvik ederler (Livingstone, 1990). Bu şekilde, maksimalizm sanatın toplumsal ve politik boyutlarını vurgulayarak toplumsal değişime katkıda bulunabilir.

SONUÇ VE TARTIŞMA

Bu makale, maksimalizmin görsel sanatlardaki önemini ve etkisini incelemiş ve tartışmıştır. Maksimalizmin kökenleri, teknikleri ve izleyici üzerindeki etkileri üzerine yapılan analizler, bu estetik akımın sanat dünyasındaki belirgin rolünü ortaya koymaktadır.

Maksimalizmin sanat tarihindeki kökenleri, Pop Art ve Minimalizm gibi öncü akımların etkisi altında şekillenmiştir. Bu akımların karşıtlığı, maksimalizmin görsel yoğunluğunu ve karmaşıklığını vurgulamıştır. Maksimalizm, sanatçıların ifade biçimlerini ve estetik tercihlerini derinlemesine etkilemiş, sanat dünyasında çeşitliliği ve yeniliği teşvik etmiştir.

Görsel sanatlardaki maksimalist teknikler, büyük ölçekli eserlerin, canlı renk paletlerinin ve karmaşık desenlerin yoğun kullanımıyla kendini gösterir. Sanatçılar, mekânın fiziksel sınırlarını zorlayarak ve çoklu katmanlar ekleyerek izleyicinin derin bir deneyim yaşamasını sağlarlar.

Maksimalizmin izleyici üzerindeki etkisi, duygusal ve bilişsel tepkilerin yanı sıra etkileşimli veya pasif bir deneyim sağlama şeklinde farklılık gösterebilir. Maksimalist eserler, izleyicide çeşitli duygusal ve düşünsel tepkiler uyandırarak sanatın gücünü vurgularlar. Sanatçıların maksimalizme yaklaşımı ise kişisel deneyimlere ve estetik tercihlere dayanır, toplumsal ve kültürel bağlamla ilişkilidir.

Sonuç olarak, maksimalizm plastik sanatlardaki evrimini ve etkisini anlamak için önemli bir kavram olup olmadığı tartışmalı bir konudur. Görsel sanatlarda etkisinin olmadığı düşünülmektedir. Bu makale, maksimalizmin sanat dünyasındaki rolünü anlamak ve gelecekteki araştırmalar için bir temel sağlamak amacıyla yazılmıştır. Maksimalizmin, sanatın çeşitli alanlarında nasıl bir rol oynadığını ve gelecekteki araştırmalar için hangi potansiyelleri taşıdığını anlamak, sanat dünyasındaki tartışmalara yeni bir bakış açısı getirmiştir.

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Analyzing Market Basket Data Using the Apriori Algorithm

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Abstract – This study addresses the fundamental concepts of Market Basket Analysis and Association Rules, which are utilized to analyze customer habits and develop sales strategies in the retail sector. Market Basket Analysis is a significant tool for understanding customer behavior based on shopping data. In this context, the theoretical structure and implementation process of the Apriori Algorithm were applied to receipts collected from markets in the Yahşihan district of Kırıkkale province before the New Year. In this study, the associations between purchased products were identified, and future policies to be implemented were determined. Consequently, it played a role in shaping marketing decisions to enable sellers to achieve better sales.

Keywords – Apriori Algorithm, Market Basket Analysis, Association Rules, Machine Learning, Artificial Intelligence

I. INTRODUCTION

Market Basket Analysis, data mining, and retail sales are among the application areas of this method. It helps determine which products customers are likely to purchase together. The core principle is to work on large datasets to provide in-depth insights into customer behavior. For instance, identifying that a customer is highly likely to buy granola when purchasing fruit and yogurt illustrates the fundamental principle of these rules. This analysis is conducted using "association rules." Market Basket Analysis enables more accurate recommendations for customers in markets and e-commerce sites, thereby increasing sales volume. In the banking sector, fraud can be detected using this rule. In the healthcare sector, it analyzes which medications patients use together and helps anticipate and prevent potential side effects. In the tourism sector, it can analyze the types of hotels or destinations users book together on travel platforms. In telecommunications, customers have different preferences for packages based on the services they bundle during subscription [1-3].

One of the most important algorithms in Market Basket Analysis is the Apriori algorithm. This algorithm identifies frequently encountered item sets in the dataset and reveals the relationships among these sets. Association Rules are one of the data mining techniques that analyze the co-occurrence of events. Data mining is the process of extracting significant information from large-scale datasets, often used to predict future events. Through association rules, past data can be analyzed to conduct future-oriented studies. The aim of this method is to identify the relationships between products that customers purchase together during shopping. This way, customer purchasing habits are better understood. Sellers can develop more profitable and effective marketing strategies based on these habits and data [4-6].

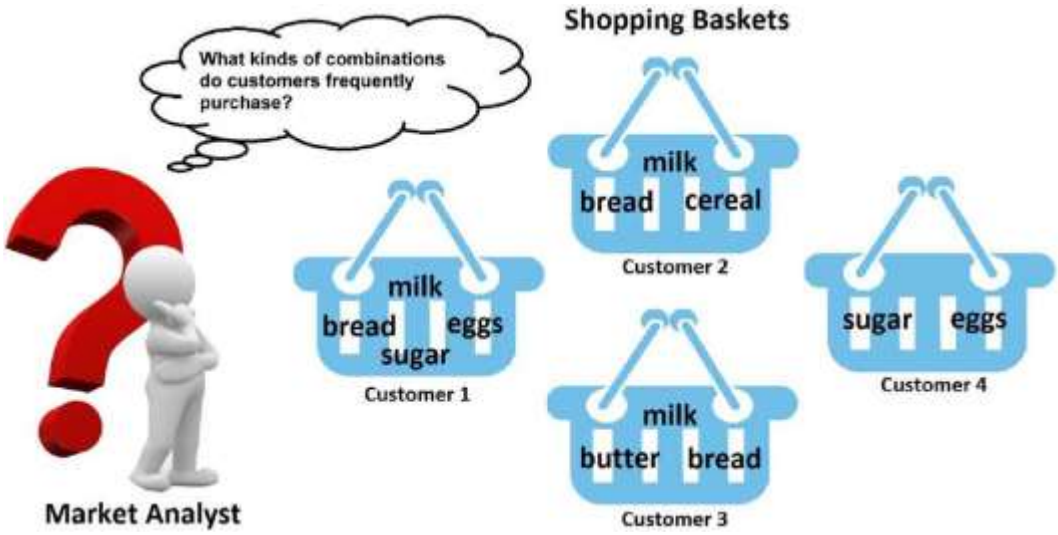

Fig. 1 Co-purchase Rates of Different Products [7]

A. Parameters of Association Rules

In association rules, six key parameters are commonly used to analyze the frequency of items occurring together in a dataset.

Support

The support value of association rules indicates how frequently a particular item set appears in the entire dataset. It is calculated using the following formula [8-9].

$$\text{Support}(X \rightarrow Y) = \text{Support}(\text{X} \cup \text{Y}) = \text{P}(\text{X} \cup \text{Y})$$

Confidence

The confidence value of association rules represents the probability that a particular item set occurs together with another item set. It is calculated using the following formula [8-9].

$$\text{Confidence}(X \rightarrow Y) = P(Y|X) = \frac{\text{Support}(\text{X} \cup \text{Y})}{\text{Support}(\text{X})}$$

Lift

The lift value of association rules is calculated by comparing the probability of X and Y occurring together with the probability of X and Y occurring independently. It is calculated using the following formula [8-9].

$$\text{Lift}\ (X \rightarrow Y) = \frac{\text{Confidence}}{\text{Expected confidence}} = \frac{\text{Confidence}\ (X \rightarrow Y)}{\text{Support}\ (Y)}$$

Conviction

The conviction value of association rules measures how strong the association rule is and how often the rule is incorrect. A high conviction value indicates a low probability of the rule being wrong, while a low conviction value indicates a high probability of the rule being wrong. It is calculated using the following formula [8-9].

$$\text{Conviction}\ (X \rightarrow Y) = \frac{1 - \text{Support}\ (\text{Y})}{1\text{-Confidence}\ (X \rightarrow Y)} = \frac{\text{P}\ (X) * P(\hat{Y})}{\text{P}\ (X \cup \hat{Y})}$$

Leverage

The leverage value of association rules is used to determine the relationship between the association rules. This value indicates the frequency of items occurring together, independently of each other. A high leverage value suggests that two items are more likely to occur together than expected. It is calculated using the following formula [8-9].

$$\text{Leverage}\ (X \rightarrow Y) = \text{Support(X,Y)-(Support(X)*Support(B))}$$

Coverage

The coverage value of association rules shows how frequently the association rules are found in the dataset. A high coverage value indicates that the rule appears in many transactions, whereas a low coverage value indicates that the rule is more specific. It is calculated using the following formula [8-9].

$$\text{Coverage}\ (X \rightarrow Y) = \text{Support(X)}$$

II. MATERIALS AND METHOD

A. *Material*

In the application conducted, a dataset comprising purchase records of 109 different products bought by a total of 500 different customers at various times was prepared. The dataset was collected from four different markets, including [A101], [Migros], [Şok], and [Bim]. A sample products of the receipt is given in Table 1.

Table 1. A sample products of the receipt

Chocolate, Chocolate, Chocolate, Plastic Bag
Chips, Nescafe, Chocolate
Chips, Pad, Plastic Bag, Juice
Banana, Cracker, Tea, Tea, Sugar
Nut, Bread, Bread
Gum, Cake
Beer, Cigarette, Plastic Bag
Juice, Chocolate, Cake, Cigarette, Plastic Bag
Chocolate, Chocolate, Chocolate, Beer, Cigarette, Cigarette, Plastic Bag
Chocolate, Chocolate, Nescafe, Plastic Bag
Chips, Oil, Tuna Fish, Plastic Bag, Redbull, Redbull, Redbull, Redbull, Redbull, Whisky
Toilet Paper, Cola, Toothpaste, Tuna Fish, Tuna Fish
Chips, Chips, Nut, Plastic Bag, Redbull, Redbull, Whisky, Cigarette, Cigarette, Cigarette, Cigarette, Cigarette
Banana, Milk, Pickle
Soda, Cola, Plastic Bag
Cake, Chocolate, Cheese
Nescafe, Nescafe, Nescafe, Nescafe, Nescafe, Nescafe, Chocolate, Chocolate

In Table 1, a portion of the dataset recorded in Excel is shown. Based on the products purchased in this manner, 109 products found in 500 receipts were individually transferred to Excel. Each product in the data presented in Table 1 is important because a policy will be applied based on the association sales of these products, and the association rules among the products will be inferred. This inference will allow the creation of combinations with different products, predicting future purchases.

B. *Method*

Apriori Algorithm

The Apriori Algorithm was developed by Agrawal and Srikant and is named for its use of prior knowledge of frequent itemsets. As one of the most widely used algorithms in the first stage of association rule mining, the Apriori Algorithm is preferred for mining frequent items. It analyzes the relationships between data using Boolean rules. This algorithm is used to create association rules and is particularly useful in market basket analysis. Specifically, it helps understand consumer purchasing routines and analyze shopping baskets based on these routines. The Apriori Algorithm is used to determine which products consumers

have previously purchased together, aiding in the arrangement of store shelves and improving product placement. As a result, this algorithm plays a role in the decision-making procedures of businesses and helps increase customer satisfaction.

The Apriori Algorithm has various advantages, including its simplicity and efficiency, higher performance in large datasets, and the ease of discovering frequency-based patterns in the dataset. However, it also has some disadvantages, such as potentially high computational costs in large datasets, especially in high-dimensional datasets, the rapid increase in the number of association rules depending on the size and complexity of the dataset, and its weakness in detecting rare patterns with low support values [10-12].

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III. RESULTS

The created dataset is organized in a Boolean formatted table. This Boolean table shows the presence or absence of all products in our dataset. The presence of a product is indicated by 1, while its absence is indicated by 0. The Figure 2 is shown as follows:

		Orange	Apple	Ayran	Bagel	Banana	Beer	Book	Bread	Bread	...	Toothpaste	Toy	Tuna Fish	Wafer	Water	Water	Wet Wipe	Whisky	Yogurt	Çiğköfte
0	False	False	False	False	False	False	False	False	False	False	...	False	False	False	False	False	False	False	False	False	False
1	False	False	False	False	False	False	False	False	False	False	...	False	False	False	False	False	False	False	False	False	False
2	False	False	False	False	False	True	False	False	False	False	...	False	False	False	False	False	False	False	False	False	False
3	False	False	False	False	False	False	False	False	True	False	...	False	False	False	False	False	False	False	False	False	False
4	False	False	False	False	False	False	False	False	False	False	...	False	False	False	False	False	False	False	False	False	False
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
495	False	False	False	False	False	False	False	False	False	False	...	False	False	False	False	True	False	False	False	False	False
496	False	False	False	False	False	False	False	False	False	False	...	False	True	False	False	False	False	False	False	False	False
497	False	False	False	False	False	False	True	False	False	False	...	False	False	False	False	False	False	False	False	False	False
498	False	False	False	False	False	False	False	False	False	False	...	False	False	False	False	False	False	False	False	False	False
499	False	False	False	False	False	True	False	False	False	False	...	False	False	False	True	True	False	False	False	False	False

Fig. 2 Presence or Absence of Products

In Figure 2, cells marked as True represent the presence of a product (1), while cells marked as False represent the absence of a product (0). Before moving on to the implementation phase with the Apriori Algorithm, it is beneficial to understand the frequency (count), support, and minimum support values.

Frequency

The frequency value indicates how many times a specific item appears in a dataset. The frequency of an item shows how often that item is found in the dataset. For example, if there are 10 receipts in the dataset and a total of 5 loaves of bread are found within those receipts, the frequency of bread is 5.

Support

The support value is obtained by dividing the frequency by the total number of entries. For example, in the scenario with 10 receipts, if the frequency of bread is 5 and the total number of entries is 10, the support value of bread would be 5/10 [11].

Minimum Support

This parameter determines the lowest support threshold that will be used to create association rules. The minimum support value is generally set based on the size and complexity of the dataset. For example, in the case of 10 receipts, since the data count is small, the minimum support value might be set to 0.1, i.e., 10% [11].

Step 1

As the first step of the Apriori Algorithm, the support values for each product in the dataset are calculated. The support results for each product are given in Figure 3.

```
Plastic Bag    0.358
Chocolate      0.274
Cigarette      0.194
Bread          0.170
Water          0.160
               ...
Grape          0.002
Fruit Juice    0.002
Flower         0.002
Book           0.002
Muffin         0.002
```

Fig. 3 Support values of products

In Figure 4, the lowest and highest support values of the products are shown.

```
Water  has the lowest support of 0.002
Plastic Bag has the highest support of 0.358
```

Fig. 4 Products with the Highest and Lowest Support Values

As the next step, products with support values below the minimum support threshold will not be included in the new table.

Step 2

After creating the new table, another table was generated to examine the co-occurrence of the remaining products. This new table contains the pairwise combinations of the products listed above. A portion of this table is shown in Figure 5.

Fig. 5 Pairwise Combinations of the Products

Figure 6 shows the True (Present) and False (Absent) states of the formed pairwise combinations.

	Orange	Apple	Ayran	Bagel	Banana	Beer	Book	Bread	Bread	...	Toothpaste	Toy	Tuna Fish	Wafer	Water	Water	Wet Wipe	Whisky	Yogurt	Çiğköfte
0	False	False	False	False	False	False	False	False	False	False	...	False	False	False	False	False	False	False	False	False	False
1	False	False	False	False	False	False	False	False	False	False	...	False	False	False	False	False	False	False	False	False	False
2	False	False	False	False	False	True	False	False	False	False	...	False	False	False	False	False	False	False	False	False	False
3	False	False	False	False	False	False	False	False	True	False	...	False	False	False	False	False	False	False	False	False	False
4	False	False	False	False	False	False	False	False	False	False	...	False	False	False	False	False	False	False	False	False	False
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
462	False	False	False	False	False	False	False	False	False	False	...	False	False	False	False	True	False	False	False	False	False
463	False	False	False	False	False	False	False	False	False	False	...	False	True	False	False	False	False	False	False	False	False
464	False	False	False	False	False	False	True	False	False	False	...	False	False	False	False	False	False	False	False	False	False
465	False	False	False	False	False	False	False	False	False	False	...	False	False	False	False	False	False	False	False	False	False
466	False	False	False	False	False	True	False	False	False	False	...	False	False	False	True	True	False	False	False	False	False

Fig. 6 Presence or Absence of Products in Formed Pairwise Combinations

Step 3

When the minimum support value is set to 0.004 and the maximum number of products is limited to 5, the support values obtained for the products are given in Figure 7.

	support	itemsets	length
0	0.383298	(Plastic Bag)	1
1	0.282655	(Chocolate)	1
2	0.188437	(Cigarette)	1
3	0.169165	(Cake)	1
4	0.167024	(Water)	1
...	...	...	...
1564	0.004283	(Chocolate, Canned Food, Cola)	3
1565	0.004283	(Chocolate, Canned Food, Cracker)	3
1566	0.004283	(Plastic Bag, Canned Food, Cigarette)	3
1567	0.004283	(Nut, Canned Food, Cola)	3
1568	0.004283	(Plastic Bag, Egg, Oil, Wet Wipe, Coffee)	5

Fig. 7 Support Values of Products After Selecting Minimum Support Value of 0.004

Step 4

In this step, the remaining data in the final table were used to identify association rules over item sets that meet a certain support threshold. In Figure 8, a customer who buys chips has a 25% likelihood of also buying nuts, or a customer who buys cola has a 22% likelihood of buying nuts.

	antecedents	consequents	antecedent support	consequent support	support	confidence	lift	leverage	conviction	zhangs_metric
0	(Nut)	(Chips)	0.074946	0.109208	0.027837	0.371429	3.401120	0.019653	1.417170	0.763177
1	(Chips)	(Nut)	0.109208	0.074946	0.027837	0.254902	3.401120	0.019653	1.241519	0.792530
2	(Nut)	(Cola)	0.074946	0.085653	0.019272	0.257143	3.002143	0.012853	1.230852	0.720936
3	(Cola)	(Nut)	0.085653	0.074946	0.019272	0.225000	3.002143	0.012853	1.193617	0.729378
4	(Plastic Bag, Nut)	(Chips)	0.038544	0.109208	0.019272	0.500000	4.578431	0.015063	1.781585	0.812918
...	...	...	...	...	...	...	...	...	...	...
10005	(Wet Wipe, Coffee)	(Plastic Bag, Egg, Oil)	0.004283	0.004283	0.004283	1.000000	233.500000	0.004264	inf	1.000000
10006	(Egg)	(Plastic Bag, Coffee, Wet Wipe, Oil)	0.019272	0.004283	0.004283	0.222222	51.888889	0.004200	1.280208	1.000000
10007	(Oil)	(Plastic Bag, Egg, Coffee, Wet Wipe)	0.029979	0.004283	0.004283	0.142857	33.357143	0.004154	1.161670	1.000000
10008	(Wet Wipe)	(Plastic Bag, Egg, Coffee, Oil)	0.021413	0.004283	0.004283	0.200000	46.700000	0.004191	1.244647	1.000000
10009	(Coffee)	(Plastic Bag, Egg, Wet Wipe, Oil)	0.068522	0.004283	0.004283	0.062500	14.593750	0.003989	1.062099	1.000000

Fig. 8 Products Purchased Together

In Figure 8, specific values were assigned to the purchase associations, and results were obtained based on these values. In summary, the values in the table above were filtered. The filtering criteria included support values greater than 0.017, confidence values greater than 0.07, conviction values greater than 1, and both antecedent and consequent support values greater than 0.005. The results were then sorted by the lift parameter in descending order. The resulting table is given in Figure 9.

	antecedents	consequents	antecedent support	consequent support	support	confidence	lift	leverage	conviction	zhangs_metric
0	(Plastic Bag, Nut)	(Chips)	0.038544	0.109208	0.019272	0.500000	4.578431	0.015063	1.781585	0.812918
1	(Chips)	(Plastic Bag, Nut)	0.109208	0.038544	0.019272	0.176471	4.578431	0.015063	1.167482	0.877404
2	(Plastic Bag, Chips)	(Nut)	0.074946	0.074946	0.019272	0.257143	3.431020	0.013655	1.245264	0.765947
3	(Nut)	(Plastic Bag, Chips)	0.074946	0.074946	0.019272	0.257143	3.431020	0.013655	1.245264	0.765947
4	(Nut)	(Chips)	0.074946	0.109208	0.027837	0.371429	3.401120	0.019653	1.417170	0.763177
5	(Chips)	(Nut)	0.109208	0.074946	0.027837	0.254902	3.401120	0.019653	1.241519	0.792530
6	(Plastic Bag, Cola)	(Chips)	0.047109	0.109208	0.017131	0.363636	3.329768	0.011986	1.399816	0.734270
7	(Chips)	(Plastic Bag, Cola)	0.109208	0.047109	0.017131	0.156863	3.329768	0.011986	1.130173	0.785457
8	(Nut)	(Cola)	0.074946	0.085653	0.019272	0.257143	3.002143	0.012853	1.230852	0.720936
9	(Cola)	(Nut)	0.085653	0.074946	0.019272	0.225000	3.002143	0.012853	1.193617	0.729378

Fig. 9 Products Purchased Together with Different Values

When the minimum support value is set to 0.005 instead of 0.004 and the maximum number of products is limited to 5, the support values obtained are given in Figure 10.

```
      support                                          itemsets  length
0    0.383298                                     (Plastic Bag)       1
1    0.282655                                       (Chocolate)       1
2    0.188437                                       (Cigarette)       1
3    0.169165                                            (Cake)       1
4    0.167024                                           (Water)       1
..        ...                                               ...     ...
566  0.006424                             (Egg, Bread, Cheese)       3
567  0.006424                             (Bread, Cheese, Oil)       3
568  0.006424                  (Chocolate, Chicken, Bread)       3
569  0.006424                     (Chocolate, Bread, Milk)       3
570  0.006424  (Plastic Bag, Chocolate, Cracker, Coffee, Water)       5
```

Fig. 10 Support Values of Products When Minimum Support Value is Set to 0.005

After setting the minimum support value to 0.05, the association rules identified from the remaining products are given in Figure 11.

	antecedents	consequents	antecedent support	consequent support	support	confidence	lift	leverage	conviction	zhangs_metric
0	(Plastic Bag, Nut)	(Chips)	0.038544	0.109208	0.019272	0.500000	4.578431	0.015063	1.781585	0.812918
1	(Nut)	(Chips)	0.074946	0.109208	0.027837	0.371429	3.401120	0.019653	1.417170	0.763177
2	(Plastic Bag, Cola)	(Chips)	0.047109	0.109208	0.017131	0.363636	3.329768	0.011986	1.399816	0.734270
3	(Nut)	(Cola)	0.074946	0.085653	0.019272	0.257143	3.002143	0.012853	1.230852	0.720936
4	(Plastic Bag, Chips)	(Nut)	0.074946	0.074946	0.019272	0.257143	3.431020	0.013655	1.245264	0.765947
5	(Nut)	(Plastic Bag, Chips)	0.074946	0.074946	0.019272	0.257143	3.431020	0.013655	1.245264	0.765947
6	(Chips)	(Nut)	0.109208	0.074946	0.027837	0.254902	3.401120	0.019653	1.241519	0.792530
7	(Cola)	(Nut)	0.085653	0.074946	0.019272	0.225000	3.002143	0.012853	1.193617	0.729378
8	(Chips)	(Plastic Bag, Nut)	0.109208	0.038544	0.019272	0.176471	4.578431	0.015063	1.167482	0.877404
9	(Chips)	(Plastic Bag, Cola)	0.109208	0.047109	0.017131	0.156863	3.329768	0.011986	1.130173	0.785457

Fig. 11 Products Purchased Together with New Support Values

Figure 11 shows the association rules after applying the following filters: support value greater than 0.013, confidence value greater than 0.004, conviction value greater than 1, and both antecedent and consequent support values greater than 0.005. The rules are sorted by the confidence parameter in descending order and given in Figure 12.

	antecedents	consequents	antecedent support	consequent support	support	confidence	lift	leverage	conviction	zhangs_metric
0	(Tomato)	(Bread)	0.027837	0.164882	0.014989	0.538462	3.265734	0.010399	1.809422	0.713656
1	(Plastic Bag, Nut)	(Chips)	0.038544	0.109208	0.019272	0.500000	4.578431	0.015063	1.781585	0.812918
2	(Nut)	(Chips)	0.074946	0.109208	0.027837	0.371429	3.401120	0.019653	1.417170	0.763177
3	(Plastic Bag, Cola)	(Chips)	0.047109	0.109208	0.017131	0.363636	3.329768	0.011986	1.389816	0.734270
4	(Nut)	(Cola)	0.074946	0.085653	0.019272	0.257143	3.002143	0.012853	1.230852	0.720936
5	(Plastic Bag, Chips)	(Nut)	0.074946	0.074946	0.019272	0.257143	3.431020	0.013655	1.245264	0.765947
6	(Nut)	(Plastic Bag, Chips)	0.074946	0.074946	0.019272	0.257143	3.431020	0.013655	1.245264	0.765947
7	(Chips)	(Nut)	0.109208	0.074946	0.027837	0.254902	3.401120	0.019653	1.241519	0.792530
8	(Cola)	(Nut)	0.085653	0.074946	0.019272	0.225000	3.002143	0.012853	1.193617	0.729378
9	(Plastic Bag, Cake)	(Coffee)	0.068522	0.068522	0.014989	0.218750	3.192383	0.010294	1.192291	0.737274
10	(Coffee)	(Plastic Bag, Cake)	0.068522	0.068522	0.014989	0.218750	3.192383	0.010294	1.192291	0.737274
11	(Chips)	(Plastic Bag, Nut)	0.109208	0.038544	0.019272	0.176471	4.578431	0.015063	1.167482	0.877404
12	(Chips)	(Plastic Bag, Cola)	0.109208	0.047109	0.017131	0.156863	3.329768	0.011986	1.130173	0.785457
13	(Bread)	(Tomato)	0.164882	0.027837	0.014989	0.090909	3.265734	0.010399	1.069379	0.830769

Fig. 12 Products Purchased Together with Different Values

IV. CONCLUSION

The results obtained from the Apriori Algorithm are a significant step in understanding the patterns in the analyzed dataset and customer habits. Evaluating the findings for business strategies and marketing decisions helps the seller achieve their goals. Additionally, repeating the analysis with a larger dataset and testing the generalizability of the results, as well as comparing the analysis results using different threshold values, play a role in determining different future strategies. Markets in the Yahşiyan district of Kırıkkale should pay attention to the product associations that will be purchased during the upcoming New Year week. According to the purchasing policies of products, emphasis should be placed on variety and stock status. Based on the sales obtained through association rules, an increase in the stock of nuts, chips, and beverages can be expected.

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Hormone Application in Berries

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Abstract – Berries, which are plants with semi-shrub or shrub plants in a botanical sense, soft fleshy, juicy, often small edible fruits, which are included in the natural flora of our country, are types of fruits that are very much loved, consumed and evaluated in various ways by producers and consumers in terms of their unique color, taste, aroma, structure and smell. It is possible to encounter different forms of one or several species in almost the entire region of our country, which is the natural distribution area. In our country, where many types of fruits are grown, the cultivation of berries types is increasing gradually and has an important place both because of the rich fruit content and because of its intensive use in the food industry.

In recent years, berries cultivation in our country has not been at the desired level, and it can not be said that we have benefited from this genetic wealth at the desired level. In general, its use as a hedge plant or the presence of one or two for hobby purposes in gardens has not allowed the cultivation of these fruit species to increase. In terms of increasing the production and consumption of berries, which have a very important place in terms of health, different plant growth regulators have recently been started to be used in order to improve both production and fruit quality.

Keywords – Plant growth regulators, Berries, Hormone, Shrub plants, Strawberries

I. INTRODUCTION

Turkey is an important gene center. It is located in a very rich flora due to the intersection point of different plant geographies and climatic conditions. An important part of this wealth is also made up of berries. These fruits, which grow spontaneously in nature and are taken into culture, are a very important food source for all kinds of wild animals that feed on plants, and also have an important place in human nutrition and health.

The interest in berries, which are among these fruit types in the world and in our country, has been increasing in recent years. Berries, which are included in the natural flora of our country with soft fleshy, juicy, often small edible fruits, are very popular, widely consumed and evaluated in various ways in the world and in our country in terms of their unique color, taste, aroma, structure and smell. Berries are becoming increasingly important in the industry due to the fact that they can be evaluated both fresh and processed [1]. Fruit types such as strawberry, raspberry, blackberry, blueberry, mulberry, pomegranate and aronia are included in the berries group and their production is increasing day by day.

In addition to the taste, aroma or smell of berries, which have a very high positive effect on human health, there has also been a large increase in their production due to the vitamins and minerals, phenolic compounds, anthocyanins and rich contents they contain. According to the Turkish Statistical Institute (TUIK) data, strawberries ranked first in berries production in our country in 2023 (676 818 tons), followed by pomegranate (638 821 tons), mulberry (71 383 tons), raspberry (7 187 tons), blueberry (5 274 tons) and blackberry (3 583 tons) respectively [2].

From the point of view of plant development and yield, the inability of organic and synthetic fertilizers used in both organic agriculture and traditional agriculture to be taken by plants at an adequate level is important for plant development and yield. The fact that the effects of fertilizers used in crop production areas are also insufficient, instead of using more intensive fertilizers per unit area to increase productivity, the use of biological fertilizers and the application of organic and inorganic fertilizers lead to an increase in the mechanism of fertilizer action and yield.

Since limited agricultural lands cannot be increased, an increase in agricultural production in an amount that will meet the need is possible only by increasing the yield received from a unit area [3]. Berries, which can be multiplied by both classical and biotechnological methods of reproduction, are especially propagated in seedling production by vaccine, steel reproduction, dipping method, through stolons in strawberries and using one of the vegetative methods in tissue culture media. Although it is known that the seed reproduction applications of berries that can reproduce spontaneously with seeds in nature are very limited, the way of reproduction has also been taken with different applications on rooting studies ([4], [5], [6], [7]- [8]). Since production by generative means cannot be possible in some berries species, new understandings have been born in terms of different cultivation systems and breeding in order to expand production areas and obtain more productive quality fruits, and different methods have been applied. One of the most important of these applications is the use of plant growth regulatory substances, i.e. hormones, in terms of both vegetative and generative reproduction. The effects of hormones on plants have been known from ancient times to the present. Hormones that can provide this effect, are present in the root zone of plants, promote plant growth and development, increase plant development, especially at the beginning of the developmental stage. In addition, they also increase the effectiveness of fertilizer use with their effects of increasing plant development by providing a compound that facilitates the use of nutrients to the plant and encouraging it to be produced [9].

When we examine the studies carried out in previous years on hormone application with berries, Akbulut and his colleagues investigated the rooting area of different hormones and their doses in cuttings production in Blueberries (*Vaccinium corymbosum* L.) in Rize Pazar district between 2013 and 2015. It has been reported that when different doses of IBA, IAA, GA3 hormones are applied to the plant materials used in the study (250 ppm, 500 ppm, 750 ppm and 1000 ppm), cuttings can be produced successfully with appropriate hormone doses for blueberry saplings, depending on where they grow and where they live [10].

In 2013, Turna and his colleagues collected mixed steels from the trial areas in the village of Simsirli, Ikizdere district of Rize province with tall blue (*Vaccinium corymbosum* L. they investigated the effect of different hormones (IBA, Polysitimulin) and environments (pearlite, peat, pumice, chestnut soil, perlite + peat mixture used in 1/1 ratio and perlite + peat in 1/1 ratio) on the production of steel. According to the results they obtained, they stated that hormone-applied steels had better rooting than non-hormone-applied steels, and the rooting rate of IBA hormone at doses of 1000 ppm and 5000 ppm was the highest compared to other hormones and doses [11].

The effects of external Tryptophan application on some biochemical and quality criteria of berries in blackberry Bursa-1 blackberry variety in berries parcel located at Gedikhasanli station in 2023 were investigated by Balci and his colleagues, according to the data obtained, they reached the conclusion that this application is positively effective in blackberry fruit [12].

Sugar and its friends have given to the Husband (*Arbutus unedo* L.) they reported that rooting was not observed in Control and NAA applications by applying different auxin doses during different steel taking periods in order to determine the effects on the rooting rate, but rooting was observed in kocayemiş steels in IBA 4000 + NAA 2000 applications with a 4000 ppm solution of IBA [13].

Metaxas et al. (2008) July November, in a study conducted by the kocayemiş wood cuttings taken between July and November provide a higher rooting rate compared to other periods and the level of K–IBA hormone 8000 ppm provides a higher rooting rate compared to IBA [7]. They found that Decoction of IBA and kocayemiş wood cuttings from the months of July to November provide a higher rooting rate [7].

in a study conducted in 2011, Koç examined the effect of different rooting ambient temperatures (18 ºC, 22 ºC and 26 ºC) and humidity values (40%, 60% and 80%) on the rooting of black mulberry wood cuttings and observed that temperature x moisture content interaction and temperature did not have a significant effect on rooting success according to the results obtained by Koç. In addition, it was reported that the highest rooting rate (63.11%) was obtained from steels planted in an environment containing 40% humidity [14].

In a study conducted by Güneş and Çekiç in 2003 to determine the characteristics of black mulberries grown in Tokat region, they recorded that the fruit weight Decayed between 3.02 and 5.72 g in the studied types [15]. Özgen et al. on the other hand, as a result of their observations on the types of black mulberry determined as a result of selection studies conducted in different regions of Turkey, they found that the fruit weight Decayed between 3.8 and 6.8 g [16].

According to Kaçal et al. to the in their study on the effects of proline and temperature applications (15°C, 20°C, 25°C and 30°C) on the germination of black mulberry seeds in 2020, the germination rate at the end of the 17-day germination period was 13 in all applications except 15°C. and 14. they reported that it reached its highest value in days [17].

In 2019, Selvi conducted a study to determine the effects of plant growth-promoting rhizobacteria on fertilizer use, growth, development and yield in strawberries grown in an unheated farmer's greenhouse in Antalya's Serik District, in light of the parameters obtained as a result of his research, along with a 33% reduction in fertilizer application. It has been stated that the application of plant growth-promoting rhizobacteria will be beneficial in terms of economy, environment and human health by reducing the production cost by enabling the reduction of synthetic chemical input used in agricultural production [9].

Lightning was introduced in 2023 in aronia (*Aronia melanocarpa* L.) according to the results obtained at the end of the 60-day period in the study conducted to investigate the effects of different hormone doses (1500, 2000 and 2500 ppm IBA) on the rooting of wood cuttings, the best callus formation rate is 55.81% at 2000 ppm in the ‘Viking’ variety, the rooting rate is 2500 ppm in the ’Viking‘ variety (73.11%), the best average root count is 2500 ppm in the application of IBA’ In Viking‘ variety (1.93 pcs/steel), the best average root thickness is in Viking’ variety (0.23mm) at 2500 ppm, he also found a good average root length at 2500 ppm (0.77 cm) in the ‘Viking' variety [18].

II. RESULTS

Studies conducted as a result of literature reviews show that the need for food, which is one of the basic needs of humanity, increasing population, insufficient agricultural land and inefficient use, etc. it can be a solution to food shortages that may occur due to causes; obtaining more efficiency from the unit area, reducing production costs, etc. for the purpose of berries, which are one of the most consumed food groups in the world,; at the beginning of the journey from seedling to seedling to tree, we can recommend increasing studies on the application of plant growth regulatory substances or hormones to berries in order to prevent possible food shortage by facilitating seed production and increasing the yield received from the unit area. Hormones, which are one of the indispensable elements in plant production today, have been the subject of many studies, and as a result of their efficient use, it has been observed that they increase the capacity of plant production efficiently.

In plant development, hormone applications plant type, hormone dose, hormone type, as well as external factors have been observed in the results of the study, which are effective, and may vary if the plant in the berries group that wants to be produced is applied hormones. Since the production method with steels is preferred rather than seeds in the studies conducted, hormone applications in seeds remain in the background compared to production studies with steel. Hormone applications in seeds can be popularized and brought to the scientific world and economy, as well as evaluated as a precaution against a possible food crisis.

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Tarihi Yapılarda Çağdaş İç Mekan Müdahalelerinde Bağlamsal Yaklaşımların İncelenmesi

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Özet **–** Mimarlık alanındaki çalışmaların arttığı bu dönemde, tarihi yapıların işlevsel dönüşümü odak noktası haline gelmiştir. Tarihi yapılar üzerindeki müdahalelerin temel hedefleri arasında, tarihi bağlamın korunarak vurgulanması ve aynı zamanda bu bağlamdan ilham alarak çağın özelliklerini yansıtması bulunmaktadır. Başka bir deyişle, özgün niteliklerin yeni tasarım sürecini etkilemesi, yeni tasarımın da özgün yapının değerini artırması amaçlanmaktadır. Bu karşılıklı ilişkiyi kurarken, tasarımcının geçmişle gelecek arasında etkileşim ve bağ kurabilmesi için özel bir strateji geliştirmesi gerekmektedir.

Tarihi yapının özgün nitelikleri ile yeni işlevin gereksinimlerini birleştirmek ve eski-yeni arasındaki ilişkiyi tanımlamak için geliştirilen yöntemlerden birisi çağdaş ektir. Bu yaklaşım, ev sahibi yapının büyük ölçüde değişmeden kalmasını sağlarken, yeni ögelerin eklenmesiyle de mekanın yapısal, estetik, strüktürel, teknik birçok açıdan farklılaşmasını sağlar. Başka bir ifadeyle, çağdaş ek müdahalesi, tasarımın bağlamı, anlamı ve sürdürülebilirliği açısından somut ve soyut unsurları ele alabilir.

Bu çalışmanın amacı, tarihi yapılarda çağdaş ek müdahalelerinin bağlam ile ilişkisini inceleyerek uyarlanabilir yeniden kullanım yaklaşımlarına etkisini belirlemektir. ICOMOS ve UNESCO tüzükleri gibi kaynaklar incelenerek bağlam ve çağdaş ek kavramları arasındaki ilişkinin kuramsal çerçevesi oluşturulmuştur. Ayrıca, kuramcı görüşleri değerlendirilerek koruma yaklaşımlarındaki "ek" kavramının nitelikleri ve bileşenleri analiz edilmiştir. Uygulanan mevcut müdahale tasarımı örnekleri, görsel veritabanı bulunduran internet kaynaklarından elde edilen görsel veriler üzerinden analiz edilerek yeni müdahale yaklaşımlarına katkı sağlamayı amaçlamaktadır.

Anahtar Kelimeler – Kültürel miras, İşlevsel dönüşüm, İç Mimarlık, Bağlam,Çağdaş ek

I. GİRİŞ

Mimarlık topluma kendi köklerini hatırlatan, kültürel katmanlardan oluşan, geleceğe yön vererek toplumsal hafızasını aktaran araçlar sunup yeni “an”lara mekan tanımaktadır. Günümüzde yaşam alanlarımız olan yapıların çoğu geçmişten izler taşımaktadır. Farklı dönemlerdeki somut ve somut olmayan değerlerin günlük yaşam pratiğine aktarılması, tasarım verisi haline getirilmesi mevcut olanın yeniden tasarlanmasında ihmal edilmektedir. Tasarımın bağlamından uzak, çok katmanlı yapısı göz önünde bulundurulmadan uygulanan müdahale yaklaşımları, nitelikli olmayan değişimlere sebep olmaktadır. Mevcut olana değer katabilmek için çağdaş ekler ve değişimler mimari pratiğin bir gerekçesi olarak ortaya çıkan bağlam kavramından bağımsız düşünülmemelidir. Bu bütüncül ilişki sebebiyle, yapıların işlevsel dönüşümünde tasarım ile bağlam ilişkisi önemli bir tartışma konusu yaratmaktadır.

Yalnızca somut ve somut olmayan tüm değerler bütününde korunması ve işlevsel olarak bulunduğu çağa adapte olacak şekilde dönüştürülmesi gereken tarihi yapılara mevcut nitelikleri anlaşılmadan ve/veya

tasarım verisi haline getirilmeden müdahale kararı alındığı için yeni nitelikler eklenememektedir. Bu çalışma son 25 yılda yapılmış seçilen örnekler değerlendirilerek tarihi yapıların yeniden işlevlendirilmesi sürecinde yeni ek/ekler ile mevcut bağlamının ilişkisine odaklanmakta ve kurulan ilişkinin özgün niteliklere etkilerini incelemektedir. Bahsedilen etkinin boyutunun anlaşılabilmesi için işlevsel dönüşüm örnekleri ticari ve kamusal mekan türlerinden seçilmiştir. Bu sebeple, kültürel mirasın korunmasına odaklanan uluslararası bildiriler ve tüzüklerdeki çağdaş eklerin müdahale yöntemleri ile ilgili maddeler/açıklamalar tespit edilerek uygulanan işlevsel dönüşümün nitelikleri analiz edilmektedir. Tarih yapı ile bağlamın entegre olduğu çağdaş ek müdahalelerinin çevresindeki fiziksel ve kültürel değeri arttırdığı ve gelecek müdahale kararları için yol gösterici olduğu anlaşılmaktadır.

II. ÇAĞDAŞ MİMARLIK VE BAĞLAM KAVRAMININ İLİŞKİSİ

Bağlam, olay veya müdahale süreçlerinin meydana geldiği ortamsal koşulları ve çevreyi kapsayan temel bir kavram olarak, felsefeden tasarıma kadar çeşitli disiplinlerde anlayışın ve yorumun şekillenmesinde kritik bir rol oynar. Dil ve iletişimden sosyal etkileşimlere ve hatta fiziksel ortamlara kadar uzanan bağlam, bilginin algılandığı ve yorumlandığı mekânları sağlar. Bağlam terim olarak ilk kullanımından önce kuramcılar tarafından farklı ifadeler ile tanıtılmıştır. 1940'lı yıllarda bağlam, Gestalt ilkelerine dayalı görsel çalışmaların etkisinin görüldüğü, mimari söylem olarak yapılı çevrenin algılanma biçimini temsil eden bir yaklaşımdı [51]. György Kepes ve Josef Albers'in 1944 tarihli Language of Vision çalışmaları, Kepes'in 1954-59 yılları arasında Kevin Lynch ile yürüttüğü The Perceptual Form of the City araştırma projesi çevrenin algısal deneyimine yönelik araştırmalara örnek verilebilir [28] [30] [32]. Sonraki yıllarda Lynch, The Image of the City kitabı ile kentsel bağlamın inşası için rehber olarak önerdiği "mental map" teorisini bu araştırmalar sonucu üretmiştir [33]. 1950'lerde farklı bir bağlam yaklaşımı olarak Alison ve Peter Smithson çevrede bulunanlara (as found) ve o çevredeki günlük sosyal pratiklere odaklanmıştır [30]. Aynı yıllarda Ernesto N. Rogers dönemin sorununu modernizmin yarattığı biçimcilik olarak tanımlamıştır [38].

Bağlamın mimari pratik tartışmalarından biri olması tarihsel sürekliliğin bir sonucudur: gündelik hayatı anlamlandırmaya ve yönlendirmeye çalışırken kullanıldığı gibi tarihi referanslar vermek için de kullanılır. İnsanın günlük yaşam pratiklerinin bir parçası olan mimarlık da de her iki kullanımı harmanlamaktadır [26]. Çevresi ile etkileşim kuran mimari tasarımlar yalnızca fiziksel özellikleriyle değil, sosyal ve kültürel ilişkileriyle de ön plana çıkar. Bu sebeple, geniş bir etki alanına sahip olan bağlam kavramı mimarlık alanında da önemli bir tartışma ortamı oluşturmaktadır. Çözümü devamlılık olarak adlandırılan, geleneklere saygılı, mimarinin tarihi çevresinin dokusuyla ve doğal, tarihi formlarıyla yansıtılarak taklit edilmediği bir yaklaşım olan, ilişkisel gerçekliğe odaklanan le preesistenze ambientali veya başka bir deyişle ambiente terimleriyle belirtilmektedir [38]. Aldo Rossi de bağlam kelimesini kullanmadan binalar ile içinde bulundukları yerin ilişkisini tanımlamak için locus kavramını kullanmıştır. 1966 yılında L'Arcitettura della Citta adlı kitabında bu yer-bina ilişkisinin mekanları birbirinden ayrıştırdığını belirtilmiştir. Rossi'ye göre oluşan bu çeşitlilik ile bağlam, süre gelen bir olgu ve bir anı temsil etmeyen, mimari kullanılarak özgünleştirilen bir kavramdır [39].

Robert Venturi'nin Context in Architectural Composition başlıklı tezi bağlam tartışmalarında önemli bir dönüm noktasıdır. 1950 yılında Princeton Üniversitesi'nde tamamlanan tezde bağlam mimari literatürde terim olarak tanımlanmıştır [50]. 1996 yılında Iconography and Electronics upon a Generic Architecture: A View from the Drafting Room kitabında yayınlanan tez çalışması kapsamında modern mimarlığı tasarımı tekil olarak ele alması ve onu çevreleyen bütünlerden kopuk değerlendirmesi yönüyle eleştirerek tasarımcıların proje alanını hem fiziksel hem de kültürel bileşenleriyle bir bütün olarak ele alması gerektiğini savunmuştur [51]. Mimar, yeni ekleme ve değişikliklerin bağlamı da etkilediğini vurgulamış, yeni tasarım müdahalelerinin tarihi dokunun görünürlüğünü arttırma etkisi olduğunu öne sürmüştür.

Mimarlık ve mekan tasarımında bağlam, bir bina veya iç mekanın gelişimini etkileyen daha geniş fiziksel, kültürel, tarihi ve çevresel koşulları ele alır. Hem yakın çevreyi hem de yapının içinde bulunduğu daha geniş bağlamı kapsayarak onun biçimini, işlevini ve anlamını şekillendirir. Pratik açıdan bağlam, bir mekanın kendi benzersiz ortamını yansıtmasını ve çevre ile karşılıklı diyalog içerisinde olması gerekliliğini öne sürer [50]. Bu, bölgeye veya bina tarzına özgü yerel malzemelerin, mimari özelliklerin

veya kültürel motiflerin entegre edilmesini içerebilir. Örneğin, kırsal bir ortamdaki çağdaş bir ev, doğal manzarayla uyum sağlamak için ahşap ve taş gibi doğal malzemeleri kullanabilirken, tarihi bir bölgedeki kentsel bir çatı katı, modern kolaylıklar sunmakla beraber orijinal mimari unsurları koruyabilir.

Dahası, mekan tasarımında bağlam, fiziksel çevrenin ötesine geçerek daha geniş kültürel ve sosyal yönleri de ele alır. Tasarımcılar yerel gelenekleri ve gündelik yaşam pratiklerini de göz önünde bulundurarak mekanı deneyimleyen kişilerde geçmişten çağrışımlar uyandıran mekanlar yaratabilirler. Bu yaklaşım, yalnızca bir mekanın estetik çekiciliğini arttırmakla kalmaz, aynı zamanda işlevselliğine ve sakinlerinin refahına da katkıda bulunur. Mekanın özünü oluşturan kültürel, çevresel ve tarihi karakterin yapılı çevrede her bir mimari tasarımı özgünleştirdiğini, bu değerlerin tasarım sürecinde göz önünde bulundurulması ile çevre ile uyumlu müdahalelerin yapılabileceğini belirtmiştir [50]. Mimari söyleme yön veren bu çalışmanın ardından, 1960'lı yılların başlarında bağlam kavramı Cornell, Washington, Colombia ve Harvard Üniversitesinde Colin Rowe tarafından yürütülen mimari tasarım stüdyo çalışmaları kapsamında tartışılarak sonuç ürünlerin kent bağlamı ile ilişkileri incelenmiştir [30]. Stüdyoda incelenen kent tasarım bağlamı ilişkisi Rowe ve Fred Koetter'in bağlamsalcılık kavramını 1978 yılında Collage City kitabında analiz etmeleri sonucunda mimarlık araştırmaları tarihinde görünür hale gelmiştir. Beş bölümden oluşan bu kitapta ilk olarak döneminin değişen tasarım anlayışları ve modernizmin dönüşümü değerlendirilir. İkinci ve üçüncü bölümde mimari elemanların bağlam ile kurduğu ve kurabileceği ilişkilere odaklanarak bunun zorluklarını ve çeşitliliğini incelemektedir. Son olarak Umberto Eco'nun örnek çalışmaları aracılığıyla uygulama önerileri verilerek eleştirel bir yaklaşım sergilenmiştir [40]. Bu noktada bağlam, sürdürülebilirlik, çevresel duyarlılık ve dolayısıyla da uyarlanabilir yeniden kullanım ile de doğrudan ilişkilenir.

Yeniden işlevlendirmede bağlam, mevcut binaların veya tarihi alanların tarihi, kültürel veya toplumsal anlamlarına saygı göstererek ve bunlara yanıt vererek yeniden kullanımı mümkün kılan tasarım ve müdahale yaklaşımlarını ifade eder. Bu kapsamda bağlamsalcılık, eski yapıların karakterini ve mirasını korurken aynı zamanda onları çağdaş ihtiyaçlara uyarlamayı amaçlayan bir alternatif olarak öne çıkar [35]. Yeniden işlevlendirme ve koruma senaryolarında bağlamsal bakış açısını ihmal etmeyen tasarımcılar, binaların orijinal özelliklerini ve malzemelerini göz önünde bulundurarak bunların sürekliliğini korumak için yeni tasarıma entegre etmektedir. Bu, yalnızca fiziki koşullara mahsus olmak zorunda da değildir: bazen çevresel koşulları ve mekanın tarihi önemini vurgulamak için de tasarımsal müdahalelerde bulunularak yeniden kullanım örüntüleri şekillendirilebilir ve sürdürülebilir açılardan da bağlamı tartışır [45]. Benzer şekilde, bağlamsalcı yaklaşım, tarihi bir bölgede, kent merkezinde veya doğal peyzajda olsun, mekanı ve binayı çevresiyle uyumlu hale getirmeyi ve yenilenen alanın bakımının da sürdürülebilir olmasını sağlamayı amaçlar.

Çevresel yaklaşım üzerinden ele alındığında bağlam, sürdürülebilir ve çevre dostu tasarım uygulamalarına öncelik verir. Yerel kaynaklı, yenilenebilir veya karbon ayak izi etkisi düşük malzemeler kullanılmasına odaklanarak ekolojik ilkelere yüzünü çevirebilir. Ayrıca, çevresel bağlam, binanın yapılı çevre ve doğa ile ilişkisini de dikkatle inceler. Sürdürülebilirlik ilkeleri, enerji verimliliği, kaynakların korunması ve ekolojik etki konusundaki kararlara rehberlik ederek çevreye duyarlı tasarım uygulamalarını teşvik eder. Bu noktadan da fiziksel açıdan sürdürülebilir bir koruma senaryosunu mümkün kılar. Doğal çevre bağlamı bitki örtüsü, topografya ve doğal yaşam ve iklim koşulları açısından değerlendirilebilir.

Mexico City'de bulunan Vasconcelos Kütüphanesi incelendiğinde bulunduğu bölgedeki doğal yeşil çevrenin ve kent dokusunun etkisi anlaşılmaktadır. Botanik bahçe ile çevrelenen bu yapı, çevresinde barındırdığı bitki örtüsü ile bulunduğu kentin doğal çevresine uyum sağlamaktadır. Bahçedeki bitki türleri ile bütünleşerek kütüphane kullanıcılarının doğa ile iç içe olmasına imkan veren bu yapı, ekolojik olarak yakın çevri ile de bütünleştirilmiştir. Kütüphane olarak kullanılan bu alanda botanik bahçe ile kurulan doğrudan ilişki sayesinde iç mekanda kitap okuma ve çeşitli etkinlik alanları için doğal bir havalandırma ve gün ışığı kaynağı sağlanmıştır (Şekil 1).

Şekil 1. (Sol): Vasconcelos Kütüphanesi'nin plan görünüşünde doğal çevre ile ilişkisi, (Sağ): Dış mekan ve yapının doğal çevre ile genel perspektif görünüşü [49].

Mimari ve yapılı çevre bağlamında topografya, iklim, komşu binalar ve altyapı olmak üzere ilgili alanın ve yapının beslendiği ve ilişkide olduğu tüm fiziksel elementler incelemeye değerdir. Bu bağlamsal yaklaşım bir binanın mimari tarzına ve özelliklerine saygı duymaya ve bunları tamamlamaya odaklanır [13]. Tasarım kararları, mevcut yapıyla uyumlu yeni tasarım öğelerini entegre ederken orijinal mimari öğeleri geliştirmek ve korumak için alınır. Bu faktörler binanın yönü, malzemeleri, ölçeği ve genel mekansal düzenlemeyle ilgili kararları etkiler.

1936'da Frank Lloyd Wright'ın tasarlamış olduğu ABD'nin Pennsylvania bölgesindeki Fallingwater tasarımı yapıların bulunduğu topografik çevreye uyumuna örnek verilebilir. 1937 yılında inşaatı tamamlanarak eğilimli arazideki şelale üzerine inşa edilen bu binanın formuna kayaların şekli düşünülerek karar verilmiştir. Yapay ve doğal arasında denge kurmayı başaran Wright, bina formu sayesinde bu ikilik arasındaki zıtlığı minimuma indirebilmiştir. Çevre koşullarının mimari tasarımı şekillendirmesine örnek olan bu tasarım yalnızca form olarak uyum sağlamakla kalmayıp kullanılan yapı malzemeleri yönünden de doğal koşullarla bütünleştirilmiştir. Cephesinde kullanılan taş ve ahşap malzemelerin yanı sıra doğal krem-bej tonlu balkon korkulukları ve düz çatı, şelalenin akış yönüne zıt fakat tamamlayıcı çizgisel yüzeyler oluşturmaktadır (Şekil 2) [16].

Şekil 2: (Sol): Fallingwater cephesi ve çevrenin topografik yapısının görünüşü, (Orta): İç mekan genel perspektif görünüşü, (Sağ): Cephe malzemeleri ve doğal çevrenin detay görünüşü [16].

Bağlam düşünüldüğünde fiziksel çevrenin algılanma biçimi mimarlıkta büyük önem taşımaktadır. Arazi kullanımı, ulaşım ve erişilebilirlik açısından bir kentin çevresel etkiler ve kentsel yapı ile mimari bağlamı yönlendirdiği söylenebilir [9].

High Line, New York'ta bulunan ve 1930'lu yıllarda inşa edilen eski bir tren yolunun parka dönüştürülmesiyle oluşturulmuştur. Kentsel ihtiyaçların dönüşümü ve toplumsal alan ihtiyacının artmasıyla atıl durumda kalan demiryolunu topluma yeniden kazandıran bu park tasarımı, fiziksel çevre unsurlarından arazi kullanımı ve ulaşım açısından referanslar barındırmaktadır [6].

Şekil 3: (Sol): High Line dönüşümü öncesi genel görünüşü (Juliette Perry, 2017)., (Sağ): Çağdaş müdahale sonrası High Line genel görünüşü (Iwan Baan, 2020).

Kent içinde nefes alan yeşil bir geçit görevindeki bu park çevre halkın sosyal etkileşimini arttırarak kamusal alan ihtiyacını karşılamakta ve ekolojik olarak sürdürülebilirliğe katkıda bulunmaktadır. Belirli bir hat üzerine inşa edilen bu park mevcut arazi kullanımını referans alarak çevre mahalle ve bölgelerle de bağlantı kurması yönüyle sosyal etkileşime de teşvik etmektedir. Bu kamusal alan sayesinde yürüyüş yolları, bisiklet yolları, oturma alanları, ekim alaları ve spor alanları gibi bünyesinde barındırdığı farklı fonksiyonları sayesinde mimari tasarım aracılığıyla bölge ile halk arasında toplumsal bağlar güçlendirilmiştir (Şekil 4).

Şekil 4: (Sol ve sağ): High Line sosyal alanları, yürüyüş ve dinlenme alanları (Rosenfield, 2011)

Öte yandan, bir bölge veya yöreye referanslar veren kültürel ve sosyal bağlam ise, mekanın bağlı olduğu yer veya topluluğun kültürel mirasını ve geleneklerini dikkate alıp bunları bir tasarım kriterine dönüştürerek işler. Demografik yapısı ve kültürel pratikleri ile mimari tasarıma yön veren bu sosyal ilişkiler Mexico City'de bulunan Museo Soumaya ve Hamburg'da bulunan Elbphilharmonie gibi tasarımlarda ilham olmuştur.

Fernando Romero'nun Mexico City'de tasarladığı müze Museo Soumaya, bölgeye ait referansları ile toplumun geleneklerine atıf yaparak modern mimarlık yaklaşımı ile entegre bir tasarıma sahiptir. Ülkenin tarihsel ve mimari anlamda sembolü haline gelmiş seramik kaplı yapıları iham alınarak tasarlanan cephe, modern yapım teknolojisi ve malzemeler ile üretilmiştir. Altıgen plakalar ile yapıyı çevreleyen cephe taşıyıcı sistemi çelikten oluşan iskeleti ile cephe boyunca döner formuyla yapıyı kaplamaktadır. Bunun yanı sıra işlev olarak da Meksika kültürünün tarihi sürekliliğine katkıda bulunan önemli eserlerin sergilenmesine de imkan tanıdığı için kültürel mirasın korunmasına katkıda bulunmaktadır (Şekil 5) [3].

Şekil 5: (Sol): Geleneksel seramik kaplı San Francisco Ecatepec Kilisesi cephe örneği (VisitMexico, 2021), (Orta): Museo Soumaya dış cephe genel görünüşü (Raul Soria), (Sağ): İç mekan sergi alanları ve taşıyıcı sistemin genel görünüşü (Adam Wiesman).

Sanat eserleri, mobilyalar, renkler ve malzemeler gibi tasarım öğeleri yerel gelenekleri, estetiği ve değerleri yansıtacak şekilde seçilir [31]. Bu türden bağlamsal bir yaklaşım, sakinlerin veya kullanıcıların kültürel kimliğiyle yankılanan alanlar yaratmayı amaçlar [42]. Ayrıca bu, mimarinin ve iç tasarımın estetik ve sembolik yönlerinin belirlenmesinde çok önemli bir rol oynar ve bina stili, süsleme ve mekânsal düzen konusundaki kararları etkileyen yerel gelenekleri, inançları ve değerleri dikkate alır.

Çin'in Zhejiang kentinde bulunan ve Songyang Story olarak bilinen tasarım Xu Tiantian ve DnA_Design and Architecture tarafından gerçekleştirilmiştir. Bölgenin kimliğini ve mimari karakterini yansıtan modern tasarım geleneksel yapım teknikleri ve malzemeler kullanılarak oluşturulmuştur. Ahşap iskelet sistemleri, yerel taşlar ve kerpiç ile örülen duvarların yanı sıra proje alanından elde edilen ahşap ve bambu hem yapı malzemesi olarak hem de iç mekanda dekoratif olarak kullanılmıştır. Bölgenin kültürel geleneklerinin sürekliliğini de yansıtan çay evi gibi fonksiyonlar ile birlikte modern kimlik kazandıran topluluk merkezi ve sahne sanatları alanı iki farklı dönemin entegrasyonunu göstermektedir (Şekil 6).

Şekil 6: (Sol): Geleneksel ve çağdaş malzeme görünüşü (Sağ): İç mekan malzeme detayları genel görünüş (The Design Museum Websitesi, 2024).

Özetle, bağlam kavramı birçok kuramcı tarafından farklı yönleri değerlendirilerek ele alınmış olsa da ortak payda olarak bu kavramın mimaride önemini vurgular niteliktedir. Doğal, fiziksel çevre, kültürel ve sosyal ilişkiler, estetik ve sanatsal bağlantılar mimari bağlamın anlaşılmasında dikkat edilmesi gereken unsurlar olarak anlaşılmaktadır (Tablo 1).

Tablo 1. Bağlamsal Yaklaşımın Genel Kriterleri ve Alt Başlıkları ile Değerlendirilmesi

Bağlamsal Yaklaşım Değerlendirmesi	
1	Doğal Çevre Bağlamı Topografya, Bitki Örtüsü ve Doğal Yaşam, İklim ve Hava Koşulları
2	Fiziksel Çevre Bağlamı Arazi Kullanımı, Ulaşım ve Erişilebilirlik
3	Kültürel ve Sosyal Bağlam Tarihsel ve Kültürel Miras, Toplumsal Yapı ve Demografi, Kültürel Pratikler ve Etkinlikler
4	Teknolojik Bağlam Yapı Teknolojileri, Malzeme Kullanımı
5	Estetik ve Sanatsal Bağlam Mimari Tarz ve Estetik, Sanatsal Unsurlar
6	Soyut Bağlam

Bu noktada yapılan literatür taraması sonucunda yapıların bağlamı ile ilişkisi değerlendirilirken şunlara dikkat edilmesi gerektiği söylenebilir:

- çevre ile diyalog içerisinde, doğal dokuyu yansıtması,
- geleneklere saygılı olması,
- eskiyi taklit etmeden kendi özgün ortamını yansıtması,
- tarihsel süreklilikte devamlılık sağlaması,
- geçmiş ile bugün arasında ilişki kurması,
- çağdaş mimari yöntemler / elemanlar kullanılarak özgünlük kazandırılması,
- mevcut tarihi verileri, gelenekleri, kültürel motifleri entegre etmesi
- yapının görünürlüğünü arttırması,
- bağlam ile ilintili işlev kazandırılırken estetik çekicilik de gözetmesi.

Bu sayede bağlam, yeni mimari tasarımlarda ve mevcut olan yapılara müdahalelerde sürece yön veren, doğru tasarım yaklaşımlarının geliştirilmesinde etkili olan ve sürdürülebilir mekanlar yaratılmasına olanak tanıyan bir değer olarak karşımıza çıkmaktadır.

Çalışmanın sonraki bölümünde tarihi yapıların korunarak yeniden işlev kazandırılması sürecinde değerlendirilmesi gereken kriterler uluslararası tüzükler ve kuramcıların çalışmaları incelenerek tespit edilecektir. Bu noktada çağdaş ek ve müdahaleler yapılırken bağımsız düşünülmemesi gereken bağlam kavramının ele alınış biçimi detaylandırılacaktır.

III. BAĞLAMSALCILIĞIN VE YENİDEN İŞLEVLENDİRMEDE ÇAĞDAŞ EKLERİN ULUSLARARASI KAYNAKLARDA DEĞERLENDİRİLMESİ

18.yüzyılın sonlarında Fransız Devrimi dünyada birçok yönden derin etkiler yaratmıştır. Siyasi etkilerinin yanında toplumsal olarak dönüm noktası niteliğindeki bu devrim insanların yaşam biçimlerini ve mevcut düzenlerine bakış açılarını değiştirmelerini sağlamıştır. İnsan yaratımı olan ve toplumsal hareketler ile değişen mimarlık disiplininde de bu devrim koruma kuramının gündeme gelmesinde etkili olmuştur. Devrimin ardından yok olan, zarar gören, değişime uğrayan kentler ve yapılar toplumların kültürel değerlerinin sürdürülebilirliği konusunda kaygı duymasına sebep olmuştur. Dünyanın yaşadığı bu büyük değişim sonucunda gündeme gelen eşitlik anlayışı, devrim öncesinde üst kesimin veya dini grupların kullanımındaki yapıların topluma ait, herkes için kültürel değere sahip mekanlar olduğu fikrini doğurmuştur. Bu sayede topluma ait hale gelen bu yapılar gelecek nesillere aktarılması gereken bir miras olarak algılanmaya başlamıştır. Eski bir devlet yapısı olan Louvre Müzesi'nin 1793 yılında kamusal alan

olarak hizmete açılması ve müzeye dönüştürülmesi bu noktada dönüm noktası niteliğindedir [35]. Temelleri Fransa'da atılan bu koruma bilinci takip eden süreçte İtalya ve İngiltere gibi ülkelerde de etkisini göstererek gelişmeye devam etmiş, mimarlıkta koruma kavramı ve bilinci bilimsel temellere oturtulmaya başlanmıştır.

19. yüzyılda koruma ve restorasyon kavramlarını bilimsel bir çalışma alanı haline getirmeyi savunan Viollet le Duc, Stylistic Recomposition akımının öncüsü olarak binaların yenilik değeri ile tarihi değerini bütünleştirmeyi savunmuştur. Bunu yaparken yapıların özgün halleriyle ve tasarlandıkları dönemin karakteristik özellikleriyle restore edilmesini desteklemiştir. Restorasyonun kişisel varsayımlardan ziyade inşa edildiği dönemin yapım teknikleri ve yerel özelliklerinin araştırılmasıyla mümkün olabileceğini öne sürmüştür. İlk yöntem olarak orijinal olana dönüşü savunsa da yapıda meydana gelen değişikliklerin ve izlerin yeni müdahalelere alan açtığını, bu sebeple dikkate alınması gerektiğini vurgulamıştır [1]. Gilbert Scott aynı yaklaşımın İngiltere'de öncüsü olarak sürdürülmesine destek olmuş fakat bu düşünce hem nitelikli bilgi kaynağı yetersizliği (yapıların orijinal hallerine dair referanslar) hem de sürecin uzaması sebebiyle eleştirilmiştir [37].

John Ruskin ise anıtın ya da yapının yalnızca antik çağ değerine sahip olmadığını düşünerek bu görüşü eleştirmiş ve restorasyon karşıtı görüşü benimsemiştir. Tarihi yapıların bakım ile sürdürülerek münkün olduğunca orijinal haliyle hayatta kalmalarını sağlayan Anti Restoration / Romantic Vision görüşünü destelemiştir. Ruskin, yaşanmışlık değerinin ve bu izlerin korunması gerektiğini savunmuştur [41]. İngiliz kuramcı William Morris de Ruskin'in görüşünü geliştirerek Arts and Crafts hareketinin temelini oluşturan tek tipleşme karşıtı bir yaklaşım ile geleneksel el sanatı gibi yöntemler ile oluşturulan tasarımların nitelikli olduğunu belirtmiştir. Luca Beltrami ise tarihi referansların koruma sürecinde en doğru kaynak olduğunu savunsa da Historical Restoration olarak adlandırılan bu teori resim, heykel ya da gravür gibi kaynakların sabit bilimsel olgulara dayanmaması, öznel unsurlara göre oluşturulması sebebiyle geçerli olamayacağı yönünden eleştirilmiştir [37].

Tüm bu yaklaşımlar dünyanın farklı yerlerinde etki eden, gelecek müdahale yaklaşımlarına yön verecek fikirler olarak litratürde yer almaktadır. Bu üç farklı fikrin sentezi niteliğindeki Contemporary Restoration, Camillo Boito öncülüğünde geliştirilmiştir. Boito, tüm bu söylemlere daha bütünsel bir perspektif katarak koruma alanının yalnızca mimari ögeleri kapsamadığını, bununla beraber koruma alanının bulunduğu bölgeye ait tarihi değerleri de kapsadığını vurgulamıştır. Restorasyon ile yapılabilecek herhangi bir değişimin yapının özgün kimliğini bozarak tarihin yanlış aktarılmasına sebep olacağını belirtmiştir. Bu alanların eğer mümkünse güçlendirilerek varlıklarının sürdürülmesinin, aksi takdirde bilimsel verilere dayandırılarak farklı ek veya müdahalelerin yapılabileceğinin altını çizmiştir. Ayırt edilebilirliği vurgulayan mimar, sonradan yapılan eklerin de tarihi alanın bir parçası olarak korunması gereken bir parça olarak ele alınması gerektiğini savunmuştur [1]. Gustavo Giovannoni, çağdaş restorasyon akımını kent ölçeğine taşıyarak yapının kent dokusu ile uyumunun, kullanılabilirliğinin ve estetik olarak çevre yapılar ile dengeli oluşunun müdahale kararlarında belirleyici olması gerektiğini belirtmiştir [54]. Mimar, 1931 yılında düzenlenen Atina Tüzüğü'nde bilimsel bir yöntem önerisiyle koruma teorisinde kullanılabilecek bu çağdaş yaklaşımları geliştirerek Boito'nun mevcut ilkelerini teorik bir temele oturtmuştur [37].

İlki Atina'da düzenlenen bir konferans ile çağdaş müdahalelerin kapsamı, ele alınış biçimi yön değiştirmiştir. Takip eden süreçte hızla gelişen bu yaklaşımlar koruma kavramının gelişip günümüze kadar tartışılmasına olanak tanımıştır. Bu noktada ilk kez çağdaş ek kavramının literatürde yer edinmesi sebebiyle Venedik Tüzüğü büyük önem taşımaktadır.

Venedik Tüzüğü, yayımlandığı 1964 yılından bu yana koruma teorisi açısından önemli belgelerden biri olmuştur [20]. Bu belgede, tarihi eser kavramının kapsamının sadece mimari eserlerle sınırlı olmadığı, aynı zamanda tarihsel süreç içerisinde var olan kültürel nitelikli unsurları da kapsadığı belirtilmektedir (Madde 1). Söz konusu kültürel değerlerin korunması sırasında miras alanlarının sosyal kullanıma uygun şekilde yeniden kullanılmasının faydası belirtilmiş, müdahale edilecek alanların özgün unsurlarının bu süreçte değiştirilmemesi gerektiği vurgulanmıştır. Yeni işlev gerektiren alanlarda da değişikliklerin tamamlanması uygun görülmektedir (Madde 5). Bütünsel koruma yaklaşımına yönelik öneriler içeren belgede eksik kalan kısımların tarihi alanın tamamıyla uyumlu ve orijinalinden ayırt edilebilecek şekilde

tamamlanması ve ekleme yapılacaksa da özgün niteliklerine zarar vermeden denge kurularak uygulanabileceği belirtilmiştir (Madde 12, 13).

1974yılında düzenlenen Modern Mimarinin Eski Çevrelerde Entegrasyonu Semineri Sonuçları (Europa Nostra) yerleşimlerin değişen koşullara uyumlu, gelişerek yeni unsurların eklenebileceği mekanlar olması gerektiğini savunmaktadır. Çevre ile entegre olarak yenilendiği ve geliştirildiği dönemin güncel teknolojisini yansıtan, eski olana saygılı tasarım yaklaşımlarının ön planda tutulduğu müdahaleler tarihi alanlar için önerilmektedir. Bu sayede çeşitli disiplinlerin bir işbirliği içinde olarak tarihi alanın bütünleştirilmiş bir koruma anlayışıyla ele alınması gerektiğini vurgulamaktadır.

1975yılının Avrupa Mimari Miras Yılı olarak belirlenmesi, ülkeler arasındaki etkileşimi artırmış, olası ve mevcut sorunlara çözüm üretme konusunda farkındalık oluşmasını sağlamıştır. Amsterdam Bildirgesi, dünya çapında kültürel miras açısından değer tanımlarının anlaşılmasını ve sürdürülmesini sağlayan birleştirici bir etkiye sahiptir [25]. Bahsi geçen planlama ve uygulamaların önemine ek olarak mirasın ancak toplumun bir parçası olmakla yaşatılabileceği, bu nedenle halkın ve özellikle genç neslin duyarlılığının çeşitli eğitimlerle artırılması gerektiği vurgulanıyor (Madde 1, i). Eğitimin her düzeyinde oluşturulması önerilen koruma bilincinin, koruma ve müdahale arasında denge kurabilmesi için farklı düzeylerdeki çalışma gruplarına yönelik referanslara da ihtiyacı olacağı açıklanmaktadır. Bu referanslar, korunan alanın iç mekanının yeniden kullanım açısından işlevsel olması durumunda müdahale yaklaşımını bağlamına göre belirlemede de önemli olacağı düşünülebilir.

Burra Tüzüğü 1979 yılında yayınlanmış, 1981 ve 1988 yıllarında revize edilmiştir. 1999 yılında getirilen son versiyonun ise 2013 yılında incelenip değiştirilmesiyle bugünkü halini almıştır. Burra Tüzüğü kültürel değeri, mekanın içinde bulunduğu tüm dönemlerin izi olan maddi ve manevi unsurlar olarak tanımlamaktadır (Madde 1,2). Yapılacak yeni müdahalenin tarihi alandaki fiziksel ve diğer kanıtları çarpıtmaması ve doğru yaklaşımı belirlemek için bilgi toplama ve analiz etme sürecinin iyi yönetilmesi gerektiği ifade edilmektedir (Madde 3.2 ve 6.1). Koruma, koşullara bağlı olarak bir kullanımın muhafaza edilmesi ya da yeniden tanımlanması, ilişkilerin ve anlamların sürdürülmesi, bakım, koruma, restorasyon, rekonstrüksiyon, adaptasyon ve yorumlama süreçlerini içerebilir; genellikle bunların birden fazlasının kombinasyonunu içerdiği belirtilmiştir. Aynı zamanda, ilgili yerlerin ve nesnelerin kültürel öneme olan katkısının muhafaza edilmesini de içermektedir (Madde 14). Mimari bağlamın korunması, bir yerin ifade ettiği, gösterdiği, çağrıştırdığı veya insanlara ilettiği anlamları anlamayı ve vurgulamayı içermesi gerektiği ifade edilmektedir. Anlamlar genellikle sembolik nitelikler ve anılar gibi somut olmayan boyutlarla ilişkili olduğu, bu nedenle mimari koruma yaklaşımlarının bu anlamları dikkate alarak şekillendirilmesi gerektiğinin altı çizilmiştir. Mimarlığın, sadece fiziksel yapıları değil, aynı zamanda mekanın sembolizmi ve insanların belleğindeki izleri koruma çabalarında önemli bir rol oynadığı; bu nedenle mimari bağlamın korunmasının, bu tür anlamların sürdürülebilirliğini kapsadığı anlatılmıştır (Madde 1.16). Tüzükte çağdaş ekin tarihi olana saygı duyduğu, kültürel önemine zarar vermediği ve gizlemediği sürece kabul edilebileceği açıklanmıştır. Bunu yaparken koruma alanındaki önemli ve anlamlı unsurların devamlılığı için farklı yöntemlerin araştırılabileceği söylenmektedir (Madde 22.1 ve 24.2) [10].

Washington Tüzüğü, geleneksel kent kültürünün bir parçası olması yönüyle küçük ve büyük tarihi kentsel alanları kapsar. Bu kapsamda yaşam alanları ile kentsel alanların arasındaki toplum belleğini oluşturan kültürel değerleri desteklemektedir [21]. Tarihi alanların korunmasında tutarlı olabilmek için somut ve somut olmayan parçalar olduğu belirtilen ilkeler ve hedefler bulunmaktadır. Kent dokusunun bileşenleri olarak tanımlanan parsel ve sokaklar, yeşil alan ve açık alanlar, binalar yalnızca kurulan fiziksel ilişki çerçevesinde ele alınmamıştır. Bu parçaların her biri doğa ve insan ile kurduğu ilişki, zaman içinde edindikleri değişik işlevler ve anlamsal ilişkiler yönünden tarihi kentsel alanlar ile birlikte düşünülerek korunması gereken bir bütün olarak belirtilmiştir (Madde 2). Koruma yöntemi belirlenirken yürütülecek çalışmanın disiplinlerarası araştırmalar sonucunda müdahale yönteminin belirlenmesi gerektiği vurgulanmıştır. Koruma planı oluşturulduktan sonra yeni işlevin tarihi alanın karakteriyle uyum içinde uygulanması gerektiği belirtilmiştir (Madde 5 ve 8).

Koruma teorisinde miras alanının bütünsel olarak ele alınması gerektiğini açıkça ortaya koyan belgelerden biri olan Nara Özgünlük Belgesi, miras alanının değerinin sadece korunmasıyla değil aynı

zamanda geliştirilmesi ile insanlık için önemli hale getirilebileceğini belirtmektedir [22] (Madde 5). Yeni değerlerin yorumlanmasının gerekliliğinin belirtildiği belgede eski ve yeni olarak algılanabilmesinin, değerlerin anlaşılmasını kolaylaştıracağı vurgulanmaktadır (Madde 9). Miras alanının iç tasarımı geliştirilirken mirasa değer katmak için belirli kaynaklara göre tasarım yöntemleri yapılması gerektiği sonucu çıkarılabilir. Bu nedenle, binanın veya anıtın inşa edildiği döneme özgü değerleri korumak ve geliştirmek için uygulanan tekniklerin kalitesini belirlemek için yalnızca güvenilir bilgi kaynaklarının mevcut olması önemlidir. Bilgi kaynaklarının çeşitli özgünlük yargıları oluşturduğunu belirten 13. madde, bu kaynakların kullanılmasının kültürel mirasın çeşitli boyutlarda tanımlanmasına olanak sağladığını açıklamaktadır.

"Principles For The Analysis Conservation an Structural Restoration of Architectural Heritage (Zimbabwe)" kararları çağdaş yönetmelik ve yapı standartlarına ilişkin ilkeler ve önerileri kapsamaktadır [23]. Zimbabwe'de belirlenen bu ilkeler açıklanmadan önce tüzükte miras alanının değerinin ve özgünlüğünün ait olduğu bütün kültürel unsurları kapsayarak değerlendirilmesi gerektiği genel bir ölçüt olarak ifade edilmektedir (Madde 1.2). İlkelerde zorunlu olmayan, kültürel değerlere uyum göstermeyen hiçbir müdahale uygun görülmemekle birlikte yapılan müdahalenin hafif ve geriye döndürülebilir, miras alanına zarar vermeyen, yapılacak olası yeni müdahaleleri engellemeyen işlemler olması istenmektedir (Madde 3.4, 3.7, 3.9). Mevcut izlere saygılı ve o izleri korumaya özen gösteren, mimari mirasın değerini arttıracak strüktürel ve işlevsel tasarım kararlarının alınması ve önceden planlaması gerektiği vurgulanmaktadır (Madde 3.12, 3.13).

Kentsel hafıza, insanların yaşadıkları mekanla olan fiziksel ilişkileri, yeni değerlerin tanımlanması açısından somut (binalar, siteler, manzaralar, rotalar, nesneler) değerlerin yanı sıra somut olmayan (anılar, anlatılar, yazılı belgeler, ritüeller, festivaller, geleneksel bilgi, değerler, dokular, renkler, kokular vb.) kültürel değerlerin de sürekli değiştiği bir döngü söz konusudur [48]. Kültürel mirasın somut olmayan değerleri de bu bütünün bir parçası olduğundan, koruma yalnızca somut değerlere uygulanmamalıdır. 2008 yılındaki Quebec Deklarasyonu, sürdürülebilir korumanın sağlanması amacıyla somut olmayan değerlerin korunmasına ilişkin ilkeleri kapsamaktadır. Mekanın birden fazla ruhu olabileceği açıklanan tüzükte somut ve somut olmayanın birbirini inşa ettiği ilişki "yerin ruhu" olarak ifade edilmektedir. Dünyadaki sürekli değişime ve etkileşime bağlı olarak var olanlara ek yeni değerlerin bu ilişki ile geliştiği ve paylaşılabildiği vurgulanmaktadır (Madde 3). Tarihi alanların birden fazla grubun/toplumun değerlerinden etkilendiği düşünüldüğünde bu alanlardaki birden fazla somut olmayan bağlamı korumak için ortak stratejiler geliştirilmesi gerektiği ifade edilmektedir (Madde 5). Özelikle kişisel bellek ile aktarıldığı düşünülen yerin ruhunun korunabilmesinde o yeri canlı tutmanın, mekan ile iletişimde olmanın gerekliliği açıklanmaktadır (Madde 8).

The Icomos Charter for the Interpretation and Presentation of Cultural Heritage Sites (Ename) 2008 yılında yayınlanmasından önceki korumaya yönelik ilkesel kararlara ek olarak bu alanların toplum tarafından anlaşılmasına ve kabul edilmesine yönelik yorumlama ve sunum ilkelerini kapsayan 7 başlık altında ele alınmıştır. Bu ilkelerin başlıca amaçları arasında miras alanlarının korunması konusunda farkındalığı artırmak, gerekli belgelemelerin yapılarak çeşitli kitlelere iletilmesini sağlamak, somut ve somut olmayan tarihi alanları sosyal bağlamları içinde korumayı açıklamak, özgünlüğe saygı göstermenin yollarını tespit etmek, sürdürülebilir korumayı sağlamak sayılabilir [19]. Üçüncü ilke olan Bağlam ve Ortam (Setting) tarihi alanların yorumlanma aşamasının bu alanların sosyal, kültürel, tarihi ve doğal bağlamları ile ilgili olması gerektiğini belirtmektedir. Bu ilke miras alanlarının analizi yapılırken evrimindeki tüm aşamaların ayırt edilebilir, anlaşılır olması gerektiğini vurgulamaktadır. Bunu yaparken somut olmayan unsurların mevcut kayıtların, bilimsel araştırmaların ve yaşayan geleneklere dayalı bakış açıları dikkate alınarak mükün olabileceği söylenmektedir (Madde 3). Özgünlük ile ilgili ilkede Nara Özgünlük Belgesi maddelerine uygun olarak mirasın yorumlanmasında toplulukların kültürel uygulama ve sosyal işlevlerine saygılı yaklaşımlar geliştirilmesi gerektiği tekrarlanmıştır (Madde 4).

2010 yılında Yeni Zelanda'da düzenlenen toplantıda o bölge ve toplumun koruma yolları gözden geçirilerek kabul edilen ulusal komite kararları belirlenmiştir. Bu toplantının maddelerini içeren ICOMOS New Zealand Charter for the Conservation of Places of Cultural Heritage Value insanlığın geri kalanı ile mevcut mirasın gelecek nesillere aktarılması konusunda ortak sorumlulukları kapsayacak şekilde

oluşturulmuştur. Mümkün olan en az müdahalenin uygulanması, kültürel miras değeri taşıyan somut ve somut olmayan anlamların kanıtlarına saygı duyulması, bütünleşik kullanımın sürekliliğinin sağlanması başlıca koruma prensipleridir (Madde 4, 5, 6). Tarihi alanın etkin kullanımının sürdürülmesi için ihtiyaç varsa fonksiyonel değişikliğinin kültürel değerle uyumlu, olumsuz etki yaratmayacak, yerin yararlı bir amaca hizmet etmesini sağlayacak şekilde belirlenmesi önerilmektedir (Madde 8) [24].

Yukarıda incelenen belgelerin her birinde vurgulanmak istenen koruma alanındaki bütünsel ilişkinin hem somut hem de soyut anlamda en önemli bileşenlerinden biri olan bağlam kavramının, koruma alanında çalışmalar geliştiren, çağdaş müdahale yaklaşımları belirleyen kuramcıların da vurguladığı bir başlık olarak görülmesidir.

Brolin (1980) çağdaş eklerin kopyalama, yeniden düzenleme ve soyutlama yöntemleriyle uygulanabileceğini düşünmektedir. Plan tipolojisi düşünüldüğünde bu yöntemlerden kopyalama benzer tasarım stili kullanılarak tarihi yapının taklidi ile orijinal dokuyu korumaya çalışır. Yeni teknolojiler ve çağın özellikleri düşünüldüğünde oluşacak uyumsuzluk sebebiyle başarılı bulunmamaktadır. Bu uyumu yakalamak da eskinin anlaşılarak yeniye entegre edilmesiyle mümkün görülmektedir [5].

James Dougles'ın organizasyon şemaları ve tüm detayları ile koruma sürecini ele aldığı Building Adaptation kitabında yeniden işlevlendirme sürdürülebilirliğin temeli olarak ifade edilmiştir [15]. 20.yüzyılın sonlarında yerel topluluğa veya çevreye getirdiği faydalar açısından katma değer olarak görülen yeniden işlevlendirmenin hem yapıların korunarak ve kullanılarak yaşatılmasına hem de inşa maliyeti açısından avantaj sağlanmasına olanak verdiği belirtilmiştir. Dougles yeniden işlevlendirmenin başarılı olabilmesi için ilk önceliğin yapının biçimsel özelliklerinin anlaşılmasına yönelik olması gerektiğini belirtmektedir. Bu analiz inşaat tekniğinin, taşıyıcı sisteminin, fiziksel durumunun yeterliliğinin, mimari değerinin ve son olarak fonksiyonel değişiminin uygunluğunun tespitinin yapılmasını kapsamaktadır. Yapılan bu araştırmaların çağdaş müdahale için belirleyici olan bağlamın anlaşılabilmesinde ön koşul olduğunu ifade etmektedir [15].

İç mekan yeniden işlevlendirme çalışmalarının incelenmesinde devrim niteliğindeki kitap İç Mimarlıkta Biçim + Yapı, Graeme Brooker ve Sally Stone'un yapı taşı haline gelmiş inceleme yaklaşımlarını içermektedir. Kitapta işlevsel dönüşüm sürecini anlayabilmek için ilk olarak mevcut mekanın temel yapı sistemlerini anlamak, bağlamını çözümlemek ve tarihini analiz etmek ile başlanmaktadır. Somut ve soyut anlamda yapı kabuğu ve çevresi anlaşıldıktan sonra iç mekan organizasyonu analiz edilmektedir. Yeni müdahale üç ana başlıkta kategorize edilirken intervention, insertion ve installation başlıkları kullanılmaktadır. Birbirinden müdahale biçimi olarak ayrışan bu üç başlığın uygulama yöntemi olarak çeşitlilik gösterdiği belirtilmektedir. Yerleştirmenin yapı içinde gizlenerek veya bağımsız iç mekan elemanlarıyla yapılabileceği gibi her iki yöntemi sentezleyerek yaklaşımlar sergilenebileceği de açıklanmaktadır. Bunu yaparken iç mekanı oluşturan temel ögeler; yüzeyler, objeler, geçitler, doğal-yapay aydınlatma elemanları veya farklı dokular olarak karşımıza çıkabileceği belirtilmektedir [7]. 2019 yılında yazarlar Re-readings: 2: Interior Architecture and the Principles of Remodelling Existing Building kitabında belirtilen üç stratejiyi daha detaylı tanımlandırıp örnekler ile detaylandırmadan önce bu müdahale tiplerinin kararının verilmesinde önemli olan bir dizi alt başlık oluşturmuşlardır. Biçim ve yapı, tarih ve fonksiyon, bağlam ve çevre, fonksiyon önerisi ve sürdürülebilir yeniden işlevlendirme anlayışlarının önemi vurgulanmıştır. Bağlam ve çevreyi ayrıca ele alan Brooker ve Stone'a göre bağlam mimarlık tarihinde çok tartışılan bir konu olsa da iç mekanın bu bağlam ile ilişkisi yeteri kadar değerlendirilmemiştir. İç mekan müdahalelerinin bulunduğu yerden bir başka konuma taşınamayan, olduğu yerin kimlğini yansıtan yerler olarak düşünülmesi gerektiğinin altı çizilmektedir [8].

Charles Bloszies Old Buildings, New Designs: Architectural Transformations kitabında tarihi yapıların zaman içinde varlıklarının tehlikeye girdiğini, bulunduğu dönemin koşullarını karşılayamadığını belirtmektedir. Özellikle iç mekanların işlevini yitirerek güncel koşullara uyum sağlayamadığını belirten Bloszies, bu yapıların sürdürülebilmesi için öncelikli olarak yapıların onarımının ve orijinal varlığı ile sürdürülmesinin kabul gördüğünü söylemektedir. Bunun mümkün olmadığı durumlarda küçük müdahale, büyük ekler, yeniden işlevlendirme müdahaleleri ile yapıların dönüştürülebildiğini eklemektedir [4]

Christian Schittich yaratıcı dönüşümler olarak nitelendirdiği Building in Existing Fabric: Refurbishment, Extensions, New Design kitap bölümünde inşa sürecinin ve yapılı çevrelere

müdahalelerin basit onarım, işlevsel dönüşüm, ekolojik müdahaleler gibi farklı yöntemler ile çözümlenmesi gerektiğini düşünmektedir. Bu noktada her birinin kararının yine eski yapının kendi kimliği tarafından yönlendirildiğini vurgulamaktadır. Yazar, yeni yöntemler kullanılsa da bağlamı eski yapının orijinal özelliklerini belirleyici unsur olarak göstermektedir [43]

Venedik Tüzüğü, Amsterdam Bildirgesi, Burra Tüzüğü gibi incelenen uluslararası belgeler dünya çapında yankı uyandıran bu gelişmelerin adı geçen kişilerin ortaya koyduğu koruma yöntemi önerileri ile günümüze kadar kümülatif bir biçimde gelişerek geldiğini göstermektedir.

Hiç şüphe yok ki incelenen tüzükler ve teorisyenlerin koruma kuramı ile ilgili fikirleri bu alanda yapılan incelemeler için geleceğe ışık tutmaktadır. Yapılan literatür taraması sonucunda yapıların korunması ve yeniden işlev kazandırılmasında dikkat edilmesi gereken nitelikler bulunmaktadır. Tarihi yapının çağdaş müdahalesi ile eski-yeni vurgusunun yapılabilmesi, bulunduğu çağa uyum sağlayabilmesi, yaşayan ve kullanılan bir mekan haline dönüştürülmesi, toplumsal belleğe zarar vermeden onu geliştirebilmesi, fiziksel karakteristiklerinin korunarak tasarıma dahil edilmesi, hafif ve kaldırılabilir yöntemlerle tasarlanması başlıca kriterlerdir (Tablo 2).

Tablo 2. Koruma Kuramı Genel Değerlendirme Kriterleri

Koruma Kuramı Genel Değerlendirme Kriterleri	
1	yeni müdahale ile eski yapının ayırt edilebilmesi
2	eski yapıya, bulunduğu döneme ayak uydurabilecek yeni müdahalelerin uygulanması
3	eski yapının yeni müdahale ile geliştirerek aktif ve kullanılabilir hale getirilmesi
4	yeni müdahalenin geri döndürülebilir olması, eski yapıya minimum zarar vermesi
5	yeni müdahalede toplumsal hafızayı koruyacak sürdürülebilir bir müdahale yönteminin uygulanması
6	somut olmayan kültürel değerlerin koruma sürecine dahil edilmesi
7	yeni müdahalenin gelecek müdahalelere imkan vermesi, sürdürülebilir bir müdahale yönteminin uygulanması

Koruma kuramı ve bağlamsalcılığın ortak noktaları şu şekilde özetlenebilir:

- Eskiyi taklit etmeden çağdaş mimari yöntemler ve elemanlar kullanılarak özgünlük kazandırılması, yeni müdahale ile eski yapının ayırt edilebilmesi,
- Eski yapının yeni müdahale ile geliştirilerek aktif ve kullanılabilir hale getirilmesi, görünürlüğünün ve kullanımının artırılması,
- Eski yapıya, bulunduğu döneme ayak uydurabilecek yeni müdahalelerin uygulanması, tarihsel sürekliliğin sağlanması,
- Yeni müdahalenin geri döndürülebilir olması, eski yapıya minimum zarar vermesi, geleneklere saygılı olması,
- İç mekanda yeni müdahalenin gelecek müdahalelere imkan vermesi, sürdürülebilir bir müdahale yöntemi uygulanması, geçmiş ile bugün arasında ilişki kurulması,
- İç mekanda somut olmayan kültürel değerlerin korunması, mevcut tarihi verilerin, geleneklerin ve kültürel motiflerin entegre edilmesi,
- Yeni müdahalede toplumsal hafızayı koruyacak sürdürülebilir bir yöntem uygulanması, bağlam ile ilintili işlev kazandırılırken estetik çekiciliğin gözetilmesi.

Üçüncü bölümde bu maddeler göz önünde bulundurularak yeniden işlevlendirme tasarımlarının iç mekan düzenlemeleri ve işlevsel dönüşüm yöntemleri ele alınacaktır.

IV. BAĞLAMSALCILIĞIN VE YENİDEN İŞLEVLENDİRMEDE ÇAĞDAŞ EKLERİN ULUSLARARASI KAYNAKLARDA DEĞERLENDİRİLMESİ

Tarihi yapıların korunması planlanırken yaşadıkları dönemde sahip oldukları fonksiyonların da adapte edilecekleri döneme uyumu gözetilmelidir. Özgün işlevi ile varlığını sürdüremeyen yapılara işlevsel dönüşümün yapılması çağdaş ekler, biçimsel müdahaleler gerektirebilir. Tasarımın rolü, genellikle çevredeki yapıları tamamlayarak veya bölgenin mimari çeşitliliğini artıran bir kontrast yaratarak mevcut çevreye yanıt vermeye ve onunla bütünleştirmeye yöneliktir [11]. Yeni tasarımlar ile dönem ihtiyaçlarına karşılık veren bu tarihi yapıların iç mekan müdahaleleri bağlamsalcılık ve koruma kuramının temel prensipleri kullanılarak belirlenen kriterler doğrultusunda incelenecektir. Yeniden işlev kazandırılan iç mekan müdahale örnekleri kamusal alan ve ticari alanlar olarak sınıflandırılacaktır.

A)Tate Modern, Herzog De Meron, 2000, Londra, İngiltere

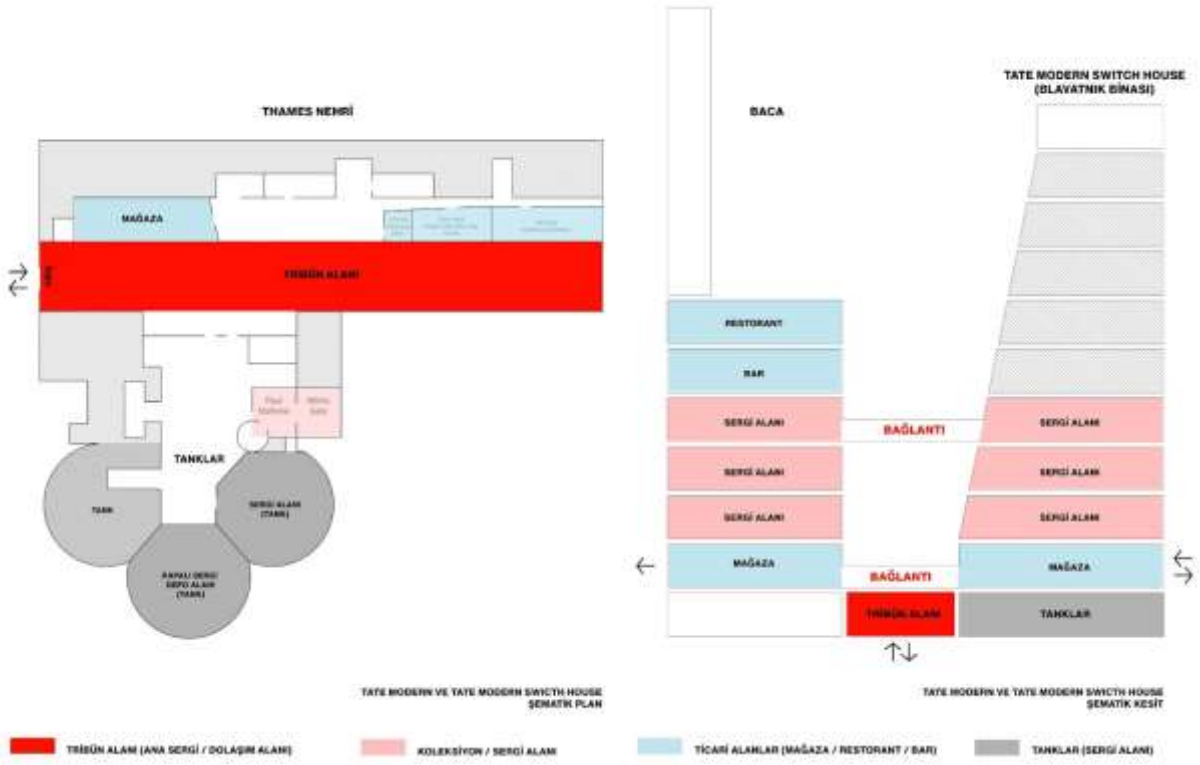
Londra'nın Banskide bölgesinde Thames Nehri'nin kıyısında konumlanan Elektrik Santrali, Giles Gilber Scott tarafından 1940'ın sonlarında tasarlanmıştır. Yapımından yaklaşık 30 yıl sonra santral işlevini kaybeden bu endüstriyel yapının müzeye dönüştürülmesi için 1995 yılında açılan proje yarışmasını Herzog de Meuron kazanmıştır. 2000 yılında tamamlanan Tate Modern, hafif müdahale yaklaşımı, endüstriyel kimliğin korunmasına yönelik kararları ile ön plana çıkmaktadır (Şekil 7.1). Yapının bacası, Thames Nehri karşısında yer alan St. Paul Katedralinin kubbesi ile eşleşerek birbirlerini tamamlayıcı bir ilişki kurmaktadır [17].

Mevcut yapının elektrik üretimi için gerekli olan 32 metrelik yüksek tavanı ve 152 metre uzunluğu gibi mekansal özellikleri, duvar kaplama malzemeleri korunmuş, çağdaş müdahale kararlarında da yapının sahip olduğu endüstriyel tasarım dili sürdürülmüştür [17]. Müzenin iç mekanındaki gün ışığı ihtiyacını karşılamak amacıyla mevcut açıklıklara cephede yatay açıklıklar ve çatı feneri eklenmiştir (Şekil 7.2). Eski plaza bölümünde büyük jeneratörlerin yer aldığı eski kazan dairesi, endüstriyel geçmişi nedeniyle müdahaleye uygun bir alan sağlayarak, farklı kotlarda galeriler oluşturulmasına olanak sağlamıştır. Tasarım sürecinde zemin kazılıp üst kat döşemeleri kaldırılmıştır. Bu sayede üst katlara erişim için kullanılan beton görünümlü rampa, ziyaretçilerin galeri mekanlarıyla görsel olarak etkileşime geçmesine olanak sağlayacak şekilde konumlandırılabilmiştir (Şekil 7.3, Şekil 7.4). Çatı feneri müdahalesiyle mekansal olarak tanımlanan eski türbin salonu, müzenin ana mekanını oluşturan bir toplanma ve dolaşım alanı haline getirilmiştir (Şekil 7.3, Şekil 7.4). Sanat enstalasyonları için elverişli genişliği ve yüksekliği sayesinde farklı sanatçıların tasarımlarının sergilenebileceği bir mekan oluşturulmuştur (Şekil 7.5).

Çelik taşıyıcılar, beton görünümlü zemin kaplama ve üst katta bulunan galerilerin balkon görünümlü çıkıntı alanlarında kullanılan polikarbon plakalar iç mekan genelinde çağdaş bir dilin hakim olmasına olanak tanımıştır. Yapay aydınlatma elemanlarının da entegre edildiği polikarbon plaka yüzeyler aynı zamanda yapının doğrusal formunu da vurgulamaktadır (Şekil 7.6). Organik forma sahip herhangi bir iç mekan unsuruna sahip olmayan müzede sergi alanları dışında mağaza, karşılama alanı ve gişe gibi iç mekanlar çelik taşıyıcıların oluşturduğu gridal plan düzenine göre konumlandırılmıştır (Şekil 7.7). Toplanma alanındaki endüstriyel tasarım dili açıkta bırakılan çelik taşıyıcılar, sabit/hareketli mobilyaların kullanılmaması, doğal görünüm kazandıran malzemelerin tercih edilmemesi ile desteklenmiştir.

Şekil 7: (1): Tate Modern'in Thames Nehri cephesinden görünüşü (Herzog &de Meuron Websitesi, 2024)., (2): Linear cephe açıklıklarının görünüşü (refHerzog &de Meuron Websitesi, 2024)., (3): Çatı feneri ve üst kat dolaşım alanı bağlantılarının görünüşü (Herzog &de Meuron Websitesi, 2024)., (4): Birinci kat dolaşım alanı, galeri boşluğu ve çatı feneri görünüşü (Yazar arşivi, 2024)., (5): Birinci kat bağlantı köprüsünden zemin kat görünüşü (Yazar arşivi)., (6): Zemin kat rampa görünüşü (Herzog &de Meuron Websitesi, 2024)., (7): İkinci kattan galeri boşluğu, rampa görünüşleri ve malzeme detayları (Yazar arşivi).

2012'de müzeye ek olarak inşa edilen Tate Modern Switch House bir diğer adıyla Tate Modern Blavatnik Building yeni galeri alanlarına ev sahipliği yapmaktadır. İkinci bir yeniden işlevlendirme önerisi olan bu ek, eski fonksiyonu yağ deposu olan üç büyük yapıdan referans alınarak dönüştürülmüştür. Form olarak silindirik bir tabana sahip bu üç ek bina, tasarım anlayışı olarak günümüz yaklaşımlarını ve yapım tekniklerini yansıtılarak ilk müdahaleyle uyum sağlayacak şekilde planlanmıştır. İç mekandaki galeri alanları ve dolaşım alanları plan organizasyonunda mevcut yapı ile ek binanın doğrudan ve dolaylı iletişimini sağlamaktadır. Bir köprü ile bağlanan bu iki ekte Tate Modern Switch House'un dördüncü katından Tate Modern'in eski kazan dairesi olan galeri alanlarına geçiş imkanı verilmektedir (Şekil 8).



Şekil 8: Tate Modern ve Tate Modern Switch House şematik plan ve kesitleri (Yazarlar tarafından düzenlendi).

Modern mimarlık dönemi endüstriyel mirası olan yapının tarihi arka planına saygılı, yapının tasarım dilinden uzaklaşmadan uygulanan çağdaş müdahale İngiltere'de işlek bir müze fonksiyonuna dönüştürüldüğü için maksimum insan kapasitesinde bir sosyal mekan dönüşümü çeşitli fonksiyonel ihtiyaçları da beraberinde getirmiştir. Örneğin galeri alanları, karşılama alanı, müze içi ticari alanlar ve sosyal alanlar plan organizasyonunda tüm iç mekanın deneyimleneceği şekilde konumlandırıldığı için mevcut kat yüksekliğinin en etkin şekilde kullanılması tasarım sürecinde karşılaşılan zorluklara örnek verilebilir. Bunun yanı sıra yapının değerini vurgulamak için geliştirilen çağdaş müdahaleler kapsamında bölgenin de sosyal ve ekonomik değerini etkileyen bir müdahalede bulunmak bir başka tasarım problemi oluşturmuştur. Bu kapsamda yeniden düzenlenen peyzaj ile binaya erişim kolaylaştırılmış ve "toplanma alanı" fikri desteklenmiştir.

Eski santral binasının 99 metre yüksekliğindeki ince uzun bacası, Thames Nehri'nin diğer tarafında bulunan St. Paul Katedrali'nin kubbesi ile bağlamsal ilişki içindedir. 1950'li yıllarda tamamlanan tuğla kaplı baca katedralin kubbesinin hemen karşısında, kubbe yüksekliği dikkate alınarak daha alçak olacak şekilde tasarlanmıştır [17]. Dini yapının varlığına da vurgu yaparak mevcut mirasın değerini arttıran bu yaklaşım orijinal yapının sahip olduğu karakteristik bağlamsal özelliklerden birini oluşturmaktadır (Şekil 9). Hem fonksiyonel olarak ihtiyaç duyulan gün ışığını sağlayacak hem de eski bacanın mevcut formu ile yarışmayacak bir çatı feneri müdahalesi hem somut hem soyut bir bağlam verisinin ürünüdür. Somut veri, baca ve katedral kubbesinin ince uzun formuna zıt yatay ve doğrusal bir çatı feneri tasarlanması iken soyut veri de hem katedralin hem de müze müdahalesinin bölge için "aydınlık" bir etkisi olması bu bağlamsal veriye örnek verilebilir. İç mekandaki kat yüksekliğinin toplanma alanında korunması tıpkı dini yapılarda olduğu gibi ziyaretçilerin içinde daha küçük hissetmesine sebep verdiği için ilahi bir his yaratmaktadır. Her ne kadar çatı feneri eklemesi yapılsa da cephedeki mevcut açıklıklara ince uzun açıklıkların eklenmesi St. Paul Katedrali'nden alınan referanslara örnek verilebilir (Şekil 9).

Şekil 9: Tate Modern ve St. Paul Katedrali'nin bağlamsal ilişkisini temsil eden görsel (Yazarlar tarafından düzenlendi).

Sonuç olarak, çağdaş müdahale sayesinde binanın erişilebilirliğini artırmış, yakın çevresini eğitim kurumları, ticari alanlar, ofisler gibi çağdaş mekanların artmasıyla bölgenin kalkınmasını sağlayarak kentin toplumsal değerine katkıda bulunmuştur. St. Paul Katedrali'nin tam karşısında konumlanan Tate Modern, endüstriyel tasarım dili ile bölgenin kültürel cazibesini arttırmış ve şehre sosyal ve ekonomik değer kazandırmıştır. Eski ve yeni arasındaki malzeme, yapım tekniği açısından uyum sağlanarak özgün endüstriyel tasarım dili korunarak vurgulanmış ve bu dil sürdürülmüştür. Özellikle, yarı şeffaf bir çatı fenerinin ve dikey eksen boyunca yatay açıklıkların eklenmesi, iç mekanı bol doğal ışıkla öne çıkarırken, orijinal dokuya minimum müdahale edilmiştir. Bu tasarım kararları, yapıyı yalnızca geçmişin izlerini taşıyan endüstriyel bir miras alanı olarak değil, aynı zamanda çağın ihtiyaçlarına uygun bir merkez olarak da dönüştürmüştür. Somut olduğu kadar soyut değerlere de saygılı bu yeni müdahale yapının özgün niteliklerine ek olarak çevredeki tarihi yapıların karakteristik özelliklerinden de referanslar alıp müdahalenin soyut değerini de artırmıştır. Çevre binalar ile renk, malzeme, doku ve ölçek olarak yaruşmayacak eklemeler bölge ile bütünleşmesini sağlarken, ayırt edilebilir olması da sağlanmıştır. Eski petrol depolarından dönüşen Tate Modern Switch House'un eklenmesiyle müze-sosyal alan bütünlüğü tamamlanarak mevcut kapasitesi arttırılmış, kullanım değeri yükseltilmiştir.

Tablo 3. Tate Modern'in Koruma Kuramı ve Bağlamsalcı Yaklaşım Ortak Değerlendirmesi

Tate Modern	Koruma Kuramı ve Bağlamsalcı Yaklaşım Ortak Değerlendirme Kriterleri		
	1	Eskiyi taklit etmeden çağdaş mimari yöntemler ve elemanlar kullanılarak özgünlük kazandırılması, yeni müdahale ile eski yapının ayırt edilebilmesi.	+
	2	Eski yapının yeni müdahale ile geliştirilerek aktif ve kullanılabilir hale getirilmesi, görünürlüğünün ve kullanımının artırılması	+
	3	Eski yapıya, bulunduğu döneme ayak uydurabilecek yeni müdahalelerin uygulanması, tarihsel sürekliliğin sağlanması	+
	4	Yeni müdahalenin geri döndürülebilir olması, eski yapıya minimum zarar vermesi, geleneklere saygılı olması	-
	5	İç mekanda yeni müdahalenin gelecek müdahalelere imkan vermesi, sürdürülebilir bir müdahale yöntemi uygulanması,	+
	6	İç mekanda somut olmayan kültürel değerlerin korunması, mevcut tarihi verilerin, geleneklerin ve kültürel motiflerin entegre edilmesi, geçmiş ile bugün arasında ilişki kurulması	+
	7	Yeni müdahalede toplumsal hafızayı koruyacak sürdürülebilir bir yöntem uygulanması, bağlam ile ilintili işlev kazandırılırken estetik çekiciliğin gözetilmesi.	+

B) Selexyz Dominicanen Kitap Dükkanı, Merkx + Girod Architects, Hollanda, Maastricht, 2006

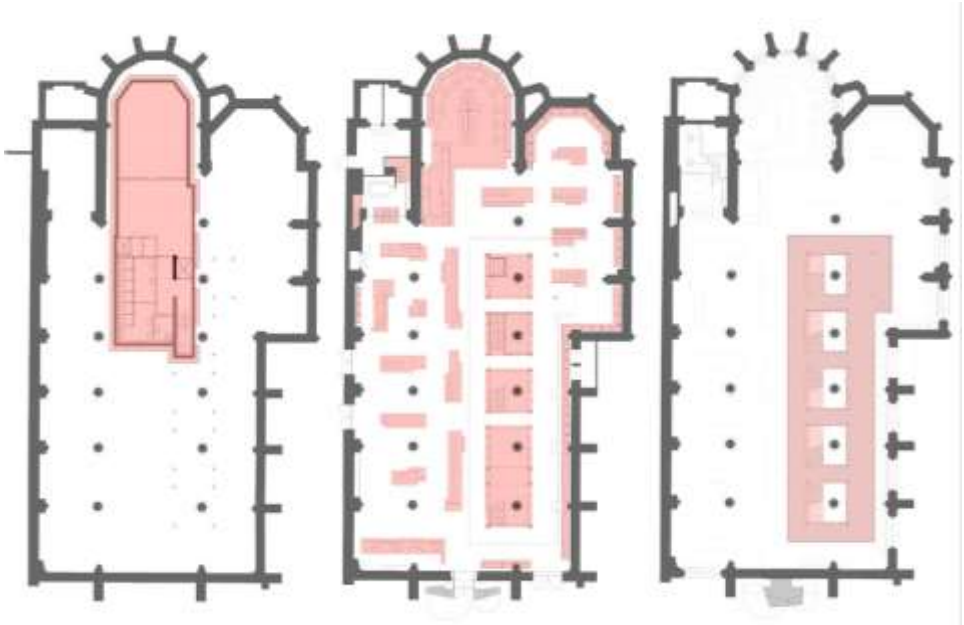
İnşaatına 13. yüzyılda başlanan günümüzde Selexyz Dominican Bookshop, Maastricht'de yer almaktadır. 1557 yılında yaşanan siyasi kriz ortamında hasar gördüğü bilinen kilise sonrasında restore edilip günümüze kadar çeşiti fonksiyonlara ev sahipliği yapmıştır [44] (Şekil 10.1). Okul, depo, sergi alanı, arşiv, posta ofisi gibi birçok amaçla kullanılsa da günümüzde Merkx + Girod Architects tasarımı olan kitap dükkanı işlevi ile varlığını sürdürmektedir [4]. Kilise içerisine çelik strüktür kullanılarak yerleştirilen kitap dükkanı kilisenin mevcut tavan yüksekliği kullanılarak iki kat şeklinde tasarlanmıştır (Şekil 10.2). 21 çelik kolon üstüne oturtulan iki katlı kitap rafları, kilisenin mevcut 5 kolonunun olduğu sağ bölüme yerleştirilmiştir. Orijinal yapının planına uygun şekilde çizgisel olarak devam eden çelik sistem orijinal yapıdan kopuk, duvar ve zemine minimum temas ederek yapının sağ tarafını kaplamaktadır. Bu strüktür üzerine kaplama yapılarak dolaşım alanları, gömme kitap rafları oluşturulmuştur. Zemin kat ve üst katlarda görsel bağlantının kopmaması için tanımlanan galeri boşlukları katlar arası erişimin sağlandığı merdiven ve asansörün konumlandırılması için de alan oluşturmuştur. Orijinal yapının sahip olduğu tonozlu tavan ile de görsel olarak dolaylı ilişkinin kurulması, eklemenin içinde bulunduğu kilise yapısının karakteristik özelliklerinden kopmamasına imkan vermiştir ((Şekil 10.7, 10.8). Yapının sol tarafında tavan yüksekliği asma kat tanımlanmadan oturma alanları yerleştirilerek kullanıcıların yapının içinde daha küçük hissedilebilecekleri o dini his korunmuştur (Şekil 10.5). Kilise yapılarının dini işlevleri sebebiyle karakteristik özellikleri olan bu yücelik hissiyatı yeni tasarımda da mekan organizasyonunu etkilemiştir. Her ne kadar çelik kolonlar ve koyu gri zemin kaplaması tercih edilse de bu mekanın sağ ve sol bölümündeki ve çağdaş müdahale içinde galeri boşlukları ile dolu-boş ilişkisi tasarımın tek bir kütle olarak algılanmasını sağlamıştır (Şekil 10.6).

Kilisenin koro alanı, kitap dükkanındaki en sosyal fonksiyon olan kahve içme alanı için tasarlanmıştır (Şekil 10.3). Sabit mobilyalar ile oturumların tanımlandığı bu alanda mobilya formu binanın tipolojik özellikleri göz önünde bulundurularak yarım daire biçimde 50 kişi kapasiteli kafe alanını oluşturmuştur (Şekil 10.4). Kilise fonksiyonu düşünüldüğünde işlevsel olarak en sosyal mekan olan bu yer, şarkıların söylendiği, etkinliklerin yapıldığı ana mekan olması yönüyle çağdaş müdahalede ile soyut olarak da

ilişkilenmektedir. Yeni işlevin en sosyal mekanı olan kafe alanı kullanım türü bakımından eski ile uyum içindedir.

Şekil 10: (1): Binanın cephe görünüşü ve gotik detayları, dış mekan sosyal alanları, (2): İç mekan girişi genel görünüş, (3), (4): Koro alanı kafe tasarımı, (5): Zemin katın sol tarafından çağdaş ekin genel görünüşü, (6): Birinci kattan tonozlar ile kurulan ilişki, (7): Çağdaş ekin strüktürel detayları, malzemeleri, (8) Birinci kat kitap rafları ve tonozların görünüşü (Archdaily, 2024).

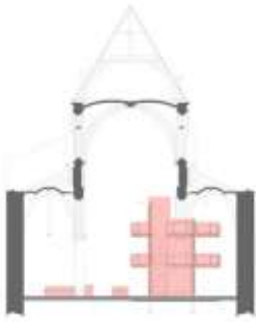
Yeni müdahale ile orijinal yapı, tarihi kimliğe zarar vermeden, ayırt edilebilir bir biçimde günümüz ihtiyaçlarını karşılayan bir fonksiyona dönüştürülmüştür. İç mekanın sağ bölümünü iki kat yüksekliği boyunca kaplayan ve kendi içinde ayrı bir kütle olarak kullanılan ek, kullanıcıları tonozlu klasik tavana daha yakın hissettirirken yapıya minimum zarar vermektedir. Buna ek olarak, yapının solunda bırakılan boşluk, gelecekte oluşabilecek ihtiyaçlara uygun hareket alanı bırakmaktadır. Aynı zamanda kurulan bu dikey ve yatay ilişki müdahale ölçeği bakımından yapının daha erişilebilir olmasını sağlamış, mevcut olanın önüne geçmeden görünürlüğünü arttırmıştır (Şekil 11).



Şekil 11: (Sol): Bodrum kat ihtiyaç alanları, tuvaletler, (Orta): Zemin kat plan çizimi ve ekler, (Sağ): Birinci kat plan çizimi ve ekler (Yazarlar tarafından düzenlenmiştir).

Hem tarihi yapı hem de çağdaş müdahale birbiri ile hem bütün hem de bağımsız olarak değerlendirilebilmektedir. Tasarım farklı dönemlerin yapım tekniklerini, malzemelerini ve kullanım ihtiyaçlarını yansıtırken renk, doku, biçim olarak birbirinin önüne geçmemektedir. Çelik strüktür üzerine koyu gri zemin ve duvar kaplamaları olmasına rağmen tarihi yapının duvarlarından koparılarak taşıtılan bu sistem yapıya minimum temasta bulunduğu için hafif görünmektedir. Soyut bağlamın mekan organizasyonu ve yapının çağdaş kimliğini etkilemesi, eski-yeni fonksiyonların bağlantısının iç mekanda ilişkili yerlerde kurulması, genel olarak kilise işlevinin bilgeliği temsil ederken kitap dükkanının da yine benzer şekilde bilgi merkezli bir odağa sahip olması çağdaş müdahalenin bağlamı ile güçlü bir ilişkiye sahip olduğunu göstermektedir. Terk edilen ve atıl durumda olan tarihi yapının sosyal bir mekana dönüştürülüp bulunduğu bölge ve hatta kent için cazibe noktası haline getirilmesi çağdaş müdahale ile yapının görünürlüğünün arttırıldığını kanıtlamaktadır (Tablo 4).

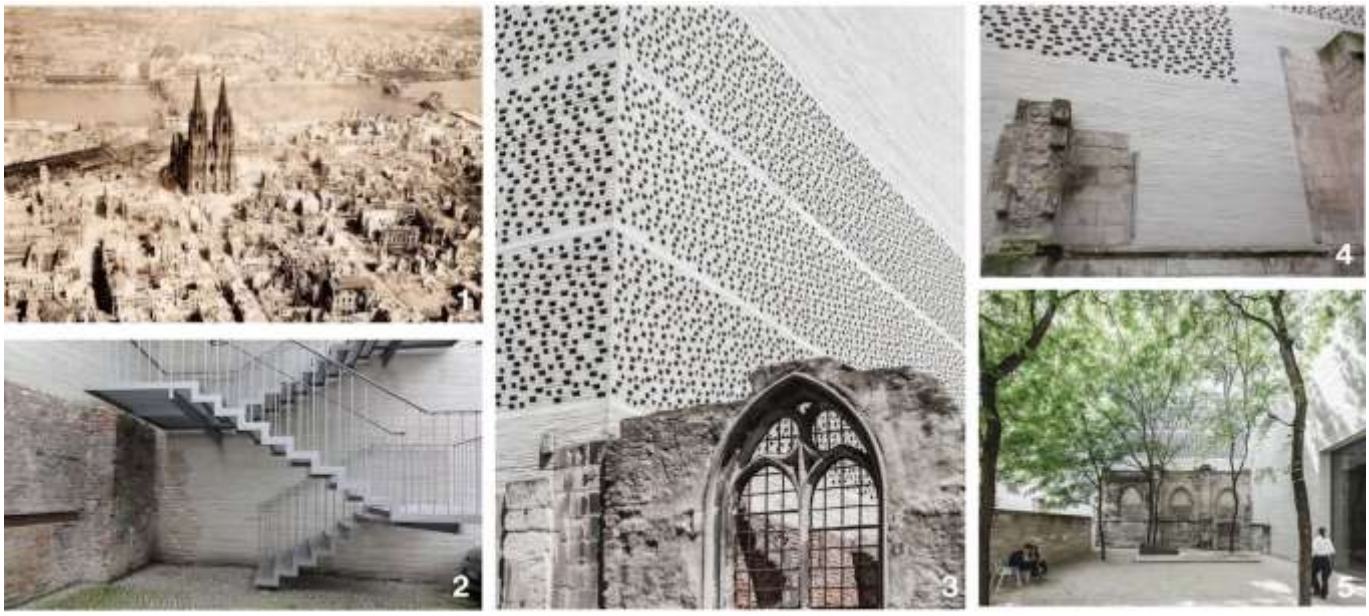
Tablo 4. Selexyz Dominicanen Kitap Dükkanı'nın Koruma Kuramı ve Bağlamsalcı Yaklaşım Ortak Değerlendirmesi

Selexyz Dominicanen Kitap Dükkanı	Koruma Kuramı ve Bağlamsalcı Yaklaşım Ortak Değerlendirme Kriterleri		
	1	Eskiyi taklit etmeden çağdaş mimari yöntemler ve elemanlar kullanılarak özgünlük kazandırılması, yeni müdahale ile eski yapının ayırt edilebilmesi	+
	2	Eski yapının yeni müdahale ile geliştirilerek aktif ve kullanılabilir hale getirilmesi, görünürlüğünün ve kullanımının artırılması	+
	3	Eski yapıya, bulunduğu döneme ayak uydurabilecek yeni müdahalelerin uygulanması, tarihsel sürekliliğin sağlanması	+
	4	Yeni müdahalenin geri döndürülebilir olması, eski yapıya minimum zarar vermesi, geleneklere saygılı olması	+
	5	İç mekanda yeni müdahalenin gelecek müdahalelere imkan vermesi, sürdürülebilir bir müdahale yöntemi uygulanması	+
	6	İç mekanda somut olmayan kültürel değerlerin korunması, mevcut tarihi verilerin, geleneklerin ve kültürel motiflerin entegre edilmesi, geçmiş ile bugün arasında ilişki kurulması	+
	7	Yeni müdahalede toplumsal hafızayı koruyacak sürdürülebilir bir yöntem uygulanması, bağlam ile ilintili işlev kazandırılırken estetik çekiciliğin gözetilmesi	+

C) Kolumba Müzesi, Peter Zumtor, , Köln, Almanya, 2007

Kolumba Müzesi, 2. yüzyıla kadar uzanan Roma yerleşimlerinden kalma farklı dönemlere ait kilise kalıntılarının bulunduğu bir alan üzerine inşa edilmiştir (Şekil 12.1). 1950'lerdeki savaş sonrası yıkımların ardından, Gotik St. Kolumba Kilisesi'nin cephe duvarlarının bir kısmı ayakta kalmıştır ve bu duvarlar arkeolojik kazı alanı olarak korunmaktadır [29]. Köln Başpiskoposluğu'nun düzenlelediği bir yarışma ile çağdaş müdahale yaklaşımı geliştirilerek korunması istenen bu alanda Köln'ün kültürel mirasının yansıtılıp büyük kitleler ile buluşturulması hedeflenmiştir. Yarışmayı İsviçreli mimar Peter Zumthor kazanmış ve yapı 2007 yılında tamamlanmıştır (Şekil 12.2, 12.3, 12.4, 12.5). Cephesindeki kalıntıların izleri referans alınarak tamamlanan iki katlı yapının iç mekanında arkeolojik kalıntılar olduğu gibi bırakılarak arkeolojik kazı alanında ziyaretçilerin üstünden geçen bir köprü ile mekanı deneyimlemeleri sağlanmıştır (Şekil 13). 2.Dünya Savaşı ile neredeyse yıkılan kiliseden geriye yalnızca dış duvarların bir kısmı ve Meryem Ana figürü (Yıkıntılardaki Madonna) ayakta kalmıştır [53]. Bunun yanı sıra savaş sonrası yıkımın ardından ayakta kalan Yıkıntılardaki Madonna halkın ibadet edebilmesi için 1950'li yıllarda Gottfried Böhm'ün tasarladığı ve orijinal fonksiyonunu sürdüren St.Columbs Şapeli (Madonna

with the Ruins) müze fonksiyonuna ait sergi alanları, etkinlik alanları ve okuma alanlarından ayrışarak orijinal fonksiyonu ile varlığını sürdürmektedir. Tarihi değerleri ve çağdaş yaklaşımları bir bütün içinde uyumlu hale getiren müze, kentin de geçmişi ile bugünü arasında kurulan ilişkinin ve tarihsel bütünlüğün simgesi haline getirilmiştir. Müzenin bulunduğu konum, müdahale yaklaşımı, plan organizasyonu ve soyut değerlerin tasarım sürecine etkisi aynı zamanda çevresel olarak ziyaretçilerin ve kentin ilişkisini yansıtmaktadır.

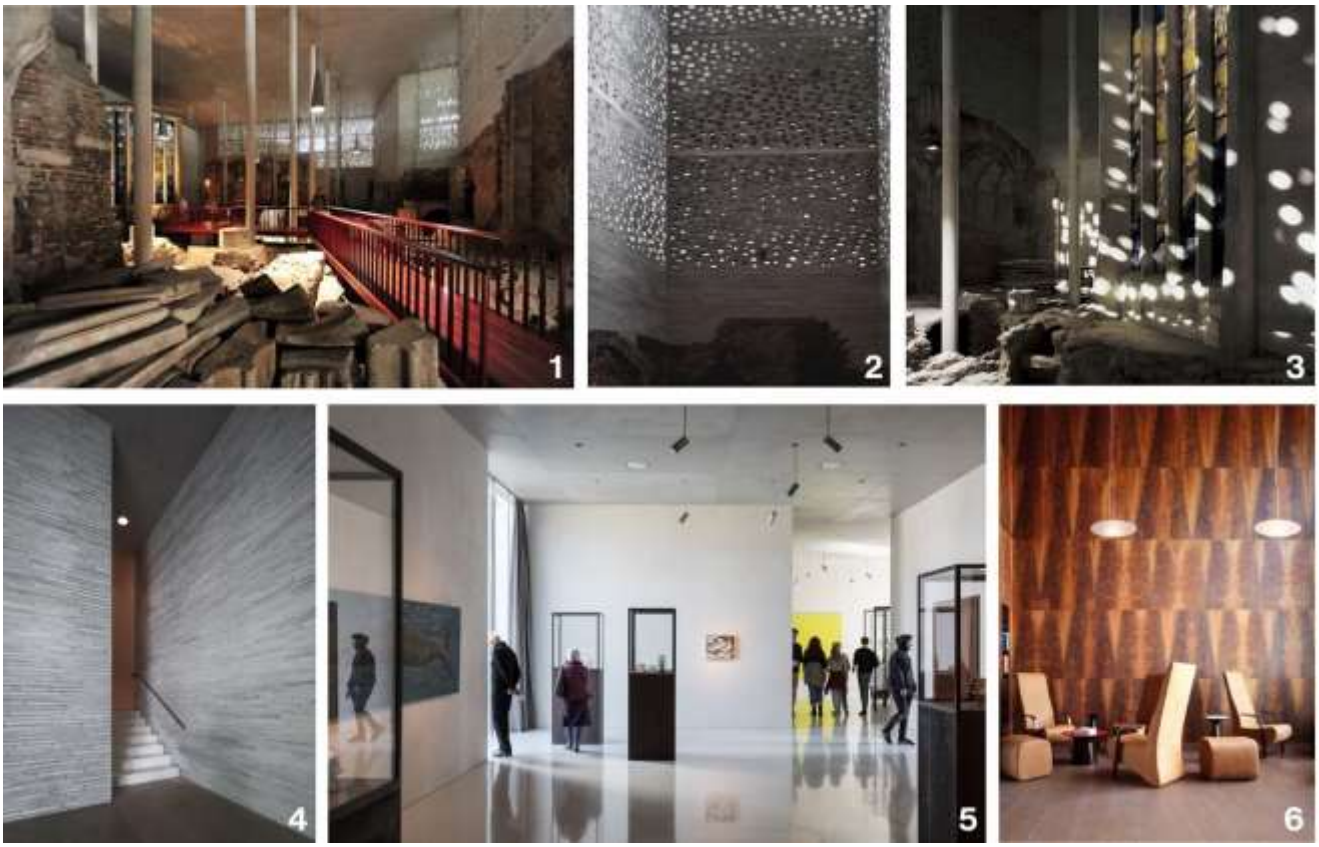


Şekil 12: (1): Kolumba Müzesi'nin savaş öncesi çevresinin genel görünüşü (James Beadling, 1945), (2), (3), (4), (5): Tarihi kalıntılar ile yeni cephe malzemesinin detay görünüşleri (Divisare, 2019).

Eski binanın ölçeğine, boyutuna ve tuğlalarına uygun olarak yığma duvar sistemi gibi orijinal binanın geleneksel yapım yöntemi referans alınarak üretilen duvarlar, 60 santimetre kalınlığındaki gri tuğlalar kullanırak müze için özel üretilmiştir [12] (Şekil 12.3, 12.4). Bu sistem içinde kurulan dolu-boş örüntü sayesinde iç mekanda oluşturulan atmosfer eski yapının Gotik diline modern bir yorum katılmış olduğunu göstermektedir. Işığın yarattığı anıtsal etkinin müze fonksiyonuna sahip çağdaş müdahalede orijinal katedralin karakteristik özelliği olan geniş açıklıklarından ilham alınarak bağlamsal bir ilişki kurulduğu anlaşılmaktadır. Müze için Petersen Tegl ve Zumtor işbirliğinde tasarlanan bu malzeme, mevcut kalıntılardan ayırt edilebilir şekilde yeni olmasına rağmen eski olanın da önüne geçmemektedir (Şekil 12.5). Bu sayede müze tasarımının temelini oluşturan eski-yeni arasındaki uyumun vurgusu cephe tasarımına da yansımaktadır. Bina kabuğu tamamlanırken oluşturulan boşluklar ise müzenin iç mekan organizasyonu, arkeolojik kalıntılar düşünülerek tasarlanmıştır (Şekil 13).

Şekil 13: (Sol): Zemin kat yeni ekler ve arkeolojik kazı alanlarının şematik plan çizimi, (Orta): Birinci kat şematik plan çizimi, (Sağ): İkinci kat şematik plan çizimi (Yazarlar tarafından düzenlenmiştir).

Zemin katta bulunan ve tarihi 2.yüzyıldan 11. ve 12. yüzyıllara uzanan eski Roma yerleşkelerinin kalıntılar ile birlikte 1950-60'lı yıllara ait izleri de barındıran arkeolojik kazı alanı, bu kattaki dolaşım şemasının oluşturulmasında belirleyici olmuştur. Müzenin dış mekan sergi alanı ve avlusu olan eski ortaçağ mezarlığının bulunduğu yer zemin kat ile bağlantılı olacak şekilde dolaşıma dahil edilmiştir. Richard Serra'nın 1997 tarihli Boğulanlar ve Kurtarılanlar isimli çelik heykeli mezarı burada olan, burada yaşayanların anısına bugün ile geçmişin birbirlerinden kopuk düşünülemeyeceğini ifade eden bir sembol olarak tasarlanmıştır [29]. Aynı katta bulunan kapalı sergi alanı arkeolojik kazı alanının merkezidir. Üzerinde ahşap bir köprü ile dolaşım sağlanan bu mekanda zemindeki kalıntılara dokunmadan, alan içinde tarihin deneyimlenmesi istenmiştir. Yıllar içinde birikerek farklı yükseklerde zeminde toplanan bu kalıntılar üzerindeki köprünün formuna da referans olmuştur. Zig-zag hatları ile binanın formuna zıt bir sirkülasyon alanı tanımlayan bu köprü, çağdaş müdahalenin yalnızca malzeme yönünden değil, biçim olarak da eski olanla ayrışmasına olanak tanımaktadır (Şekil 14.1, 14.2, 14.3). Dar bir merdiven ile çıkılan birinci kattaki açık sergi alanı kattaki genel sirkülasyon alanı boyunca konumlandırılmıştır (Şekil 14.4, 14.5). Buna ek olarak kapalı bir sergi odası da yerleştirilerek ışığın minimum ulaştığı bu alanın açık sergiden ayrışması istenmiştir. Bu karanlık odada genel aydınlatma olmadan yalnızca sergi vitrinlerini etkileyen noktasal aydınlatma kullanılması, yalnızca sergilenen değerli parçalara odaklanılmasını sağlamaktır [36]. İkinci katta tıpkı zemin kattaki gibi çizgisel olmayan, karmaşık bir dolaşım şeması oluşturulmuştur. Çeşitli sergiler kat içindeki oh farklı noktalarda yer alırken müze içinde diğer mekanlardan malzeme ve kullanım açısından farklılaşan okuma odası bulunmaktadır. Dört açık sergi dışında kapalı sergi alanları üç farklı yerde, kendi içinde iki alana ayrılan mekanlar olarak tasarlanmıştır. Okuma odası tamamı ahşap kaplı duvarları ve Köln manzaralı pencereden aldığı ışığı ile rahat oturumların olduğu, sosyal alan olarak dinlenme-okuma fonksiyonlarını bünyesinde barındıran bir oda olarak kurgulanmıştır. Mimar tasarımın tamamında hakim olan brütal görünümü bu odada kontrast oluşturarak sıcak bir mekana dönüştürmüştür. Suni deri hareketli oturum elemanları ziyaretçilerin tekil ya da ikili-üçlü gruplar halinde zaman geçirmesine imkan vermektedir (Şekil 14.6) [2].



Şekil 14: (1): Zemin kat arkeolojik kazı kalıntıları ve zig-zag ahşap köprü (Archdaily, 2024), (2), (3): Zemin kat duvar ve malzeme detayları (Divisare, 2019), (4): Birinci kata çıkan merdiven girişi (Divisare, 2019), (5): Birinci kat sergi alanları (ref), (6): İkinci kat okuma odası genel görünüş ve malzeme detayları (Archdaily, 2024).

Kolumba Müzesi çağdaş müdahalesi gerek yapılı çevreye ekleri gerekse iç mekan düzenlemeleriyle yapının sahip olduğu tarihi, sosyal ve kültürel değeri arttırmaktadır. Tarihi olanın önüne geçmeden, bütünleşerek kent için odak noktası haline gelmiştir. Bulunduğu dönemin ihtiyaçlarından biri olan müze fonksiyonuna ev sahipliği yaparken tarihte bir yolculuk yaşanmasına fırsat tanıyan iç mekan düzenlemeleri, kent ile doğal çevre bağlantısını koparmayan duvar tasarımları, kültürel aktivite ve sosyal alan çözümleri çağdaş müdahalenin başarısını göstermektedir. Birçok bağlam unsuru ile ilişkilendirilerek tasarlanan yapı yalnızca somut referansları tasarımda kullanmakla yetinmeyip soyut değerleri de mekansallaştırmıştır. Örneğin yıkımı, yok oluşu temsil eden soğuk duvar, tarihin içinde sıkışmışlığa bir çözüm gibi geliştirilen dolu-boş cephe yapısı, günümüzdeki sosyalliği, hareketi yansıtan dinamik plan organizasyonu ve ahşap, deri gibi malzemelerin kullanılması sıralanabilir. Müdahalenin tarihsel sürekliliği sağlaması, yapının kullanım değerini arttırması, estetik bütünlüğü koruyarak hem toplumsal hafızayı hem de ihtiyaç duyulan işlevleri sürdürmesi, iç mekan tasarımına bağlam verilerini entegre etmesi olumlu görülebilecekken yapılan müdahalenin geri döndürülemeyecek kadar büyük oranda olması olumsuz olarak nitelendirilebilir.

Tablo 5. Kolumba Müzesi'nin Koruma Kuramı ve Bağlamsalcı Yaklaşım Ortak Değerlendirmesi

Kolumba Müzesi	Koruma Kuramı ve Bağlamsalcı Yaklaşım Ortak Değerlendirme Kriterleri		
	1	Eskiyi taklit etmeden çağdaş mimari yöntemler ve elemanlar kullanılarak özgünlük kazandırılması, yeni müdahale ile eski yapının ayırt edilebilmesi	+
	2	Eski yapının yeni müdahale ile geliştirilerek aktif ve kullanılabilir hale getirilmesi, görünürlüğünün ve kullanımının artırılması	+
	3	Eski yapıya, bulunduğu döneme ayak uydurabilecek yeni müdahalelerin uygulanması, tarihsel sürekliliğin sağlanması	+
	4	Yeni müdahalenin geri döndürülebilir olması, eski yapıya minimum zarar vermesi, geleneklere saygılı olması	-
	5	İç mekanda yeni müdahalenin gelecek müdahalelere imkan vermesi, sürdürülebilir bir müdahale yöntemi uygulanması	-
	6	İç mekanda somut olmayan kültürel değerlerin korunması, mevcut tarihi verilerin, geleneklerin ve kültürel motiflerin entegre edilmesi, geçmiş ile bugün arasında ilişki kurulması	+
	7	Yeni müdahalede toplumsal hafızayı koruyacak sürdürülebilir bir yöntem uygulanması, bağlam ile ilintili işlev kazandırılırken estetik çekiciliğin gözetilmesi	+

D) Dovecote Stüdyo, Haworth Tompkins, İngiltere, Snape Maltings, 2009

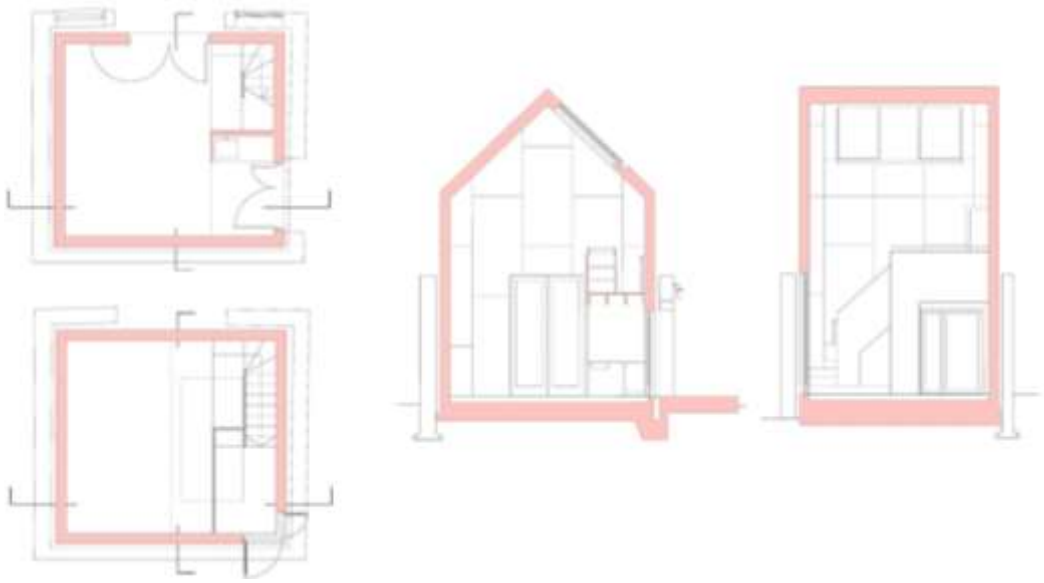
1970'den bu yana atıl durumda kalan tuğla yapı, gelişmekte olan Snape Malting müzik festivali alanının içinde bulunmaktadır (Şekil 15.1). Çevresindeki endüstriyel miras alanlarının kullanılabilir hale getirilmesine rağmen terk edilmiş ve yıkılmak üzere unutulan bu yapı, yeni tasarımla günümüzde varlığını sürdürebilmektedir (Şekil 15.2). Çağdaş müdahale, eski bir güvercinlik binasının müzisyenlerin prova yapabileceği bir müzik stüdyosu işlevi ile beraber gerekli toplantıların yapıldığı ve geçici sergi alanı olarak kullanılabilecek bir fonksiyona dönüşümünü kapsar. Haworth Tompkins tarafında tasarlanan yeni ek, üst tarafı yıkılan yapının içine yerleştirilmesiyle tasarlanmıştır. Bu ekleme için kullanılan 1200 x

2400 mm çelik plakalar, mevcut tuğla ile renk bakımından uyumlu olacak corten malzeme ile oluşturulmuştur (Şekil 15.3). Zaman geçtikçe hava koşulları sebebiyle paslanarak eskiyen bu malzeme, mevcut yapıdan ayırt edilebilirken aynı zamanda bütünlük oluşturmaktadır. Zemin ve birinci kattan oluşan bu kütle içinde iç mekan organizasyonu yapının gün ışığını en iyi şekilde alması sağlayarak oluşturulmuştur (Şekil 15.4). Zemin katta bulunan prova alanının, alanının yanı sıra birinci kattaki çalışma alanının pencere açıklıklarının belirlenmesinde etkili olduğu söylenebilir (Şekil 15.5). Örneğin birinci katta bir köşe boyunca dönen pencere iç mekan dış mekan bağlantısı kurulmasına olanak tanırken tavandaki çatı penceresi ile birlikte her iki katın da gün ışığı seviyesini arttırmaktadır (Şekil 15.6). Cephedeki metal ve soğuk görüntünün aksine iç mekan duvarları ladin kontrplakla kaplanarak daha sıcak ve doğal bir etki oluşturulmuştur. Hem özel hem de kamusal fonksiyona sahip olan yeni mekanda mutfak merdiven altına gizlenmiş, giriş ve holü oluşturan alanda tavan yüksekliği hissettirilmek istenmiştir. Akustiğin göz ardı edilmediği bu alanda tavana ve duvarlara yalıtım malzemeleri entegre edilmiştir [6].

Şekil 15: (1): Atıl durumdaki orijinal yap üstten görünüşü, (2): Çağdaş ekin yerleşim yönteminin görünüşü, (3): Binanın önden görünüşü, (4), (5): Zemin kat sağ ve sol taraf genel görünüşler, (6) Birinci kat köşe penceresi detayı (Archdaily, 2024).

Çağdaş müdahale hem soyut hem de somut birçok referans barındırmaktadır. İngiliz mimar bu yerleştirme müdahalesini yapının yıkılan fakat geçmişte ne biçimde var olabildiği öngörülebilen bu kısmı için hayalet benzetmesi yapmaktadır. Her ne kadar yeni malzeme ve yapım teknolojileri kullanılsa da bu ek orijinal yapının kontürünü oluşturduğu hat ile yükselerek geçmiş izleri bugün için somutlaştırabilmektedir (Şekil 16). Bulunduğu çevrenin doğal çevre özelliklerine de saygılı olan bu müdahale, cephede ve yapının çevresinde yerleşik hale gelen yeşil alanlara da saygı duyarak tarihi sürekliliğin bir parçası olması yönüyle korunduğu görülmektedir. Tarihi yapının Snape Malting bölgesinde bulunan Suffolk Nehri'ne birinci kattaki köşe penceresi ile dolaylı ilişki içinde olması, yeni

tasarımın doğal ve çevresel bağlam ile güçlü ilişkiler oluşturduğunu göstermektedir. Son olarak yapının geçmiş fonksiyonuna bakıldığında güvercinler için bir barınak olarak kullanılması, çağdaş müdahaledeki çelik, sert ve kafes gibi görüntünün de aslında bağlamsal bir ilişki sonucu oluşturulduğunu kanıtlar niteliktedir.



Şekil 16: (Sol Üst ve Alt): Zemin kat ve birinci kat plan çizimleri, (Orta ve Sağ): Kesit çizimleri ile çağdaş ek fonksiyonlarının detayları (Yazarlar tarafından düzenlenmiştir).

Özetle, yeniden işlevlendirme müdahalesi ile yapının özgünlük değeri artmış, eski yapıdan ayırt edilebilmiştir. Unutulmuş haldeki yapı tekrar kullanılmaya başlanarak tarihi yapının sosyal değeri arttırılmıştır. Yapı hali hazırda dönüşmekte olan festival alanına çağdaş müdahale sayesinde uyum sağlamış, tarihsel süreklilik korunmuştur. Yerleştirilen yeni tasarım tarihi yapıya zarar vermiyor olsa da iç mekan tek bir obje gibi ele alınıp tasarlandığı için yeni müdahalelere kısıtlı alan bırakmaktadır. Bağlamsal verileri tasarım girdisi haline getirip yapının hem işlevsel hem de estetik değerini arttıran tasarımcılar eskinin korunmasını ve yaşayan bir iç mekana dönüşmesi sağlanmıştır (Tablo 6).

Tablo 6. Dovecote Stüdyo'nun Koruma Kuramı ve Bağlamsalcı Yaklaşım Ortak Değerlendirmesi

Dovecote Stüdyo		Koruma Kuramı ve Bağlamsalcı Yaklaşım Ortak Değerlendirme Kriterleri	
	1	Eskiyi taklit etmeden çağdaş mimari yöntemler ve elemanlar kullanılarak özgünlük kazandırılması, yeni müdahale ile eski yapının ayırt edilebilmesi	+
	2	Eski yapının yeni müdahale ile geliştirilerek aktif ve kullanılabilir hale getirilmesi, görünürlüğünün ve kullanımının artırılması	+
	3	Eski yapıya, bulunduğu döneme ayak uydurabilecek yeni müdahalelerin uygulanması, tarihsel sürekliliğin sağlanması	+
	4	Yeni müdahalenin geri döndürülebilir olması, eski yapıya minimum zarar vermesi, geleneklere saygılı olması	+
	5	İç mekanda yeni müdahalenin gelecek müdahalelere imkan vermesi, sürdürülebilir bir müdahale yöntemi uygulanması	-
	6	İç mekanda somut olmayan kültürel değerlerin korunması, mevcut tarihi verilerin, geleneklerin ve kültürel motiflerin entegre edilmesi, geçmiş ile bugün arasında ilişki kurulması	+
	7	Yeni müdahalede toplumsal hafızayı koruyacak sürdürülebilir bir yöntem uygulanması, bağlam ile ilintili işlev kazandırılırken estetik çekiciliğin gözetilmesi	+

V. TARTIŞMA VE SONUÇ

Tarihi yapıların iç mekanlarına uygulanan çağdaş müdahale yaklaşımları göstermektedir ki yapıların geçmiş fonksiyonları, karakteristik özellikleri, bulundukları bölge için ifade ettikleri anlam, bağlamı ile kurduğu ilişki yeni müdahaleyi biçim ve plan organizasyonu açısından büyük ölçüde etkilemektedir. Ticari ya da kamusal ihtiyaçlara hizmet eden fonksiyonlara adapte edilseler bile bu yapılara günümüz ihtiyaçlarına uygun fonksiyonlar kazandırılmasında form olarak tarihi yapının kendisi yön vermektedir. Tate Modern'de endüstriyel miras yapısı kamusal bir alana dönüştürülürken çağdaş müdahalenin en belirgin eklerinden biri olan çatı feneri yapının sahip olduğu çizgisel plan düzeni göz önünde bulundurularak, müzenin gün ışığı ihtiyacını karşılayacak şekilde cam kaplama ile oluşturulmuştur. Yapının bulunduğu çevre ile etkileşimini arttırmayı amaçlayan peyzaj düzenlemeleri ve giriş alanları iç mekan - dış mekan arasında güçlü bir ilişki kurulmasını sağlayarak yapıya erişimi kolaylaştırmıştır. Öte yandan Kolumba Müzesi'nde yine müze fonksiyonu kazandırılırken bu sefer eski yapı içinde günümüze kadar ulaşan arkeolojik kazı alanı eski kilise binasının karakteristik özelliklerinden biri olan ışık ile vurgulanmış, cephede bırakılan boşluklar ile tuğlaların arasından bu kazı alanını bir nevi gün yüzüne çıkaran ışık hüzmesi yaratılmıştır. Aynı zamanda doğal havalandırma imkanı veren bu boşluklar ile iç mekan - dış mekan bütünlüğü cephe tasarımı sayesinde oluşturulmuştur. Aynı ihtiyaca hizmet eden farklı geçmişlere sahip bu iki projeden yapıların mimari kimliklerinin yeni müdahale sürecinde ne kadar büyük bir öneme sahip olduğu anlaşılmaktadır. Selexyz Dominicanen Kitap Dükkanı için tasarlanan çağdaş ek tasarımının orijinal kilise yapısının geleneksel tonozlu taşıyıcı sistemi ile zıt fakat uyumlu bir ilişki kurduğu görülmektedir. Yine yapının özgün kimliğini yansıtan tavan yüksekliği, plan tipi, yapım teknolojisi gibi faktörlerin çağdaş müdahalede tasarımı etkileyen başlıca tasarım verileri olarak kullanıldığı söylenebilir. Hacmin doğru algılanıp kitap dükkanı fonksiyonuna dönüşümünde yapının kullanım kapasitesi geliştirilerek kafe gibi mekanların eklenebilmesine olanak tanınmıştır. Dovecote Stüdyo'da da tıpkı kitap dükkanı gibi kamusal kullanıma imkan veren etkinlik mekanı, prova mekanı gibi ihtiyaçların tek bir hacimde, eski yapının fiziksel özellikleri gözetilerek çözümlenmiştir. Tarihi yapının

tuğla görünümü ile zıt fakat çevredeki diğer tarihi yapıların endüstriyel kimliği ile uyumlu çelik taşıyıcı sistem, iç mekanda osb ladin kaplama plakalar ve akustik yalıtım malzemeleri kullanılarak çağdaş fonksiyon için uygun koşulların sağlanmasına imkan vermiştir. Buradan da anlaşılmaktadır ki somut ve soyut referanslar kullanılarak tasarlanan yeniden işlevlendirme projeleri hayata geçirilerek yapıların kullanılabilirliği arttırılmaktadır.

Sonuç olarak yapılan literatür taramaları ve örnek incelemeleri göstermektedir ki koruma kavramı tarihi süreklilik içerisinde zamanla gelişip değişerek güncel yöntemlerin oluşmasına zemin oluşturmuştur. Tarihi yapıların işlevsel dönüşümünde iç mekanların çağdaş ihtiyaçlar ile uyumunu inceleyen ve bu noktada tasarımlara bağlam kavramının etkisini analiz eden bu makalede, koruma – bağlam ilişkisi anlaşılmaya ve ortak noktaları belirlenmeye çalışılmıştır. Yeniden işlevlendirme örnekleri incelenerek anlaşılmıştır ki yapıların korunması ve bulunduğu çağ ile güçlü ilişkiler kurmasında bağlamsal veriler tasarımların niteliklerini arttırmaktadır. Unutulan ve/veya kullanılmayan bu eski yapılara sosyal değer kazandırılırken, yeni ekin müdahale biçimi tespit edilirken alınan bağlamsal referanslar tasarımcılara hareket alanı tanımaktadır. Var olana yeni değerlerin eklenmesinin, var iken görünemeyen değerlere somut ve soyut yeni anlamlar kazandırılmasının önünü açan koruma kuramı müdahalelerin başarılı olabilmesi için eski yapıya biçim olarak saygılı, hafif, eklendiği dönemi yansıtan, geleneklerin sürdürülmesine imkan tanıyan, sosyal değerin arttırıldığı korurken kullanılabilen tasarımların başarıyı arttıracağını söylemektedir. Bu sayede çağdaş ek yapılacak tarihi yapıların bağlamının anlaşılması ve uygun yöntemlerle aktarılarak tasarım sürecinde kullanılması, iç mekan müdahalelerinin özgün ve ayırt edilebilecek düzeyde başarılı sonuçlar yaratmasını mümkün kılacaktır.

Tablo 7. Örnek Çalışmaları Genel Değerlendirme Tablosu

ÖRNEKLER	1	2	3	4	5	6	7
	Eskiyi taklit etmeden çağdaş mimari yöntemler ve elemanlar kullanılarak özgünlük kazandırılması, yeni müdahale ile eski yapının ayırt edilebilmesi	**Eski yapının yeni müdahale ile geliştirilerek aktif ve kullanılabilir hale getirilmesi, görünürlüğünün ve kullanımının artırılması**	**Eski yapıya, bulunduğu döneme ayak uydurabilecek yeni müdahalelerin uygulanması, tarihsel sürekliliğin sağlanması**	**Yeni müdahalenin geri döndürülebilir olması, eski yapıya minimum zarar vermesi, geleneklere saygılı olması**	**İç mekanda yeni müdahalenin gelecek müdahalelere imkan vermesi, sürdürülebilir bir müdahale yöntemi uygulanması**	**İç mekanda somut olmayan kültürel değerlerin korunması, mevcut tarihi verilerin, geleneklerin ve kültürel motiflerin entegre edilmesi, geçmiş ile bugün arasında ilişki kurulması**	**Yeni müdahalede toplumsal hafızayı koruyacak sürdürülebilir bir yöntem uygulanması, bağlam ile ilintili işlev kazandırılırken estetik çekiciliğin gözetilmesi**
	+	+	+	-	+	+	+
	+	+	+	+	+	+	+
	+	+	+	-	-	+	+
	+	+	+	+	-	+	+

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The Impact Of Foreign Aid On Economic Growth In Mena Countries

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Abstract – Foreign aid can have either a beneficial or negative impact on economic growth. The role of foreign aid in supporting growth by augmenting local savings has been a focus. Great argument.
Foreign assistance inflows to MEMA have grown significantly, from $20.99 billion in 1990 to $34.44 billion in 2021. However, this did not have a favorable influence on ODA or economic growth.
This study selectively examined the empirical relationship between foreign aid and economic growth in eight countries in the Middle East and North Africa region: Algeria, Tunisia,Egypt, Jordan, Lebanon,Iran, Morocco, and Oman, using panel data from 1990 to 2021. The analysis uses a panel data technique: cointegration tests, pooled group mean/lagged automatic distribution. The cointegration result shows a long-run relationship; The PMG/ARDL model also shows a negative and long-run association between foreign aid and economic growth in selected countries in the MENA region. When we apply the cross-sectional PMG/ARDL test to the short-run coefficients, all countries, using the cross-sectional PMG/ARDL test to the short-run coefficients, all countries have a negative long-run relationship between economic growth and foreign aid. Economy. The exception is Algeria and Morocco, which have a positive association between foreign aid and long-term economic growth. However, Tunisia does not have a statistically significant relationship between foreign aid and economic growth.

Keywords – Foreign Aid, Economic Growth, Mena Countries

I. INTRODUCTION

Foreign aid, also known as international aid or assistance, is the voluntary transfer of resources, funds, technical expertise, or support between nations or international organizations in order to stimulate economic growth, alleviate poverty, address humanitarian crises, and improve overall well-being in recipient countries. This help, in the form of grants or concessional loans, is critical to developing countries' economic stability, welfare, and long-term growth. While the OECD regards Official Development Assistance (ODA) as important in encouraging economic growth and well-being, the impact of foreign aid is varied. Positive impacts include economic growth and employment creation, however negative consequences include reliance, wasteful resource usage, and economic distortions such as the Dutch disease. The efficiency of foreign aid is strongly dependent on the structural and administrative circumstances of the receiving nations, with strong institutions being critical for maximizing its effects and guaranteeing long-term economic growth.

The database and economic research unit have been enlarged to better understand the impact of foreign aid on MENA economies. This thesis will concentrate on eight MENA states: Algeria, Egypt, Jordan, Morocco, Iran, Lebanon, Tunisia, and Oman, due to the necessity for additional material on the eight chosen nations while discussing the MENA area. The primary research topic is to determine the influence of foreign aid on GDP and the magnitude of that impact in the MENA area, with a focus on the selected countries. The study provides rest in the form of shadows. The following section discusses the method with the data, including the empirical model required and the empirical approach. Section 3 provides detailed results and discussion. Section 4 discusses the conclusion.

II. Littérature review

Several studies have shown that foreign aid positively impacts economic growth. For instance, Golder et al. (2021) found a positive relationship between foreign aid and growth in Bangladesh, using Autoregressive Distrusted Lag (ARDL) bounds tests. In Sudan, Mustafa et al. (2019) found a long-term positive relationship between aid and growth, by using Autoregressive Distrusted Lag (ARDL) bounds tests.. Moolio and Kong (2016) found a long-term cointegration relationship between economic growth and foreign aid in Lao PDR, Cambodia, Vietnam, and Myanmar, by using panel cointegration tests, panel fully modified ordinary least squares (FMOLS), and panel dynamic ordinary least squares (DOLS) estimators. Tait and Chatterjee (2015) found that foreign aid positively affects growth in 25 Sub-Saharan African countries in the long run between 1970-2012. Furthermore, aids for social infrastructure, such as health and education, have a strong effect on growth. Sahoo and Sethi (2013) found that foreign aid positively affects both development and economic growth, with the growth effect being stronger from 1975-76 to 2009-10 using the Ordinary Least Square (OLS) test. Mitra (2013) also found a long-term relationship between aid and growth in Cambodia. Using a structural VECM between 1971 and 2009. Asteriou (2009) found a positive relationship between aid and growth in five South Asian countries. Using freshly developed panel unit root tests, mean group, and pooled mean group estimate approaches on cross-country panel data.

On the contrary, Studies indicate a long-term negative correlation between growth and foreign aid, supporting the claims of some scholars that foreign aid has a detrimental influence on GDP. According to Adebayo and Kalmaz (2020) found a long-term association between Nigeria's economic growth, foreign aid, trade, gross fixed capital creation, and inflation rate using novel econometric tools. Appiah-Konadu et al. (2016) found a link between aid and economic growth in Ghana from 1972 to 2012, with labor, capital, and government spending benefiting the economy in both the long and short terms. utilizing the ARDL and error correction term techniques. connections. However, foreign aid and interest payments on external debt had a detrimental effect on growth. Tüzemen and Tüzemen (2015) examined the influence of foreign aid on Turkey's economic development between 1967 and 2013.using the Johansen cointegration test and Error

Correction Model. Mbah and Amassoma (2014) found a negative association between foreign aid and economic development in Nigeria from 1981 to 2012, with the cointegration test and error correction model.

III. DATA AND METHODOLOGY

1 DATA SET

The study uses secondary data. Annual panel data on AID, EX, and GCG are independent variables, while the dependent variables are GDPPC for selected MENA countries, which we acquired using World Bank measures. This variable refers to the available data in WB from 2002 and 2022. We utilize EViews (version 12) for econometric analysis.

This research uses an empirical relationship model between foreign aid (ODA), Exports of goods and services (EXP)and Gross Capital Formation (GCF), and was advanced to execute MENA economic growth. Founded on studies of khan et al. (2019), , use the under model expressing the connection among foreign aid and economic growth. The empirical association that is implicitly presented as follows will be analyzed using the model below:

GDPPC =F(ODA, , GCF, EXP)..... eq 1 3

As a result of converting equation 1 into linear function:

$GDPPC = \beta +$ ODA + β GCF + β EXP + ε i,t 0 1 i,t 2 i,t 3 i,t 4 i,t i,t

Where:

i = 1, ..., N =8 (countries),

N: cross-sectional units

t =1990,....., T=2022 (time),

β0: slope or intercept or constant of the model,

..... eq 2

β , β , β , , : the coefficient of the explanatory variables in the model, 123

$\varepsilon i,t$: the error term.

And finally, we include the natural log for both side in eq 2. By transfiguring variables obsessed by log, all slope constants will be understood as elasticity. ampere plus of elasticity is that it might aid free the model from the tricky of sequential correlation.

ln($GDPPC$)=β +β LNODA +β LNEXP +β $LNGCF$ + i,t 0 1 i,t 2 i,t 3 i, ,t

$\varepsilon i,t$..... eq

3.

2. Estimation Technique

Pesaran et al. (1999) predicted that the PMG estimator associated with combining would equal the average of the coefficients at the conclusion of the cross-sectional. We utilize the ARDL model since it is appropriate for our data collection. First and foremost, unlike this study, it allows for a combination of stationary variables such as level I (0) and first different I (1) rather than second different I (2). Additionally, it is excellent for research with small sample numbers.

The ARDL (p, q) model utilized in this research may be represented as follows:.

$$.\text{LNGDPPC}_{it}= \theta+\sum_{J=1}^{p} Y_{ij}(\text{LNGDPPC})_{i,t-j}+\sum_{J=1}^{q} Y_{ij}\ \text{LNODA}_{i,t-j} +$$

$$\sum_{J=1}^{p} Y_{ij}\ \text{LNGCF}_{i;t-j}++\sum_{J=1}^{p} Y_{ij}(\text{LNGEXP})_{j=1} \qquad (4)$$

Equation can be stated using Pesaran and Smith's (1999) panel ARDL for

$$(\Delta LNGDPPC)_{i,t} = \theta_0 + \emptyset(LNGDPPC)_{it-1} + \theta_{1t} LN\text{ODA}_{i,t-1} + \theta_{2t} LNFDI_{i,t-1} + \theta_{3t} LNGCF_{i,t-1} + \gamma_{ij} \Delta LN\text{ODA}_{i,t-j} + \theta_{5t} LN\text{EXP}_{i,t-1} + \sum_{j=1}^{P} \text{Y}_{ij} (\Delta LNGDPPC)_{i,t-j} + \sum_{j=1}^{q} \text{Y}_{ij} \Delta LN\text{ODA}_{i,t-j} + \sum_{j=1}^{P} \text{Y}_{ij} \Delta LN\text{GCF}_{i,t-j} + \sum_{j=1}^{q} \gamma_{ij} \Delta LN\text{EXP}_{i,t-j} \quad (5)$$

The equation for LNGDPPC is as follows: $\emptyset$ is the initial lagged coefficient, $\theta 0$ is the constant term, $\theta 1t$ to $\theta 6t$ are long-run constant elasticities, ij is for short-run constants, p indicates lag for the dependent variable, q indicates lag for independent variables, and $\varepsilon i,t$ represents error remaining constant elasticity.

The link to ECM was first made by Engle and Granger (1987). The majority of the factors offered by ECM may affect the variables. The model's variables can form long-term associations, as shown by the ECM's statistical significance and negative sign. The co-integration of the variables may be validated most easily with this method (Bannerjee et al. 1998). The co-integrated variables' error correction model (ECM) describes how an independent variable affects the dependent variables. The divergence in the dependent variable indicates the relationship between the short-term and long-term equilibria..

The next step is to estimate equation 5 using the ARDL technique in instruction to create the short- and long-term subtleties limits now that there is a co-integration link between the variables. Equation 6's error correction is displayed below

$$EC_{i,t} = (\Delta LNGDPPC)_{i,t} - \theta_0 - \sum_{J=1}^{P} \text{Y}_{ij} (LNGDPPC)_{i,t-j} + \sum_{j=1}^{q} \text{Y}_{ij} LN\text{ODA}_{i,t-j} + \sum_{j=1}^{P} \text{Y}_{ij} LN\text{GCF}_{i,t-j} + \sum_{j=1}^{q} \gamma_{ij} LN\text{EXP}_{i,t-j} \quad (6)$$

Next, a time series variable is referred to as the "Granger cause," per Granger (1969).When and only when **β** leads Y to previous values of Y. Granger causality may be used to distinguish between unidirectionality and bidirectionality. Though bi-directionality departs from X to Y if X granger cause Y and Y granger cause X ($X \rightarrow Y$), it is regarded to be un-directional **β** to Y if X granger cause Y but Y doesn't granger X ($X \rightarrow Y$). If two variables do not cause one another, then there is no directionality between them and they are independent of one another.

$$x_{i,t} = \beta_0 + \sum_{i=1}^{n} \beta_i y_{t-1} + u_{i,t} \quad (7)$$

$$y_{i,t} = \beta_0 + \sum_{i=1}^{n} \forall_i x_{t-1} + \aleph_{i,t} \quad (8)$$

IV. RESULTS OF DATA

1. Descriptive Analysis

Descriptive statistics include mean, median, maximum, minimum, and standard deviation, as well as skewness and kurtosis. Descriptive statistics were used to examine the trends of all independent and dependent variables.

Table 1: Descriptive Analysis

	LNGDP	LNGCF	LNEXP	LNODA
Mean	8.407	3.284	3.384	20.068
Median	8.276	3.318	3.409	20.191
Maximum	10.038	3.927	4.019	22.795
Minimum	7.659	1.678	2.336	16.906
Std.Dev	0.490	0.374	0.362	1.134
Skewness	1.564	-0.922	-0.504	-0.208
Kurtosis	5.595	4.864	2.865	2.633

Source student's compilation from E-view 12

The mean value of LNGDPPC is 8.40 and the median value of LNGDPPC is 8.27
The maximum of LNGDPPC is 10.03 and minimum value of LNGDPPC is 7.65, standard deviation of LNGDP is 0.49. The mean value of LNGCF is 3.28 and the median value of LNGCF is 3.31. The maximum of LNGCF is 3.92 and minimum value of LNGCF is 1.67, standard deviation of LNGF is 0.37.

The mean value of LNEXP is 3.38 and the median value of LNEXP is 3.40 The maximum of LNEXP is 4.01 and minimum value of LNEXP is 2.33, standard deviation of LNEXP is 0.36. The mean value of LNODA is 20.06 and the median value of LNODA is 20.19 The maximum of LNODA is 22.79 and minimum value of LNODA is 16.90, the standard deviation of LNODA is 1.13
All variables are negatively skewed because the value of skewness is less than zero, except LNGDPPC. All variables that have kurtosis less than 3 except LNGDPPC and LNGCF, these mean the kurtosis variables that have kurtosis less than 3 have a very lox and implied very extreme deviation from normality(Kurtosis levels between 4 and 50 were seen as a very signification departure from normality by Engle and Patton (2001)).

2 Correlation Matrix

The study uses pairwise correlation of the independent variables to determine identity alignment in the analysis, but no explanation of causality. Beginning with the highest relation 1 and the lowest correlation I between independent variables, the analysis indicates whether the relationship between two variables is positive or negative. When the correlation value is 0, there is no correlation between variables, however, when it is one, there is a perfect correlation between variables.

Table 2 :Correlation matrix

	LNGDPPC	LNGCF	LNEXP	LNODA
GDP	1			
GCF	-0.188	1		
EXP	-0.059	0.049	1	
ODA	0.274	-0.491	0.080	1

Source student's compilation from E-view 12

Table 2 shows that LNGDPPC is positively correlated with LNODA and negatively correlated with LNEXP and LNGCF. LNCGF has a positive relation with LNEXP and a negative relation with LNODA. LNEXP is positively correlated with LNODA

the correlation between LNGDPPC and LNODA is the highest one (0.274). The lowest correlation is between LNGCF and LNODA (-0.295).

3 Cross Section Dependence

The experimental investigation investigated the properties of LNEXP, LNODA,and LNGCH on LNGDPPC. Table 3 depicts the effect of cross-seasonal dependency. The null hypothesis (of) no cross-sectional dependency and the alteras. Hypothesis (H): Cross-sectional dependency. The H hypothesis is accepted when the p-value is greater than 5%, indicating no cross-sectional dependency. Breuch-Pagan IM, Persaran scaled M, and Persaran CD all have a probability smaller than 0.05, implying that they reject Ho and hence stimulate cross-section dependency.

Table 3 : Residuel Cross-Section Depend Test

TEST	Statistic	P-Value
Breusch-Pagan LM	172.396	0.000
Pesaran Scaled LM	19.295	0.000
Pesaran CD	10.222	0.000

Source student's compilation from E-view 12

4 Unit Root Testing Results

4..1 First-Generation Panel Unit Root Test

Table 4 contains the findings of the LLC, IPS, ADF, and PP panel unit root tests, as well as the stationary at levels and initial differences for each variable. The significance level of the test statistic is used to decide whether to accept or reject the hypothesis. The null hypothesis (Ho) is rejected and accepted in significant test statistics at 1%, 5%, and 10% significance levels. The findings indicate that LNGDPPC is stationary at I(0), whereas LNGCF, LNEXP, and LNODA are stationary at I(1).

.4.2 Second-generation Panel Unit Root Test

A second-generation panel unit root test of this type is the cross-sectionally improved test. The proposed IPS (CIPS) exam by Pesaran (2007). Pesaran made a subtle one-time addition to the regression equation that was utilized for testing in order to explicitly account for a common component. correlation between cross-sectional data. Unit root test is the null hypothesis ($H0$), and there is no unit root test as the alternative hypothesis ($H1$). Table 5 displays the CIPS test results. Table 5 displays the same outcome as the first generation unit root test, showing that LNGDPPC is the only entity stationary at I (0) and LNODA, LNEX, and LNGCF stationary at I (1).

Table 5: Results of second-generation panel unit root.

	CIPS		
	I	I (1)	Conclusion
	t-stat	t-stat	
LNGDPPC	-2.995***	-3.161***	**I (0)**
LNREM	-1.77	-3.396***	**I (1)**
LNGCF	-1.945	-6.160***	**I (1)**
LNGCF	**-1.683**	**-3.81*** **	**I (1)**

Source student's compilation from E-view 12

5 Panel Cointegration Test

This study employed the panel cointegration technique to show that the variables under examination are long-run cointegrated. This approach includes Pedroni Residual Cointegration, Kao Residual Cointegration, and Johansen-Fisher Panel Cointegration Tests. For analysis, we will employ Johansen-Fisher Panel Cointegration, which provides two sorts of results: trace test statistics and max-eigen test statistics.

Ho: There is no cointegration. (Null hypothesis).
H. denotes cointegration. (Alternative hypothesis)

If the value is not statistically significant, we are given the null hypothesis. Kao Residual cointegration is accomplished in the completed ADF statistics. The hypothesis for this test is that there is no cointegration. We reject Ho if the p-value is smaller than alpha, suggesting that we have a long-term association. The Pedroni residual co-integration test is a statistical test that detects long-term correlations or co-integration between two or more variables. Pedroni (1999) introduced this test, which is now frequently used in econometrics and data analysis.

According to the results in Table 6, five of the eleven tests are statistically significant at various levels of confidence (1%, 5%, 10%), implying that there is a long-run relationship (cointegration) between the dependent and independent variables. For this reason, we used the Johansen-Fisher panel and the Kao Residual Cointegration test.

Table 6:pedoroni Residual Co-Integration Test

Dependent Variable: Lngdppc				
Alternative Hypothesis: Common Ar Coefs. (Within-Dimension)				
	statistic	Prob	Weighted statistic	prob
Panel V-Statistic	3.823***	0.0001	4.104***	0.000
Panel Rho-Statistic	-0.3104	0.3781	0.0799	0.529
Panel Pp-Statistic	-4.406***	0.000	-2.4405*	0.054
Panel Adf-Statistic	-1.175	0.113	-0.799	0.211
Alternative Hypothesis: Individual Ar Coefs. (Between-Dimension)				
	statistic	Prob		
Group Rho-Statistic	1.433	0.924		
Group Pp-Statistic	-1.698**	0.008		
Group Adf-Statistic	-0.214	0.41		

Source student's compilation from E-view 12

Refer to table 7, shows the results of the Johansen-Fisher panel cointegration test.
The Fisher statistics from the trace and max-eigen test illustrate the attendance of four cointegration equations as the 3 primary stats in trace test statistics and 2states in the mac-eigen test are statistically significant at a level of 1%. we reject Ho's existing cointegration. representative that a long-run association happens.

Table 7: Johansen-Fisher Panel Cointegration Test Result

HYPOTHESIZED	FS (TRACE TEST)	P-VALUE	FS (MAX-EIGEN TEST)	P-VALUE
NONE	287.82***	0.0000	262.19***	0.0000
AT MOST 1	245.31***	0.0000	138.07***	0.0000
AT MOST 2	22.31***	0.0000	16.90***	0.0001
AT MOST 3	23.99***	0.0001	23.33***	0.0001

Source:student's compilation from E-view 12

Note:***.*Show level of significance at 1% and 5% respectively

Refer to table 8, the result Kao Residual Cointegration is very significant at 0.01 level of significance, reject $H_{0,\ the}$ representative that long-run relation exists

Table 8: Resultat Of Kao Residual Cointegration

	T-Statistic	Prob
ADF	-3.17384***	0.0008
Residual Variance	0.409683	
HAC Variane	0.248198	

Source student's compilation from E-view 12
Note :*** significance at 1%

6 Determination of the Optimal Lag Length Using VAR Model :

According to (VAR) analysis, the ideal lag length is 4 based on a Rorterion, FPE criteria, HQ criterion,. As a result, the optimal length for estimating the PMG/ARDL model is at time (t-4). As demonstrated, Table9 and Figure 1 were acquired in the following order.

Table 9 : VAR Large Order Selection Criteria

LAG	LOGL	LR	FPE	AIC	SC	HQ
0	-60.535	NA	0.004862	6.090	6.090	6.0518
1	420.344	1992.918	2.19^{e}-07	-3.983	-3.654*	-3.805
2	468..408	61.415	1.86^{e}-07	-4.144	-3.552	-3.904*
3	468.407	29.776	1.87^{e}-07	-4.143	-3.288	-3.797
4	486.638	33.375*	1.83^{e}-07*	-4.1655*	-3.048	-3.713
5	497.046	18.642	1.93^{e}-07	-4.1099	-2.729	-3.551
6	510.099	22.857	2.00^{e}-07	-4.080	-2.43	-3.415

Source : student's compilation from E-view 12

Note :*indicate lag order selected by criterion

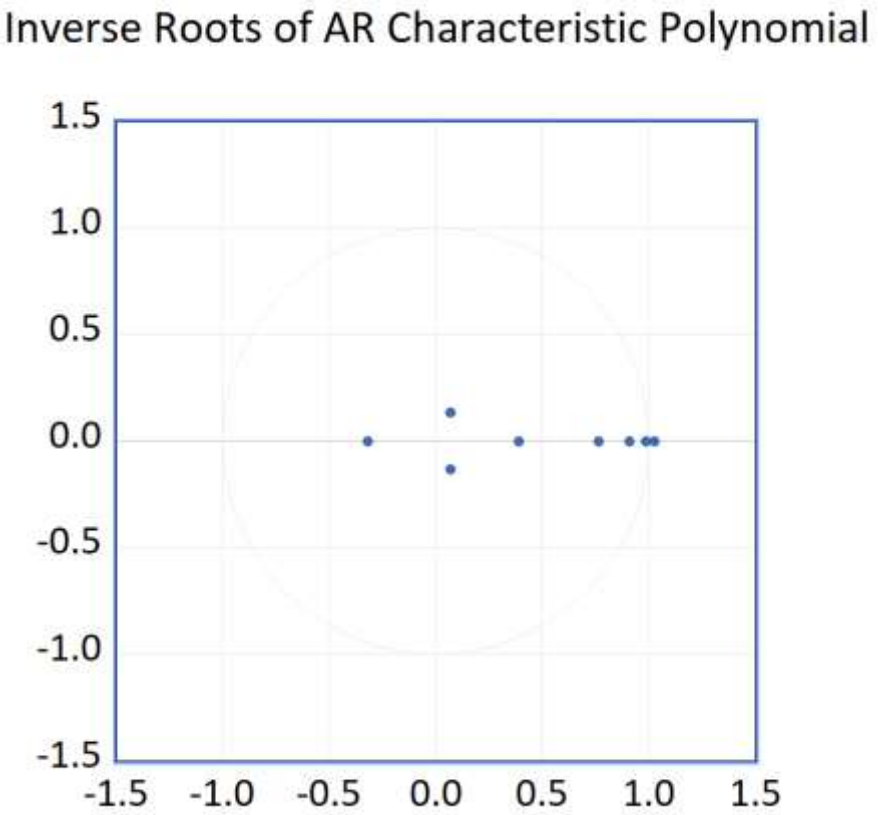

Figure 15: The inverse Roots of The AR Characteristic Polynomial

Source student's compilation from E-view 12

7. The Long-Run and Short-Run ARDL

Table 10: result of long-run and short-run ARDL

Depende Variable GDPPC			
	coefficient	Std. Error	t-statistic
Long-Run Coefficien			
LnODA	-0.162***	0.061	-2.643
LnGCF	0.390***	0.108	3.595
LnEXP	0.426	0.080	5.296
Error Correction Coefficient(Ec)	-0.007***	0.0063	-1.170
Short-Run Coefficien			
D(LnODA)	2.182	7.5506	0.287
D(LnGCF)	1.444	1.496.164	1.135
D (LnEXP)	-1492.901	219.592	-0.997
Observation	241	241	241

Note :***.*Show level of significance at 1% and 5% respectively

The findings also show a long-term positive relationship between LNGDPPC and LNGCF, with an equivalent significance level of 1%. This indicates that increasing LNGCF by one unit will reduce LNGDPPC by 0.390%. In the near run, there is a positive but negligible correlation between these two factors. The data suggest a long-term positive and substantial relationship between INEXP and LNGDPPC, however it is inconsequential. In the short run, the insigniticant is negative. The coefficient value of the

error correction term (EC) is -0.007, indicating that it requires a speed of modification of 0.007 to achieve the current year's equilibrium placement. The data also show that this EC coefficient value is negative and statistically significant at the 1% significance level.

8. ARDL Results Country-Specific.

The results shown in Table 11 illustrate that the C term is negative and significant in all selected countries. In Algeria, the C term is -0.198, indicating that 19.8% of the disequilibrium will adjust to long-run equilibrium within one year. In Egypt, the C term is -0.125, meaning that 12.5% of the disequilibrium will correct itself annually. In Iran, the C term is -0.080, signifying that 8% of the disequilibrium will converge to long-run equilibrium each year. In Lebanon, the C term is -0.130, showing that 13% of the disequilibrium will adjust to long-run equilibrium annually.For Jordan, the C term is -0.310, indicating that 31% of the disequilibrium will correct itself within one year. In Oman, the C term is -0.250, meaning that 25% of the disequilibrium will converge to long-run equilibrium annually. Lastly, in Tunisia, the C term is -0.150, signifying that 15% of the disequilibrium will adjust to long-run equilibrium each year.

The variable foreign aid is found significant at the 1% level in all nations. The variable LNODA is found significant with a positive sign only in Algeria (0.019). Morocco (0.165) gave favorably to LNGDPPC, while Tunisia (0.007) was negligible and unfavorable in comparison to other nations. The predicted LNODA values for Egypt, Lebanon, Iran, Oman, and Jordan are -0.180, -0.751, -0.280, -0.45, and -0.870, respectively. Forgein ais contributed the most in the case of Morocco and the least in Jordan.

The indicator LNEXP is both significant and negative in all countries, with the exception of Algeria, which is positive and significant (0.0009), indicating that it donated adversely to LNGDPPC in the panel nations.
Capital values are forecast to be -0.545, -0.0675, -0.254, -0.045, -0.005, -0.305, and -0.192 for Egypt, Morocco, Lebanon, Tunisia, Iran, Oman, and Jordan.

LNGCF's characteristics show that it has a major influence on economic growth across all nations. The estimated parameter values in Algeria, Lebanon, and Iran are -0.590, -0.285, and -0.070, respectively, implying that a 100% increase in LNGCF would reduce LNGDPPC by 59%, 28.5%, and 7%, respectively. The parameter values for Egypt, Morocco, Tunisia, Oman, and Jordan are 0.365, 0.981, 0.074, 0.003, and 0.048, respectively, indicating that a 100% change would affect economic growth by 36.5%, 98.1%, 7.4%, 0.3%, and 48%.

9. Causality test outcomes

The Granger causality test was employed in this work to estimate the long- and short-term outcomes before examining the direction of the relationship between the variables under investigation. There is no evidence of a causal relationship between REM and LNGDPPC in Table 12's results.

Table 12: Causality test outcomes

Pair-Wise Variables	**F-Statistic**	**P-Value**	**Causal Association**
LNODA→**LNGDPPC**	0.801	0.449	**NO**
LNGDPPC→LNODA	**1.651**	**0.1941**	**NO**

Source student's compilation from E-view 12

V. Conclusion

This study examines how foreign aid contributes to economic growth in a few chosen Middle Eastern and North African nations (Oman, Algeria, Egypt, Jordan, Lebanon, Morocco, Iran, Tunisia, and Algeria). Based on yearly time series data from 2002 to 2020, the empirical findings are presented. To evaluate the correlation between foreign aid and economic growth, the pooled mean group/autoregressive distributed (PMG/ARDL) model was employed. A long-term, negative correlation between foreign aid and economic development was discovered, and cross-sectional dependency tests validated the link. For every 1% increase in foreign aid, the INGDPPC decreased by 0.162%. LNODA and economic growth were shown to be positively correlated in Algeria and Morocco, but not in Tunisia, according to the cross-sectional short-run coefficient test. LNODA had a protracted and unfavorable relationship with Egypt, Jordan, Oman, Iran, and Lebanon.

Table 4: Results Of Panel Unit Root

	At Level				At First Difference				
Variable	LLC	IPS	ADF	PP	LLC	IPS	ADF	PP	conclusion
LNGDPPC	-1.435 (0.051)	0.340 (0.033)	12.952 (0.676)	23.359 (0.010)	-3.296 (0.0005)	-5.720 (0.720)	64.230 (0.514)	121.750 (0.085)	I(0)
LNGCF	1.040 (0.851)	0.260 (0.602)	26.719 (0.044)	20.825 (0.185)	-7.422 (0.000)	-8.607 (0.000)	112.792 (0.000)	144.403 (0.000)	I(1)
LNODA	-0.005 (0.498)	-0.975 (0.164)	20.702 (0.1902)	31.959 (0.010)	-7.4111 (0.000)	-10.320 (0.000)	122.906 (0.000)	229.689 (0.000)	I(1)
LNEXP	0.4657 (0.678)	-0.051 (0.4795)	21.770 (0.1508)	16.357 (0.4283)	-5.320 (0.000).	-8.553 (0.000)	98.865 (0.000)	149.984 (0.000)	I(1)

Table 10: ARDL results country-specific.

	ALGERIA	**EGYPTE**	**MORROCO**	**LEBANON**	**TUNISIA**	**IRAN**	**OMAN**	**JORDAN**
EC	-0.198 (0.0002)	-0.125 (0.000)	-0.076 (0.003)	-0.130 (0.000)	-0.150 (0.000)	-0.080 (0.000)	-0.250 (0.000)	-0.310 (0.000)
LNODA	0.019 (0.000)	-0.180 (0.0006)	0.165 (0.0023)	-0.751 (0.000)	0.0007 (0.0005)	-0.280 (0.0000)	-0.45 (0.000)	-0.0061 (0.0003)
LNCGF	-0.590 (0.008)	0.365 (0.0015)	0.981 (0.0002)	-0.285 (0.0000)	0.074 (-0.083)	-0.070 (0.0031)	0.003 (0.004)	0.048 (0.000)
LNEXP	1.451 (0.0009)	-0.545 (0.0000)	-0.675 (0.211)	-0.254 (0.000)	-0.045 (0.000)	-0.005 (0.6046)	-0.305 (0.0004)	0.192 (0.0040)
C	1.345 (0.0213)	0.902 (0.0005)	0.540 (0.044)	2.650 (0.0057)	1.031 (0.010)	0.079 (0.000)	0.780 (0.0045)	2.035 (0.0009)

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Dünya'da ve Türkiye'de Mobilya Sektörü Dış Ticaretinin İncelenmesi

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Özet - Dünya mobilya sektörünün 2023 yılındaki ihracatı 297,951,145 bin dolar olmuştur. Çin 121,033,004 bin dolarlık ihracatı ile bu ihracatın % 40'ı aşan kısmını ihraç etmektedir. Dünya genelinde Avrupa mobilya üretiminde merkezi iken, son 18-20 yılda mobilya üretiminin ağırlığının Çin merkezli olarak doğuya kaydığı görülmüştür. Ancak, Almanya, İtalya ve Polonya gibi ülkeler mobilya sektörü açısından hala önemini devam ettiren ülkelerdir Mobilya sektörü ülkemize ekonomik katma değer ve istihdam açısından önemli bir yere sahiptir. Türkiye'nin mobilya ihracatından elde ettiği ihracat geliri 2023 yılında ise 5,14 milyar dolar bu sektördeki dış ticaret fazlası ise 4,08 milyar dolar olmuştur. 2023 yılında Türkiye mobilya sektörü 4,08 milyar dolar dış ticaret fazlası vermiştir.
Dünya mobilya sektöründe son yıllarda rekabet artmakta olup Vietnam, Polonya, Meksika önemli ihracat artışı sağlayan ülkelerdir. Türkiye'nin Dünya mobilya pazarındaki sürdürülebilir rekabet gücü, başta Çin olmak üzere bu ülkeler ile rekabet gücünü arttıran diğer ülkelere karşı maliyet, teknoloji, tasarım, pazarlama ve marka konularındaki başarılı politika ve uygulamalarına bağlıdır. Rekabetin giderek arttığı ve Çin'in Dünya ihracatının %40'ını gerçekleştirdiği ve kalan % 60'lık dünya pazarında sürdürülebilir rekabet gücü ve ihracat artışı mobilya sektörü için rekabet gücünü arttırıcı politika ve uygulamaların üretilmesini gerektirdiği ortadadır.

Anahtar Kelimeler: Mobilya Sektörü, Dış Ticaret, Türkiye, Dünya, İhracat, İthalat

I. GİRİŞ

Mobilya; oturma, yatma, çalışma, yemek yeme, dinlenme ve bazı eşyaların muhafaza edilmesi işlerinde kolaylık ve rahatlık sağlayan sabit ya da taşınabilir eşyalar olmaktadır. Malzeme olarak ahşap, metal, plastik ya da bunların bir arada kullanımı ile imal edilmektedir. Fonksiyonel olarak mobilyaları; döşemeli oturma grupları, döşemesiz oturma grupları, yatak odası mobilyaları, mutfak mobilyaları, yemek odası mobilyaları ve oturma odası takımları, kütüphane, vitrin ve benzeri mobilyalar, büro mobilyaları, büro mobilyaları olarak gruplandırmak mümkün olmaktadır. (Kayacıklı ve Emil, 2033:7).

Giderek kuvvetlenen küreselleşme süreci ve ulusal pazarların dışa açılmasıyla sınır aşırı mobilya ticareti devamlı olarak yükselme göstermektedir. Buna bağlı olarak mobilya pazarı günden güne daha fazla uluslararası bir nitelik kazanmaktadır. "Emerging Markets" olarak isimlendirilen gelişmekte olan pazarların gösterdiği dinamizmin mobilya sektörünün büyüme oranları için ek bir itici güç oluşturacağı varsayılmaktadır. (Gürpınar, 2007). Sektörün büyük bir kısmı düşük ücretli, emek yoğun ve düşük teknolojili; "alıcı güdümlü" olarak adlandırılabilir. Mobilya sektörünün kaynak ve emek yoğun olması, sektörde gelişmekte olan ülkelere ve firmalarına küresel ekonomiye katılımlarını sağlamak için büyük fırsatlar sunmaktadır. (Adıgüzel, 2016).

Uluslararası mobilya ticareti, tasarım trendlerinden ve tüketici tercihlerinden büyük ölçüde etkilenmektedir. Bazı ülkeler yenilikçi tasarımlarını ve yaratıcı mobilya sunumlarını sergileyerek dış pazarlarda rekabet

avantajı elde etmektedir. Ayrıca, lüks mobilyalar, antika mobilyalar ve özel yapım mobilyalar gibi özel ürünler mobilya sektöründe yaygın olarak ticarete konu olmaktadır. Bu ürünler belirli talepleri karşılamakta ve genellikle farklı ülkelere ihraç edilmektedir (Emikönel, 2022:4).

Dünya genelinde Avrupa mobilya üretiminde merkezi iken, son 18-20 yılda mobilya üretiminin ağırlığının Çin merkezli olarak doğuya kaydığı görülmüştür. Ancak, Almanya, İtalya ve Polonya gibi ülkeler mobilya sektörü açısından hala önemini devam ettiren ülkelerdir (Canıdemir,2018).. Çin, mobilya üretiminde büyük farkla önde olup, İtalya, Almanya ve ABD dünya mobilya üretiminin yarısından fazlasını gerçekleştirmektedir. Fransa, Japonya, İspanya, Kanada ve Polonya'nın diğer üreticiler olarak dünya mobilya üretiminde etkili rol oynadığı fark edilmektedir (Sakarya ve Doğan, 2016:5). Gelir artışı ve düşük işgücü maliyetleriyle beraber artan iç talep, Çin'in mobilya üretim merkezi konumuna getirmiştir. Almanya ve ABD teknoloji kullanımının sağladığı avantajlardan ve hammadde üreticisi konumlarından faydalanırken, İtalya tasarımla ön plana çıkmaktadır. (Kalkınma Bakanlığı, 2015)

AB'nin en büyük mobilya tüketicileri Fransa, Almanya, İspanya ve Hollanda'dır. Bu ülkeler nüfus yapısı itibariyle dışa açık, çok fazla seyahat eden, çok kültürlü insanları ile de mobilya tüketiminde farklı kültürlerin özelliklerinden etkilenmektedir. Kaplanmış/ döşenmiş oturma grupları ve mutfak mobilyası AB mobilya piyasasında en çok talep gören ürünlerdir. Önümüzdeki yıllarda AB mobilya pazarındaki büyümenin yavaşlaması ön görülmektedir. Bununla beraber geleneksel mobilyadan modern mobilyaya doğru olan eğilimin sürmesi ve mobilya tasarım ve tarzındaki çeşitliliğindeki artması beklenmektedir. Ayrıca AB tüketim kalıbında ön plana çıkan bir diğer mühim mesele de var olan mobilya gruplarına uyum sağlayabilen bağımsız mobilya parçalarının set/takım olarak mobilya alımlarına göre Pazar paylarını arttırıyor olmasıdır. (TC Ticaret Bakanlığı, 2021).

Mobilya sektörü ülkemize ekonomik katma değer ve istihdam açısından önemli bir yere sahiptir. Özellikle 2001 yılından günümüze dış ticaret fazlası veren Türkiye mobilya sektörü yıllardır ihracatını arttırmaktadır. İhracatta yakalanan bu sürecin devam ederek dış pazardaki tecrübelerle beraber mobilya sanayisinin önümüzdeki yıllarda daha hızlı gelişmesi ön görülmektedir. (Güleç, 2016:15)

2022 yılında Türkiye'nin mobilya ihracatından elde ettiği ihracat geliri 5,26 milyar dolara ulaşmış 2023 yılında ise 5,14 milyar dolar olmuştur. 2023 yılında Türkiye mobilya sektörü 4,08 milyar dolar dış ticaret fazlası vermiştir. Çalışmada Türkiye'nin dış ticaretinde ve dış ticaret fazlası veren önemli sektörlerden biri olarak mobilya sektörünün Dünya'da ve Türkiye'de dış ticareti incelenmektedir.

II. MATERYAL VE YÖNTEM

Bu çalışmada Dünya ve Türkiye ekonomisinde mobilya sektörünün dış ticareti incelenmektedir. Yöntem olarak literatür taraması ve Dünya ve Türkiye ekonomisinin dış ticaret verileri kullanmaktadır. Dünya ve Türkiye'nin mobilya sektörü dış ticaret verileri Dünya Ticaret Örgütü Trademap sitesinden alınmıştır. Çalışmada 2019-2023 yılları arası Dünya ve Türkiye mobilya sektörü ihracat, ithalat ve dış ticaret dengesine ilişkin veriler, tablolar ve grafikler yer almakta ve bu verilerin yorumlanması ile dünyada ve Türkiye'de mobilya sektörü dış ticareti incelenmektedir. Mobilya sektörü dış ticareti uluslararası ticarette kullanılan Harmonize Sistem (HS) 4 dijitli sınıflandırma (Gümrük Tarife İstatistik Pozisyon (GTIP)) bazında irdelenmiştir. HS/GTİP 94'te yer alan mobilya sektörünün 4 dijitli açılımı/ürünleri aşağıda verilmiştir.

GTİP No: 9401

GTIP 9401 numaralı ürün, "Kolay Taşınabilir Mobilyalar" kategorisinde yer almakta olup, bu ürün grubuna genellikle koltuklar, sandalyeler, kanepe ve oturma grupları dahildir. GTIP 9401 kapsamındaki ürünler,

taşınabilir oturma mobilyalarını içermekte ve hastane yatakları gibi özel kullanım mobilyaları bu kapsam dışında kalmaktadır. Bu kategorideki mobilyalar, genellikle ev, ofis, dış mekân ve ticari alanlarda kullanılmak üzere tasarlanmıştır.

GTİP No: 9402

GTIP 9402 numaralı ürün, "Tıbbi, Cerrahi, Dişçilik veya Veterinerlik Mobilyaları; Berber Koltukları ve Benzeri Koltuklar ve Bunların Parçaları" kategorisinde yer almaktadır. Bu ürün grubu, özellikle sağlık ve bakım hizmetlerinde kullanılan özel mobilyaları içermektedir. GTIP 9402 kapsamındaki ürünler, hastane yatakları, dişçi koltukları, cerrahi masalar gibi özel amaçlı mobilyalar ile berber koltukları ve benzerlerini kapsamaktadır. Bu kategorideki mobilyalar, genellikle sağlık kurumları, veteriner klinikleri, diş muayenehaneleri ve berber/kuaför salonları gibi alanlarda kullanılmak üzere tasarlanmıştır.

GTİP No: 9403

GTIP 9403 numaralı ürün, "Diğer Mobilyalar ve Bunların Aksam ve Parçaları" kategorisinde yer almakta olup, çeşitli mobilya türlerini kapsamaktadır. Bu ürün grubu, genellikle ev, ofis ve ticari alanlarda kullanılan geniş bir yelpazede mobilyaları kapsar. Bu kategorideki mobilyalar, çeşitli alanlarda kullanılmak üzere tasarlanmış olup hem estetik hem de fonksiyonel özelliklere sahiptir. Evlerde kullanılan mobilyalar arasında yatak odası takımları, yemek odası takımları, kitaplıklar ve depolama üniteleri bulunmaktadır. Ofis ortamlarında ise çalışma masaları, dolaplar, raf sistemleri ve toplantı masaları gibi fonksiyonel mobilyalar yer alır. Ticari alanlarda ise vitrinler, tezgahlar ve müşteri hizmet alanları için tasarlanmış özel mobilyalar bu kategoriye dahildir.

GTİP No: 9404

GTIP 9404 numaralı ürün, "Yatak Taksimleri ve Benzer Mobilyalar" kategorisinde yer almakta olup, bu grup özellikle uyuma ve dinlenme amaçlı mobilyaları içermektedir. GTIP 9404 kapsamındaki ürünler arasında somyalar, yatak bazaları, yataklar, şilteler ve bu mobilyaların aksam ve parçaları bulunmaktadır. Bu kategorideki mobilyalar, evlerde, otellerde ve diğer konaklama tesislerinde kullanılmak üzere tasarlanmıştır. Uyku ve dinlenme konforunu sağlamak için üretilen bu mobilyalar, ergonomik ve sağlık açısından destekleyici özelliklere sahiptir. Örneğin, yatak bazaları ve somyalar, şiltelerin yerleştirileceği sağlam yapılar sunarken, çeşitli konfor seviyelerine sahip şilteler, uyku kalitesini artırmak için farklı malzemelerden üretilir.

GTİP No: 9405

GTIP 9405 numaralı ürün, "Lambalar ve Aydınlatma Cihazları (fenerler ve benzeri taşınabilir elektrik lambaları hariç) ve Bunların Parçaları" kategorisini kapsamaktadır. Bu grup, geniş bir yelpazede aydınlatma çözümlerini içermekte olup, me iç hem dış mekanlarda kullanılan çeşitli aydınlatma cihazlarını kapsamaktadır. GTIP 9045 kapsamındaki ürünler arasında tavan lambaları, duvar lambaları, masa lambaları, zemin lambaları, avizeler ve benzeri aydınlatma cihazları bulunur. GTIP 9405 kapsamındaki aydınlatma cihazları estetik ve işlevsel özellikleriyle dikkat çeker Evler, ofisler, ticari alanlar, dış mekanlar gibi çeşitli alanlarda kullanılmak üzere tasarlanmışlardır.

GTİP No: 9406

GTIP 9406 numaralı ürün, "Prefabrik Yapılar" kategorisinde yer almakta olup, çeşitli amaçlara hizmet eden önceden imal edilmiş yapı birimlerini kapsamaktadır. Bu gruba dahil olan ürünler arasında modüler evler, ofisler, ticari yapılar, inşaat şantiyelerinde kullanılan geçici yapılar, depolar ve benzeri prefabrik yapılar

bulunur. GTIP 9406 kapsamındaki yapılar, hızlı kurulumu, taşınabilirliği ve esnek kullanımı ile dikkat çekmektedir.

III. DÜNYA MOBİLYA TİCARETİ

Mobilya sektörünün dünya ekonomisinde yarattığı katma değer ve istihdamın yanı sıra uluslararası ticarette de önemli bir yeri vardır. İhracat konusunda özellikle Asya ülkeleri, ön plandadır. Avrupa Birliği, dünyadaki mobilya sektörünün en büyük pazarlarından biridir. Avrupa'da birçok ülke, mobilya üretimi ve tüketimi açısından önemli bir konumdadır (Karadağ, 2020).

Mobilya sektörünün dünya ihracatı içindeki payı 2021 yılında önemli bir artışla 324,810,047 bin ABD dolarına ulaşılmıştır. Ancak, 2022 yılında toplam dünya ihracat değeri 311,040,067 bin ABD dolara, 2023 yılında 297 milyar dolara gerilemiştir. Tablo 1'de 2019-2023 yılları arası Dünya mobilya ihracatının 4 dijitli ürünlere göre dağılımı yer almaktadır.

Tablo 1. Dünya Mobilya İhracatı, 2019-2023

GTİP No	Bin dolar				
	2019	2020	2021	2022	2023
94	261,226,636	263,976,607	325,038,239	311,225,547	297,951,145
9402	4,106,982	4,617,947	4,956,585	5,131,375	5,188,621
9403	90,266,776	93,557,807	114,643,920	112,751,453	106,846,813
9405	56,173,138	58,763,830	74,487,522	69,025,891	63,269,885
9404	19,254,978	19,236,657	23,314,358	21,809,286	21,246,487
9406	9,250,408	8,791,808	10,966,745	12,773,760	11,698,185
9401	81,455,629	78,456,326	96,054,761	88,638,520	88,465,802

Kaynak: www.trademap.org

Dünya Mobilya İthalatı

Tablo 2: Dünya Mobilya İthalatçısı İlk 10 Ülke, 2019-2023, bin dolar

İthalatçılar	2019	2020	2021	2022	2023
Dünya	243,477,168	231,762,634	289,349,868	290,586,733	261,535,317
Amerika Birleşik Devletleri	66,842,480	65,457,994	81,318,355	86,736,616	69,006,761
Almanya	21,057,544	21,191,685	25,682,045	24,605,339	22,696,876
İngiltere	11,867,701	10,386,937	14,305,158	14,543,852	12,532,878
Fransa	11,892,481	10,822,515	14,176,129	13,888,723	12,626,102
Kanada	9,179,990	8,299,452	9,905,915	10,651,953	9,557,095
Hollanda	7,528,131	7,935,435	10,223,331	9,554,987	9,317,265
Japonya	8,354,581	8,056,976	8,961,757	8,859,508	7,934,651
Avusturalya	4,560,542	4,678,007	5,571,307	5,703,951	4,791,172

İspanya	4,631,777	4,207,848	5,551,098	5,522,200	5,732,008
İsviçre	4,430,996	4,536,045	5,323,739	5,195,470	5,172,003

Kaynak: www.trademap.org

Tablo 2'de yer alan 2019-2023 yılları arasındaki dünya mobilya ithalat verileri incelendiğinde, COVID-19 pandemisinin küresel ticaret üzerindeki etkileri açıkça görülmektedir. 2019'da 243,477,168 olan ithalat hacmi, 2020'de pandeminin etkisiyle 231,762,634'e düşmüştür. Ancak, 2021 ve 2022 yıllarında toparlanma yaşanmış ve ithalat hacmi sırasıyla 289,349,868 ve 290,586,733'e yükselmiştir. Bu artış, pandeminin ekonomik faaliyetler üzerindeki olumsuz etkilerinin azalması ve küresel ekonominin toparlanma sürecine girmesiyle açıklanması mümkün olmaktadır.

Amerika Birleşik Devletleri'nin ithalat verileri, ülkenin ekonomik dalgalanmalarını yansıtmaktadır. 2019'da 66,842,480 olan ithalat hacmi, 2020'de hafif bir düşüşle 65,457,994'e gerilemiştir. Ancak, 2021 ve 2022 yıllarında belirgin bir artış kaydedilmiş ve ithalat hacmi sırasıyla 81,318,355 ve 86,736,616'ya yükselmiştir. Bu artış, ABD ekonomisinin pandeminin etkilerinden kurtulma sürecine girdiğini göstermektedir. 2023 yılında ise ithalat hacmi 69,006,761'e düşerek tekrar 2019-2020 seviyelerine gerilemiştir.

Almanya'nın ithalat verileri, 2019'dan 2020'ye nispeten istikrarlı kalmıştır. 2019'da 21,057,544 olan ithalat hacmi, 2020'de 21,191,685 olarak kaydedilmiştir. Ancak, 2021'de ithalat hacmi 25,682,045'e yükselerek önemli bir artış göstermiştir. 2022 ve 2023 yıllarında ise ithalat hacmi sırasıyla 24,605,339 ve 22,696,876'ya düşmüştür.

Birleşik Krallık'ın ithalat verileri incelendiğinde, 2019'dan 2020'ye ithalat hacminde bir düşüş görülmektedir. 2019'da 11,867,701 olan ithalat hacmi, 2020'de 10,386,937'ye gerilemiştir. 2021 ve 2022 yıllarında toparlanma yaşanmış ve ithalat hacmi sırasıyla 14,305,158 ve 14,543,852'ye yükselmiştir. Ancak, 2023 yılında ithalat hacmi yeniden düşerek 12,532,878'e gerilemiştir. Bu durum, Birleşik Krallık'ın Brexit sonrası ekonomik belirsizlikleri ve küresel ticaret dinamikleriyle ilişkili olabilir.

Fransa'nın ithalat verileri, pandeminin etkilerini ve sonrasındaki toparlanma sürecini yansıtmaktadır. 2019'da 11,892,481 olan ithalat hacmi, 2020'de 10,822,515'e düşmüştür. 2021 ve 2022 yıllarında ithalat hacmi sırasıyla 14,176,129 ve 13,888,723'e yükselmiştir. Ancak, 2023 yılında ithalat hacmi tekrar düşerek 12,626,102 olarak kaydedilmiştir.

Kanada'nın ithalat hacmi 2019'dan 2020'ye düşmüş, ardından 2021 ve 2022'de artış göstermiştir. 2019'da 9,179,990 olan ithalat hacmi, 2020'de 8,299,452'ye düşmüş, 2021'de 9,905,915'e ve 2022'de 10,651,953'e yükselmiştir. Ancak, 2023 yılında ithalat hacmi 9,557,095'e gerilemiştir.

Hollanda'nın ithalat verileri, 2019'dan 2020'ye artmış, 2021'de zirveye ulaşmış ve 2022'de biraz düşmüştür. 2019'da 7,528,131 olan ithalat hacmi, 2020'de 7,935,435'e, 2021'de ise 10,223,331'e yükselmiştir. 2022'de 9,554,987'ye ve 2023'te 9,317,265'e düşmüştür.

Japonya'nın ithalat hacmi 2019'dan 2020'ye düşmüş, 2021'de artmış ve 2022'de hafif bir düşüş yaşamıştır. 2019'da 8,354,581 olan ithalat hacmi, 2020'de 8,056,976'ya, 2021'de 8,961,757'ye yükselmiştir. 2022'de 8,859,508'e ve 2023'te 7,934,651'e düşmüştür.

Avustralya'nın ithalat hacmi 2019'dan 2020'ye artmış, 2021 ve 2022'de zirveye ulaşmış, ancak 2023'te düşüş göstermiştir. 2019'da 4,560,542 olan ithalat hacmi, 2020'de 4,678,007'ye, 2021'de 5,571,307'ye ve 2022'de 5,703,951'e yükselmiştir. 2023'te ise ithalat hacmi 4,791,172'ye düşmüştür.

İspanya'nın ithalat hacmi 2019'dan 2020'ye düşmüş, 2021 ve 2022'de artmış ve 2023'te hafif bir artış daha göstermiştir. 2019'da 4,631,777 olan ithalat hacmi, 2020'de 4,207,848'e, 2021'de 5,551,098'e ve 2022'de 5,522,200'e yükselmiştir. 2023'te ise ithalat hacmi 5,732,008'e çıkmıştır.

İsviçre'nin ithalat hacmi 2019'dan 2020'ye artmış, 2021'de zirveye ulaşmış ve 2022'de hafif bir düşüş göstermiştir. 2019'da 4,430,996 olan ithalat hacmi, 2020'de 4,536,045'e, 2021'de 5,323,739'a yükselmiştir. 2022'de 5,195,470'e ve 2023'te 5,172,003'e düşmüştür.

Dünya Mobilya İhracatı

Tablo 3: Dünya Mobilya İhracatçısı İlk 10 Ülke Ve Türkiye, 2019-2023, Bin Dolar

İhracatçılar	2019	2020	2021	2022	2023
Dünya	261,077,894	263,839,879	324,810,047	311,040,067	297,951,145
Çin Halk Cumhuriyeti	99,063,088	109,366,915	139,481,266	130,893,407	121,033,004
Almanya	17,861,644	16,494,955	19,473,946	18,722,254	18,571,817
Polonya	14,689,114	14,394,281	17,641,656	12,087,656	17,776,285
Vietnam	9,487,582	11,982,026	13,833,399	13,901,442	15,892,277
İtalya	13,994,740	12,653,666	15,874,595	16,049,705	15,803,005
Meksika	10,296,728	9,112,154	11,078,427	12,783,517	12,899,322
Amerika Birleşik Devletleri	10,245,746	8,512,601	9,277,421	10,087,139	10,055,768
Hollanda	4,897,578	5,123,274	6,664,541	5,966,452	6,632,681
Kanada	5,885,554	4,944,960	5,565,216	6,575,348	6,401,343
Çek Cumhuriyeti	5,386,608	5,151,703	5,804,971	5,740,680	6,362,049
11.Türkiye	**3,868,865**	**3,897,049**	**4,788,354**	**5,260,727**	**5,149,153**

Kaynak: www.trademap.org verileri kullanılarak hazırlanmıştır.

Dünya genelinde ihracat verileri incelendiğinde, 2019 yılında toplam ihracatın 261,077,894 bin ABD doları olduğu görülmektedir. Bu rakam 2020 yılında 263,839,879 bin ABD dolarına çıkarak küçük bir artış göstermiştir. 2021 yılında ise önemli bir artışla 324,810,047 bin ABD dolarına ulaşılmıştır. Ancak, 2022 yılında toplam dünya ihracat değeri 311,040,067 bin ABD dolara, 2023 yılında 297 milyar dolara gerilemiştir.

Çin Halk Cumhuriyeti, 2019 yılında 99,063,088 bin ABD doları olan ihracatını, 2020 yılında 109,366,915 bin ABD dolarına yükseltmiştir. 2021 yılında ise bu rakam 139,481,266 bin ABD dolarına ulaşmıştır. Ancak, 2022 yılında ihracat 130,893,407 bin ABD dolarına düşmüştür. 2023 yılında 121 milyar dolar olmuştur. Çin'in ihracattaki bu artışı, ülkenin küresel ticaretteki güçlü konumunu ve geniş üretim kapasitesini yansıtmaktadır.

Almanya'nın ihracatı, 2019 yılında 17,861,644 bin ABD doları olarak kaydedilmiştir. 2020 yılında ihracat 16,494,955 bin ABD dolarına gerilemiştir. 2021 yılında 19,473,946 bin ABD dolarına yükselen ihracat, 2022 yılında 18,722,254 bin ABD dolarına düşmüştür. 2023 yılında ise hafif bir düşüşle 18,571,817 bin ABD dolarına gerilemiştir.

İtalya'nın ihracat rakamları, 2019 yılında 13,994,740 bin ABD doları iken, 2020 yılında 12,653,666 bin ABD dolarına düşmüştür. 2021 yılında ihracat 15,874,595 bin ABD dolarına yükselmiş ve 2022 yılında

16,049,705 bin ABD doları olmuştur. 2023 yılında ise küçük bir düşüşle 15,803,005 bin ABD dolarına gerilemiştir.

Vietnam, 2019 yılında 9,487,582 bin ABD doları ihracat gerçekleştirmiştir. 2020 yılında bu rakam 11,982,026 bin ABD dolarına yükselmiştir. 2021 yılında ihracat 13,833,399 bin ABD doları, 2022 yılında ise 13,901,442; 2023 yılında 15,892,277 bin ABD doları olarak kaydedilmiştir. Vietnam'ın ihracatında sürekli bir artış gözlenmekte olup, ülkenin büyüyen ekonomik gücünü ve küresel ticaretteki artan rolünü yansıtmaktadır.

Meksika'nın ihracatı, 2019 yılında 10,296,728 bin ABD doları iken, 2020 yılında 9,112,154 bin ABD dolarına düşmüştür. 2021 yılında ihracat 11,078,427 bin ABD doları, 2022 yılında ise 12,783,517; 2023 yılında 12,899,322 bin ABD doları olarak kaydedilmiştir. Meksika'nın ihracatındaki bu artış, ülkenin ABD ve diğer pazarlara olan güçlü bağlarını yansıtmaktadır.

Polonya'nın ihracat rakamları, 2019 yılında 14,689,114 bin ABD doları olarak kaydedilmiştir. 2020 yılında 14,394,281 bin ABD dolarına düşmüştür. 2021 yılında ihracat 17,641,656 bin ABD dolarına yükselmiş, ancak 2022 yılında 12,087,656 bin ABD dolarına gerilemiştir. 2023 yılında ise tekrar artarak 17,776,285 bin ABD dolarına ulaşmıştır.

Polonya'nın ihracat rakamları, 2019 yılında 14,689,114 bin ABD doları olarak kaydedilmiştir. 2020 yılında 14,394,281 bin ABD dolarına düşmüştür. 2021 yılında ihracat 17,641,656 bin ABD dolarına yükselmiş, ancak 2022 yılında 12,087,656 bin ABD dolarına gerilemiştir. 2023 yılında ise tekrar artarak 17,776,285 bin ABD dolarına ulaşmıştır.

Kanada'nın ihracatı, 2019 yılında 5,885,554 bin ABD doları iken, 2020 yılında 4,944,960 bin ABD dolarına düşmüştür. 2021 yılında ihracat 5,565,216 bin ABD doları, 2022 yılında ise 6,575,348 bin ABD doları olarak kaydedilmiştir. 2023 yılında ise hafif bir düşüşle 6,401,343 bin ABD dolarına gerilemiştir.

Hollanda'nın ihracat rakamları, 2019 yılında 4,897,578 bin ABD doları iken, 2020 yılında 5,123,274 bin ABD dolarına yükselmiştir. 2021 yılında ihracat 6,664,541 bin ABD doları, 2022 yılında ise 5,966,452 bin ABD doları olmuştur. 2023 yılında ise tekrar artarak 6,632,681 bin ABD dolarına ulaşmıştır.

Çek Cumhuriyeti'nin ihracatı, 2019 yılında 5,386,608 bin ABD doları iken, 2020 yılında 5,151,703 bin ABD dolarına düşmüştür. 2021 yılında ihracat 5,804,971 bin ABD doları, 2022 yılında ise 5,740,680 bin ABD doları olarak kaydedilmiştir. 2023 yılında ise tekrar artarak 6,362,049 bin ABD dolarına ulaşmıştır.

Türkiye'nin ihracat rakamları, 2019 yılında 3,868,865 bin ABD doları iken, 2020 yılında 3,897,049 bin ABD dolarına yükselmiştir. 2021 yılında ihracat 4,788,354 bin ABD doları, 2022 yılında ise 5,260,727 bin ABD doları olarak kaydedilmiştir. 2023 yılında ise hafif bir düşüşle 5,149,153 bin ABD dolarına gerilemiştir.

2023 yılı dünya mobilya ihracat verileri, toplam 297,951,145 bin ABD doları olarak gerçekleşmiştir. Bu verilerde, Çin Halk Cumhuriyeti 121,033,004 bin ABD doları ile dünya mobilya ihracatının %40.7'sini gerçekleştirerek sektörde rekabet üstü bir konumda olduğunu göstermektedir. Almanya ise 18,571,817 bin ABD doları ile dünya toplamının %6.2'sini oluşturarak ikinci sırada yer almaktadır.

2023 yılı için diğer önemli mobilya ihracatçıları arasında, İtalya 15,803,005 bin ABD doları ile %5.3, Vietnam 15,892,277 bin ABD doları ile %5,3, ve Meksika 12,899,322 bin ABD doları ile %4.3 oranında dünya mobilya ihracatına katkı sağlamaktadır. Türkiye'nin dünya mobilya ihracatındaki payı %1.7 olarak gerçekleşmiştir. Bu veriler, Avrupa ve Asya ülkelerinin küresel mobilya ticaretinde önemli roller oynadığını, ayrıca Amerika kıtasındaki ülkelerin de dikkate değer ihracat performansları sergilediğini göstermektedir.

Ülkelerin Mobilya Dış Ticaret Dengesi

Tablo 4: Mobilya Sektöründe En Yüksek Dış Ticaret Fazlası Veren 10 Ülke,2019-2023, Bin Dolar

Partnerler	2019	2020	2021	2022	2023
Çin	95,540,741	106,466,632	136,280,102	128,062,078	118,593,783
Vietnam	8,522,855	10,889,696	12,647,539	12,769,152	13,011,173
İtalya	10,059,007	8,977,008	11,024,002	10,865,241	10,912,210
Polonya	10,708,482	10,285,555	11,933,798	9,525,395	12,764,122
Meksika	6,537,943	6,092,635	7,019,880	8,171,421	8,495,075
Türkiye	**3,110,706**	**3,176,277**	**3,991,648**	**4,354,694**	**4,081,752**
Litvanya	2,033,185	2,112,353	2,645,796	2,810,486	2,578,000
Malezya	2,020,739	2,205,971	1,955,304	2,082,790	1,793,942
Çek Cumhuriyeti	1,812,471	1,814,288	1,734,298	1,674,453	1,970,233
Romanya	1,609,133	1,200,847	1,250,735	1,278,661	1,236,850

Kaynak: ITC Trademap verilerinden yararlanılarak yapılmıştır.

2023 yılı dünya mobilya ticaret verilerine göre, Çin Halk Cumhuriyeti, 118,593,783 bin ABD dolar mobilya sektöründe en fazla dış ticaret fazlası veren ülkedir. Bu yüksek oran, Çin'in geniş üretim kapasitesi ve küresel pazarlardaki güçlü rekabetçiliğini göstermektedir. Çin, düşük maliyetli üretim avantajı ve geniş iç pazarı sayesinde mobilya sektöründe lider konumunu sürdürmektedir.
Vietnam, 13,011,173 bin ABD doları dış ticaret fazlası verirken bu yükselişi ülkenin düşük işgücü maliyetleri ve artan üretim kapasitesi ile açıklanabilir. Polonya, 12,764,122 bin ABD doları; İtalya, 10,912,210 bin ABD doları ile dünya genelinde önemli bir oyuncular olarak öne çıkmaktadır. İtalya, yüksek kaliteli ve tasarım odaklı mobilyaları ile tanınmakta ve bu da ülkenin küresel pazardaki rekabet gücünü artırmaktadır. Polonya'nın bu performansı, ülkenin güçlü üretim altyapısı ve Avrupa pazarlarına yakınlığı ile desteklenmektedir. Meksika, 8,495,075 bin ABD doları mobilya ihracatı ile küresel pazarda rekabetçi bir konumda bulunmaktadır.

Litvanya, 2,578,000 bin ABD doları, Malezya 1,793,942 bin ABD doları dış ticaret fazlası gerçekleştirmiştir. Litvanya'nın performansı, özellikle Avrupa pazarlarına olan coğrafi yakınlığı ve iş gücü maliyet avantajları ile ilişkilidir. Malezya ise, Asya'nın yükselen ekonomileri arasında yer alarak, mobilya sektöründe rekabetçi bir konuma sahiptir. Çek Cumhuriyeti ve Romanya ise sırasıyla 1,970,233 bin ABD doları ve 1,236,850 bin ABD doları fazla ile, Orta ve Doğu Avrupa'nın mobilya ticaretinde önemli rol oynadığını göstermektedir.

Türkiye, 2023 yılında mobilya sektöründe 4,081,752 bin ABD doları dış ticaret fazlası ile en fazla dış ticaret fazlası veren 6. Ülke olmuştur.

IV.TÜRKİYE'NİN MOBİLYA SEKTÖRÜ DIŞ TİCARETİ

Türkiye, hem Avrupa Birliği hem de dünya pazarında mobilya üretimi konusunda önemli bir aktördür. Türk mobilya üretimi konusunda önemli bir aktördür. Türk mobilya sektörü, çeşitli mobilya türleri ve tarzları üreten birçok küçük, orta ve büyük ölçekli işletmeyi içermektedir. Türkiye mobilya ihracatında önemli bir paya sahiptir. Özellikle Türk mobilyaları, Avrupa, Ortadoğu, Kuzey Afrika ve diğer pazarlarda talep görmektedir. Mobilya sektörü, Türkiye'de önemli bir istihdam kaynağıdır. Birçok mobilya fabrikası ve

atölye, sektörde çalışanlara istihdam imkânı sağlamaktadır. Aynı zamanda, sektörde tasarım, üretim, satış ve pazarlama gibi farklı pozisyonlarda istihdam edilen birçok kişi bulunmaktadır (İSO,2024).

Türkiye mobilya sektörünün GTİP 4 lü fasıllara göre 2019-2023 yılları arasındaki ihracat, ithalat ve dış ticaret dengesi rakamları Tablo da yer almaktadır.

Tablo 5. Türkiye Mobilya Sektörünün Fasıllara Göre İhracatı,2019-2023

GTİP No		Bin dolar				
		2019	2020	2021	2022	2023
9403		1,762,848	1,751,199	2,210,538	2,472,474	2,378,848
9405		248,366	231,702	296,513	332,884	304,376
9402		62,739	113,502	94,040	115,680	93,814
9401		1,294,052	1,162,942	1,462,201	1,623,956	1,693,387
9404		296,185	398,940	459,731	420,107	373,363
9406		204,675	238,764	265,331	295,625	301,753

Kaynak: ITC Trademap verilerinden yararlanılarak hazırlanmıştır.

Türkiye en fazla ihracatı 2,378,848 bin dolar ile GTİP 9403 faslında gerçekleştirmektedir.

Tablo 6. Türkiye Mobilya Sektörünün Fasıllara Göre İthalatı,2019-2023

GTİP No		Bin dolar				
		2019	2020	2021	2022	2023
9402		20,410	19,442	27,416	20,391	15,522
9403		149,374	125,148	153,140	207,639	257,483
9405		195,809	194,804	212,595	237,527	263,507
9404		34,794	34,061	38,913	41,669	50,137
9406		8,384	27,248	21,516	17,475	59,148
9401		349,388	320,069	343,125	381,332	421,608

Kaynak: ITC Trademap verilerinden yararlanılarak hazırlanmıştır.

Türkiye en fazla ithalatı 421,608 bin dolar ile GTİP 9401 faslında gerçekleştirmektedir.

Tablo 7. Türkiye Mobilya Sektörünün Fasıllara Göre Dış Ticaret Dengesi,2019-2023

GTİP No	Bin dolar				
	2019	2020	2021	2022	2023
9402	42,329	94,060	66,624	95,289	78,292
9403	1,613,474	1,626,051	2,057,398	2,264,835	2,121,365
9405	52,557	36,898	83,918	95,357	40,869
9401	944,664	842,873	1,119,076	1,242,624	1,271,779
9404	261,391	364,879	420,818	378,438	323,226
9406	196,291	211,516	243,815	278,150	242,605

Kaynak: ITC Trademap verilerinden yararlanılarak hazırlanmıştır.

Türkiye her fasılda dış ticaret fazlası vermekle birlikte en fazla 2,121,365 bin dolar ile GTİP 9403 faslında gerçekleştirmektedir.

Tablo 8. Türkiye'nin En Çok Mobilya İhracatı Yaptığı 10 Ülke, 2019-2023, bin dolar

İthalatçılar	2019	2020	2021	2022	2023
Dünya	3,868,865	3,897,049	4,788,354	5,260,727	5,149,153
Almanya	360,716	366,227	450,582	504,821	526,618
Irak	532,230	508,351	555,319	540,772	505,532
Amerika Birleşik Devletleri	195,882	276,292	331,793	297,371	280,960
Fransa	180,785	177,123	233,020	237,298	249,936
Birleşik Krallık	142,899	154,340	207,256	214,879	210,279
Romanya	92,843	116,163	132,750	178,610	197,013
Suudi Arabistan	212,568	198,355	6,058	41,515	177,207
Libya	207,345	146,651	202,472	179,494	176,318
Israil	125,156	144,215	217,325	229,988	166,357
Hollanda	95,853	105,672	142,917	169,765	161,486

Kaynak: ITC Trademap verilerinden yararlanılmıştır.

Türkiye'nin mobilya ihracat verileri, 2019'dan 2023'e kadar önemli bir büyüme göstermektedir. 2019 yılında 3,868,865 bin ABD doları olan toplam ihracat, 2022 yılında 5,260,727 bin ABD dolarına ulaşmış, 2023 yılında ise hafif bir düşüşle 5,149,153 bin ABD doları olmuştur.

Almanya'nın, 2019 yılında 360,716 bin ABD doları olan ithalatı, 2023 yılında 526,618 bin ABD dolara çıkmış ve Türkiye'nin en büyük ihracat pazarlarından biri olmuştur. Irak ise, 2019'da 532,230 bin ABD doları olan ithalatını 2022'de 540,772 bin ABD doları seviyesine çıkarırken, 2023'te 505,532 bin ABD dolarına gerilemiştir. Irak'ın Türkiye'nin mobilya ihracatındaki önemli konumu, coğrafi yakınlık ve ticari ilişkilerin gücünü göstermektedir.

Amerika Birleşik Devletleri, 2019'da 195,882 bin ABD doları olan ithalatını 2021'de 331,793 bin ABD dolarına yükseltmiş, ancak 2022 ve 2023 yıllarında sırasıyla 297,371 bin ve 280,960 bin ABD doları seviyelerine gerilemiştir. ABD pazarı, Türkiye için önemli bir ihracat destinasyonu olmaya devam etmekte, ancak dalgalanmalar küresel ticaret dinamiklerinden etkilenmektedir. Fransa ve Birleşik Krallık da önemli pazarlar arasında yer almakta; Fransa'nın ithalatı 2019'da 180,785 bin ABD dolarından 2023'te 249,936 bin ABD dolarına, Birleşik Krallık'ın ithalatı ise aynı dönemde 142,899 bin ABD dolarından 210,279 bin ABD dolarına yükselmiştir.

Romanya, 2019'da 92,843 bin ABD doları olan ithalatını 2023'te 197,013 bin ABD dolarına çıkararak, Türkiye'nin mobilya ihracatında önemli bir artış sergilemiştir. Bu artış, Romanya'nın büyüyen inşaat sektörü ve artan mobilya talebi ile açıklanabilir. Suudi Arabistan'da 2020 ve 2021 yıllarında mobilya ithalatında önemli bir düşüş yaşanmış olsa da 2022 ve 2023 yıllarında toparlanarak 177,207 bin ABD dolarına ulaşmıştır. Libya, İsrail ve Hollanda da Türkiye'nin mobilya ihracatında dikkat çekici pazarlar arasında yer almakta; bu ülkeler sırasıyla 2023 yılında 176,318 bin, 166,357 bin ve 161,486 bin ABD doları ithalat gerçekleştirmişlerdir.

Türkiye'nin mobilya ihracatındaki büyüme, ülkenin üretim kapasitesi, kalite standartları ve uluslararası pazarlardaki rekabet gücünün artışını yansıtmaktadır. Özellikle Avrupa ve Orta Doğu ülkeleri, Türkiye'nin mobilya ihracatında önemli rotalar olmaya devam etmektedir. Türkiye'nin coğrafi konumu, lojistik avantajları ve ticaret ilişkileri, bu büyümeyi destekleyen başlıca faktörlerdir. Ancak, bazı pazarlarda dalgalanmalar yaşanması, küresel ticaret dinamikleri ve ekonomik koşullardan kaynaklanmaktadır. Bu veriler, Türkiye'nin mobilya sektöründeki potansiyelini ve küresel pazarlardaki konumunu anlamak için önemli bir perspektif sunmaktadır.

Türkiye’nin Mobilya İthalatı

Tablo 9. Türkiye’nin En Çok Mobilya İthalatı Yaptığı 10 Ülke, 2019-2023,bin dolar

İhracatçılar	2019	2020	2021	2022	2023
Dünya	758,159	720,772	796,706	906,033	1,067,401
Çin Halk Cumhuriyeti	180,139	197,668	224,082	246,520	285,030
İtalya	83,529	73,803	102,521	100,036	135,841
Almanya	88,067	68,294	76,503	90,493	103,603
Polonya	56,633	64,352	59,925	77,100	93,985
Amerika Birleşik Devletleri	41,620	21,271	25,923	39,747	47,111
Fransa	27,702	18,339	16,428	23,742	32,158
Romanya	25,630	27,116	27,598	27,489	32,000
İspanya	20,467	13,104	17,406	12,773	25,900
Çek Cumhuriyeti	9,808	8,898	12,022	21,248	24,028
İsveç	5,534	15,459	6,644	12,129	22,182

Kaynak: ITC Trademap verilerinden yararlanılarak hazırlanmıştır.

Türkiye’nin mobilya ithalat verileri, 2019'dan 2023'e kadar çeşitli ülkelerden gerçekleştirilen ithalat miktarlarını içermektedir.

- Çin Halk Cumhuriyeti: 2019 yılında 180,139 bin ABD doları olan Çin Halk Cumhuriyeti'nden yapılan mobilya ithalatı, 2023 yılında 285,030 bin ABD dolarına ulaşmıştır. Bu sürekli artış, Çin'in

Türkiye için önemli bir mobilya tedarikçisi olduğunu göstermektedir. Çin'in geniş üretim kapasitesi ve düşük maliyetli üretim avantajları, Türkiye'nin mobilya ithalatında bu ülkeyi tercih etmesinin ana sebebi olmaktadır.

- İtalya: İtalya'dan yapılan mobilya ithalatı, 2019 yılında 83,529 bin ABD doları iken, 2023 yılında 135,841 bin ABD dolarına yükselmiştir. İtalya'nın mobilya sektörü, tasarım ve kalite odaklı ürünleri ile tanınmaktadır. Bu nedenle, Türkiye'nin İtalya'dan yaptığı ithalatın artışı, yüksek kaliteli ve tasarım odaklı mobilyalara olan talebin arttığını göstermektedir.
- Almanya: Almanya'dan yapılan mobilya ithalatı, 2019 yılında 88,067 bin ABD doları iken, 2023 yılında 103,603 bin ABD dolarına ulaşmıştır. Almanya, mühendislik ve üretim kalitesi ile tanınan bir ülkedir. Bu artış, Türkiye'nin Alman mobilyalarına olan güvenini ve talebini yansıtmaktadır.

- **Polonya:** Polonya'dan yapılan mobilya ithalatı, 2019 yılında 56,633 bin ABD doları iken, 2023 yılında 93,985 bin ABD dolarına yükselmiştir. Polonya, Avrupa'da önemli bir mobilya üretim merkezi olarak öne çıkmaktadır.

- **Amerika Birleşik Devletleri:** Amerika Birleşik Devletleri'nden yapılan mobilya ithalatı, 2019 yılında 41,620 bin ABD doları iken, 2023 yılında 47,111 bin ABD dolarına çıkmıştır. ABD'den yapılan ithalatın artışı, Amerikan mobilyalarının Türkiye pazarında talep gördüğünü ve rekabetçi bir konumda olduğunu göstermektedir.

- **Fransa:** Fransa'dan yapılan mobilya ithalatı, 2019 yılında 27,702 bin ABD doları iken, 2023 yılında 32,158 bin ABD dolarına ulaşmıştır.

- **Romanya:** Romanya'dan yapılan mobilya ithalatı, 2019 yılında 25,630 bin ABD doları iken, 2023 yılında 32,000 bin ABD dolarına yükselmiştir.

- **İspanya:** İspanya'dan yapılan mobilya ithalatı, 2019 yılında 20,467 bin ABD doları iken, 2023 yılında 25,900 bin ABD dolarına çıkmıştır.

- **Çek Cumhuriyeti:** Çek Cumhuriyeti'nden yapılan mobilya ithalatı, 2019 yılında 9,808 bin ABD doları iken, 2023 yılında 24,028 bin ABD dolarına yükselmiştir.

- **İsveç:** İsveç'ten yapılan mobilya ithalatı, 2019 yılında 5,534 bin ABD doları iken, 2023 yılında 22,182 bin ABD dolarına yükselmiştir. İsveç, dünya genelinde tanınan mobilya markaları ve sürdürülebilir üretim yaklaşımları ile dikkat çekmektedir. Örnek olarak "İkea" markası dünya genelinde tanınan bir mobilya imalat sanayi markası olmaktadır.

2019'dan 2023'e kadar olan dönemde Türkiye'nin mobilya ithalatında genel bir artış trendi gözlenmektedir. 2019 yılında 758,159 bin ABD doları olan toplam ithalat, 2023 yılında 1,067,401 bin ABD dolarına yükselmiştir. Bu artış, Türkiye'nin mobilya ithalatında büyüyen pazarını ve çeşitli ülkelerden gelen mobilyalara olan talebin arttığını göstermektedir. Çin Halk Cumhuriyeti, İtalya, Almanya ve Polonya gibi ülkeler, Türkiye'nin mobilya ithalatında başlıca tedarikçiler olarak öne çıkmaktadır.

V.TARTIŞMA

Çin, Almanya, İtalya, Polonya, Vietnam, Meksika, ABD ve Türkiye'nin de aralarında bulunduğu ülkeler, mobilya üretimi ve ihracatında önemli oyunculardır ve çeşitli mobilya ürünleri sunarak küresel pazarları ele geçirmeye çalışmaktadır.

Türkiye'nin mobilya ihracat verileri, 2019'dan 2023'e kadar önemli bir büyüme göstermektedir. 2019 yılında 3,868,865 bin ABD doları olan toplam ihracat, 2022 yılında 5,260,727 bin ABD dolarına ulaşmış, 2023 yılında ise hafif bir düşüşle 5,149,153 bin ABD doları olarak kaydedilmiştir. Bu artış trendi, Türkiye'nin mobilya sektöründe uluslararası pazarlardaki rekabet gücünün arttığını göstermektedir.

Rekabetin giderek arttığı ve Çin'in Dünya ihracatının %40'ını gerçekleştirdiği ve kalan % 60'lık dünya pazarında sürdürülebilir rekabet gücü ve ihracat artışı mobilya sektörü için rekabet gücünü arttırıcı politika ve uygulamaların üretilmesini gerektirdiği ortadadır. Bu noktada Devlet, Mobilya sektörü firma, kürüm ve kuruluşları ile Üniversitelerin işbirliği içerisinde olması gerektiği değerlendirilmektedir.

VI.SONUÇLAR

Çalışmada mobilya sektörünün Dünya'da ve Türkiye'de dış ticareti incelenmiştir. Dünya mobilya sektörünün 2023 yılındaki ihracatı 297,951,145 bin dolar olmuştur. Çin 121,033,004 bin dolarlık ihracatı ile bu ihracatın % 40'ı aşan kısmını ihraç etmektedir. Yine Çin 118 milyar dolar dış ticaret fazlası vererek bu sektörde diğer ülkelerin açık ara önünde yer almaktadır. Almanya 18,571,817 bin dolar ile ikinci en büyük ihracatçı ülke olurken Vietnam ve İtalya sırası ile 15,803,005 bin dolar ve 18,571,817 dolar ile benzer miktarlarla üçüncü ve dördüncü en büyük ihracatçı ülkelerdir. Daha sonra sırası ile Meksika, Polonya, ABD, Kanada, Hollanda, Çek Cumhuriyeti ilk on sırada yer almaktadırlar. Türkiye 5,149,153 bin dolarlık ihracatı ile 11. Sırada yer almaktadır.
Dünya mobilya sektörünün 2023 yılındaki İthalatında ise

Türkiye'nin mobilya ihracatından elde ettiği ihracat geliri 2023 yılında ise 5,14 milyar dolar bu sektördeki dış ticaret fazlası ise 4,08 milyar dolar olmuştur. 2023 yılında Türkiye mobilya sektörü 4,08 milyar dolar dış ticaret fazlası vermiştir.

Dünya mobilya ithalatında 2023 yılında Amerika Birleşik Devletleri 69,006,761 bin dolar ile ilk sırada Almanya 22,696,876 dolar ile ithalatta da ikinci sırada, İngiltere 12,532,878 bin dolar ile üçüncü sırada yer almaktadır. Fransa, Kanada, Hollanda, Japonya, Avusturalya, İspanya ve İsviçre ilk on ülke içinde yer almaktadır. Türkiye mobilya sektörü ithalatı adı geçen yılda 1,067,401 bin dolar ithalat yapmıştır.

Dünya mobilya sektörünün 2023 yılındaki ihracatında mobilya kategorileri içerisinde en fazla GTİP 9403 106,846,813 bin dolarlık ihracat yapılırken GTİP 9401 faslında 88,465,802 bin dolarlık, GTİP 9405 faslında 63,269,885 bin dolarlık GTİP 9404 faslında ise 21,246,487 bin dolarlık GTİP 9406 faslında 11,698,185 bin dolarlık, GTİP 9402 faslında 5,188,621 dolarlık ihracat yapılmıştır.

Dünya mobilya sektöründe son yıllarda rekabet artmakta olup Vietnam, Polonya, Meksika önemli ihracat artışı sağlayan ülkelerdir. Türkiye'nin Dünya mobilya pazarındaki sürdürülebilir rekabet gücü, başta Çin olmak üzere bu ülkeler ile rekabet gücünü arttıran diğer ülkelere karşı maliyet, teknoloji, tasarım, pazarlama ve marka konularındaki başarılı politika ve uygulamalarına bağlıdır.

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Some New Simpson Type Inequalities for Multiplicative s-Convexity

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Abstract – In this study, we obtain new generalizations and refinements for Simpson type inequalities in the setting of multiplicative calculus. First, we prove a new identity for multiplicative differentiable functions. Then, using this identity we obtain a new Simpson type inequality for multiplicatively s-convex functions. We also discuss some special cases. The findings of this work may stimulate further research for the researchers working in this field.

Keywords –Multiplicative s-convexity, multiplicative calculus, Simpson's inequality

I. INTRODUCTION

Let I be an interval of real numbers. A function $f: I \to R$ is said to be convex, if

$$f(t\varkappa + (1-t)y) \leq tf(\varkappa) + (1-t)f(y) \tag{1}$$

holds for all $\varkappa, y \in I$ and all $t \in [0,1]$.

Convexity of functions is a powerful approach extensively employed to address various challenges in both pure and applied research. The application of convexity has led to the discovery of numerous extensions and generalizations of integral inequalities, along with their valuable applications (refer to [1-6]). Several studies have demonstrated that many of the results obtained concerning these inequalities are direct outcomes of the applications of convex functions.

The following inequality, identified as Simpson's inequality, ranks among the most widely recognized outcomes in the literature:

Theorem 1. Let $f: [a,b] \to R$ be a four times continuously differentiable mapping on (a,b) and $\|f^{(4)}\|_\infty = \sup_{\varkappa \in (a,b)} \left|f^{(4)}(\varkappa)\right| < \infty$. Then, the following inequality holds:

$$\left|\frac{1}{3}\left[\frac{f(a)+f(b)}{2} + 2f\left(\frac{a+b}{2}\right)\right] - \frac{1}{b-a}\int_a^b f(\varkappa)d\varkappa\right| \leq \frac{1}{2880}\|f^{(4)}\|_\infty (b-a)^4 \tag{2}$$

For some extensions and generalizations of the Simpson's type inequalities using novel and innovative methods, see [7-12] and the corresponding references cited therein.

In [7], Dragomir et al. gave the following Simpson's inequality for which the remainder is expressed in terms of derivatives lower than the fourth.

Theorem 2. Let $f:[a,b]\to R$ be a differentiable mapping whose derivative is continuous on (a,b) and $f'\in L[a,b]$. Then, the following inequality holds:

$$\left|\frac{1}{3}\left[\frac{f(a)+f(b)}{2}+2f\left(\frac{a+b}{2}\right)\right]-\frac{1}{b-a}\int_a^b f(\varkappa)d\varkappa\right|\leq\frac{b-a}{3}\|f'\|_1$$

where $\|f'\|_1=\int_a^b|f'(\varkappa)|d\varkappa$.

In [7], the bound of inequality (2) for L-Lipschitzian mapping was given by $\frac{5}{36}L(b-a)$.

Definition 1. [13] A function $f:I\to(0,\infty)$ is said to be multiplicatively convex, if

$$f((1-t)\varkappa+ty)\leq[f(\varkappa)]^{1-t}[f(y)]^t \tag{3}$$

for all $\varkappa,y\in I$ and $t\in[0,1]$.

Definition 2. [14] A function $f:I\to(0,\infty)$ is said to be multiplicatively s-convex, where $s\in(0,1]$, if

$$f((1-t)\varkappa+ty)\leq[f(\varkappa)]^{(1-t)^s}[f(y)]^{t^s} \tag{4}$$

for all $\varkappa,y\in I$ and $t\in[0,1]$.

It is obvious that for $s=1$, the inequality (4) reduces to the inequality (3).

Now, let's recall certain definitions, properties, and concepts related to differentiation and multiplicative integration.

Definition 3. [15] Let $f:\mathbb{R}\to\mathbb{R}^+$be a positive function. The multiplicative derivative of the function f noted by f^* is defined as follows:

$$\frac{d^*f}{dt}=f^*(t)=\lim_{h\to0}\left(\frac{f(t+h)}{f(t)}\right)^{\frac{1}{h}}$$

Remark 1. If f has positive values and is differentiable at t, then f^* exists and the relation between f^* and ordinary derivative f' is as follows:

$$f^*(t)=e^{(\ln f(t))'}=e^{\frac{f'(t)}{f(t)}}$$

The multiplicative derivative admits the following properties:

Theorem 3. [15] Let f and g be multiplicatively differentiable functions, and c is arbitrary constant. Then functions cf, $fg, f+g, f/g$ and f^g are * differentiable and

1. $(cf)^*(t)=f^*(t)$,
2. $(fg)^*(t)=f^*(t)g^*(t)$,
3. $(f+g)^*(t)=f^*(t)^{\frac{f(t)}{f(t)+g(t)}}g^*(t)^{\frac{g(t)}{f(t)+g(t)}}$,

4. $\left(\frac{f}{g}\right)^{*}(t)=\frac{f^{*}(t)}{g^{*}(t)}$,

5. $(f^{g})^{*}(t)=f^{*}(t)^{g(t)}f(t)^{g'(t)}$.

The relationship connecting the Riemann integral to the * integral can be expressed as follows:

Proposition 1. [15] If f is Riemann integrable on $[a,b]$, then f is * integrable on $[a,b]$ and

$$\int_a^b (f(\varkappa))^{d\varkappa}=e^{b}\ln\,(f(\varkappa))d\varkappa$$

* integral yields the following results and properties:

Theorem 4. [15] Let f be a positive and Riemann integrable on $[a,b]$, then f is * integrable on $[a,b]$ and

1. $\int_a^b((f(\varkappa))^{p})^{d\varkappa}=\left(\int_a^b(f(\varkappa))^{d\varkappa}\right)^{p}$,

2. $\int_a^b(f(\varkappa)g(\varkappa))^{d\varkappa}=\int_a^b(f(\varkappa))^{d\varkappa}\int_a^b(g(\varkappa))^{d\varkappa}$,

3. $\int_a^b\left(\frac{f(\varkappa)}{g(\varkappa)}\right)^{d\varkappa}=\frac{\int_a^b(f(\varkappa))^{d\varkappa}}{\int_a^b(g(\varkappa))^{d\varkappa}}$,

4. $\int_a^b(f(\varkappa))^{d\varkappa}=\int_a^c(f(\varkappa))^{d\varkappa}\int_c^b(f(\varkappa))^{d\varkappa}, a<c<b$,

5. $\int_a^a(f(\varkappa))^{d\varkappa}=1$ and $\int_a^b(f(\varkappa))^{d\varkappa}=\left(\int_b^a(f(\varkappa))^{d\varkappa}\right)^{-1}$.

* integration by parts is given as follows:

Theorem 5. [15] Let $f:[a,b]\to\mathbb{R}$ be multiplicative differentiable, let $g:[a,b]\to\mathbb{R}$ be differentiable so the function f^{g} is * integrable, and

$$\int_a^b\left(f^{*}(\varkappa)^{g(\varkappa)}\right)^{d\varkappa}=\frac{f(b)^{g(b)}}{f(a)^{g(a)}}\times\frac{1}{\int_a^b\left(f(\varkappa)^{g'(\varkappa)}\right)^{d\varkappa}}$$

II. MAIN RESULTS

Lemma 1. Let $f:[a,b]\to\mathbb{R}^{+}$be a^{*} differentiable mapping on $[a,b]$ with $a<b$. If f^{*} is * integrable on $[a,b]$, then

$$(f(a))^{\frac{1}{6}}\left(f\left(\frac{a+b}{2}\right)\right)^{\frac{2}{3}}(f(b))^{\frac{1}{6}}\left(\int_a^b(f(\varkappa))^{d\varkappa}\right)^{\frac{1}{a-b}}$$

$$=\left(\int_0^1\left(f^{*}\left(\frac{1+t}{2}b+\frac{1-t}{2}a\right)^{\left(\frac{t}{2}-\frac{1}{3}\right)}\right)^{dt}\right)^{\frac{b-a}{2}}\left(\int_0^1\left(f^{*}\left(\frac{1+t}{2}a+\frac{1-t}{2}b\right)^{\left(\frac{1}{3}-\frac{t}{2}\right)}\right)^{dt}\right)^{\frac{b-a}{2}}.$$

Proof. Let

$$I_1 = \left(\int_0^1 \left(f^* \left(\frac{1+t}{2} b + \frac{1-t}{2} a \right)^{\left(\frac{t}{2} - \frac{1}{3}\right)} \right)^{dt} \right)^{\frac{b-a}{2}}$$

and

$$I_2 = \left(\int_0^1 \left(f^* \left(\frac{1+t}{2} a + \frac{1-t}{2} b \right)^{\left(\frac{1}{3} - \frac{t}{2}\right)} \right)^{dt} \right)^{\frac{b-a}{2}}.$$

Using the integration by parts for * integrals, we have

$$I_1 = \left(\int_0^1 \left(f^* \left(\frac{1+t}{2} b + \frac{1-t}{2} a \right)^{\left(\frac{t}{2} - \frac{1}{3}\right)} \right)^{dt} \right)^{\frac{b-a}{2}}$$

$$= \int_0^1 \left(f^* \left(\frac{1+t}{2} b + \frac{1-t}{2} a \right)^{\frac{b-a}{2}\left(\frac{t}{2} - \frac{1}{3}\right)} \right)^{dt}$$

$$= \frac{(f(b))^{\frac{1}{6}}}{\left(f\left(\frac{a+b}{2} \right) \right)^{-\frac{1}{3}}} \cdot \frac{1}{\int_0^1 \left(f\left(\frac{1+t}{2} b + \frac{1-t}{2} a \right)^{\frac{1}{2}} \right)^{dt}}$$

$$= (f(b))^{\frac{1}{6}} \left(f\left(\frac{a+b}{2} \right) \right)^{\frac{1}{3}} \left(\int_0^1 \left(f\left(\frac{1+t}{2} b + \frac{1-t}{2} a \right)^{dt} \right)^{-\frac{1}{2}} \right)$$

$$= (f(b))^{\frac{1}{6}} \left(f\left(\frac{a+b}{2} \right) \right)^{\frac{1}{3}} \left(\int_{\frac{a+b}{2}}^b (f(x))^{dx} \right)^{\frac{1}{a-b}}.$$

$$I_2 = \left(\int_0^1 \left(f^* \left(\frac{1+t}{2} a + \frac{1-t}{2} b \right)^{\left(\frac{1}{3} - \frac{t}{2}\right)} \right)^{dt} \right)^{\frac{b-a}{2}}$$

$$= \int_0^1 \left(f^* \left(\frac{1+t}{2} a + \frac{1-t}{2} b \right)^{\frac{a-b}{2}\left(\frac{t}{2} - \frac{1}{3}\right)} \right)^{dt}$$

$$= \frac{(f(a))^{\frac{1}{6}}}{\left(f\left(\frac{a+b}{2} \right) \right)^{-\frac{1}{3}}} \cdot \frac{1}{\int_0^1 \left(f\left(\frac{1+t}{2} a + \frac{1-t}{2} b \right)^{\frac{1}{2}} \right)^{dt}}$$

$$= (f(a))^{\frac{1}{6}} \left(f\left(\frac{a+b}{2} \right) \right)^{\frac{1}{3}} \left(\int_0^1 \left(f\left(\frac{1+t}{2} a + \frac{1-t}{2} b \right)^{dt} \right)^{-\frac{1}{2}} \right)$$

$$= (f(a))^{\frac{1}{6}}\left(f\left(\frac{a+b}{2}\right)\right)^{\frac{1}{3}}\left(\int_a^{\frac{a+b}{2}} (f(\varkappa))^{d\varkappa}\right)^{\frac{1}{a-b}}.$$

Multiplying above equalities, we have

$$I_1 \times I_2 = (f(b))^{\frac{1}{6}}\left(f\left(\frac{a+b}{2}\right)\right)^{\frac{1}{3}}\left(\int_{\frac{a+b}{2}}^{b} (f(\varkappa))^{d\varkappa}\right)^{\frac{1}{a-b}} f(a))^{\frac{1}{6}}\left(f\left(\frac{a+b}{2}\right)\right)^{\frac{1}{3}}\left(\int_a^{\frac{a+b}{2}} (f(\varkappa))^{d\varkappa}\right)^{\frac{1}{a-b}}$$

$$= \left((f(a))^{\frac{1}{6}}\left(f\left(\frac{a+b}{2}\right)\right)^{\frac{2}{3}}(f(b))^{\frac{1}{6}}\right)\left(\int_a^{\frac{a+b}{2}} (f(\varkappa))^{d\varkappa}\int_{\frac{a+b}{2}}^{b} (f(\varkappa))^{d\varkappa}\right)^{\frac{1}{a-b}}$$

$$= \left((f(a))\left(f\left(\frac{a+b}{2}\right)\right)^{4}(f(b))\right)^{\frac{1}{6}}\left(\int_a^{b} (f(\varkappa))^{d\varkappa}\right)^{\frac{1}{a-b}}.$$

So, the proof is completed.

Theorem 6. Let $f:[a,b]\to\mathbb{R}^+$ be a^* differentiable mapping on $[a,b]$ with $a<b$. If f^* is multiplicative s-convex on $[a,b]$, then the following Simpson-type inequality holds:

$$\left|\left((f(a))\left(f\left(\frac{a+b}{2}\right)\right)^{4}(f(b))\right)^{\frac{1}{6}}\left(\int_a^{b} (f(\varkappa))^{d\varkappa}\right)^{\frac{1}{a-b}}\right| \le \left((f^*(a))(f^*(b))\right)^{\frac{(s-4)6^{s+1}+2\times5^{s+2}-2\times3^{s+2}+2}{6^{s+2}(s+1)(s+2)}(b-a)} \quad (5)$$

Proof. From Lemma 1 and properties of * integral, we get

$$\left|\left((f(a))\left(f\left(\frac{a+b}{2}\right)\right)^{4}(f(b))\right)^{\frac{1}{6}}\left(\int_a^{b} (f(\varkappa))^{d\varkappa}\right)^{\frac{1}{a-b}}\right|$$

$$\le \left(\exp\frac{b-a}{2}\int_0^1 \left|\ln\left(f^*\left(\frac{1+t}{2}b+\frac{1-t}{2}a\right)^{\left(\frac{t}{2}-\frac{1}{3}\right)}\right)\right|dt\right)\left(\exp\frac{b-a}{2}\int_0^1 \left|\ln\left(f^*\left(\frac{1+t}{2}a+\frac{1-t}{2}b\right)^{\left(\frac{1}{3}-\frac{t}{2}\right)}\right)\right|dt\right)$$

$$\le \left(\exp\frac{b-a}{2}\int_0^1 \left|\frac{t}{2}-\frac{1}{3}\right|\left|\ln\left(f^*\left(\frac{1+t}{2}b+\frac{1-t}{2}a\right)\right)\right|dt\right)\left(\exp\frac{b-a}{2}\int_0^1 \left|\frac{1}{3}-\frac{t}{2}\right|\left|\ln\left(f^*\left(\frac{1+t}{2}a+\frac{1-t}{2}b\right)\right)\right|dt\right)$$

By using the multiplicative s-convexity of f^*, we have

$$\left|\left((f(a))\left(f\left(\frac{a+b}{2}\right)\right)^4(f(b))\right)^{\frac{1}{6}}\left(\int_a^b (f(x))^{dx}\right)^{\frac{1}{a-b}}\right|$$

$$\leq \left(\exp\frac{b-a}{2}\int_0^1 \left|\frac{t}{2}-\frac{1}{3}\right|\left|\ln\left((f^*(b))^{\left(\frac{1+t}{2}\right)^s}(f^*(a))^{\left(\frac{1-t}{2}\right)^s}\right)\right|dt\right)\left(\exp\frac{b-a}{2}\int_0^1 \left|\frac{1}{3}-\frac{t}{2}\right|\left|\ln\left((f^*(a))^{\left(\frac{1+t}{2}\right)^s}(f^*(b))^{\left(\frac{1-t}{2}\right)^s}\right)\right|dt\right)$$

$$= \exp\frac{b-a}{2}\int_0^1 \left|\frac{t}{2}-\frac{1}{3}\right|\left[\left(\frac{1+t}{2}\right)^s \ln(f^*(b)) + \left(\frac{1-t}{2}\right)^s \ln(f^*(a))\right]dt$$

$$= \exp\frac{b-a}{2^{s+1}}\int_0^1 \left|\frac{t}{2}-\frac{1}{3}\right|[(1+t)^s+(1-t)^s][\ln(f^*(a))+\ln(f^*(b))]dt$$

It is easy to observe that

$$\int_0^1 \left|\frac{t}{2}-\frac{1}{3}\right|[(1+t)^s+(1-t)^s]dt$$

$$= \int_0^{\frac{2}{3}}\left(\frac{1}{3}-\frac{t}{2}\right)[(1+t)^s+(1-t)^s]dt + \int_{\frac{2}{3}}^1\left(\frac{t}{2}-\frac{1}{3}\right)[(1+t)^s+(1-t)^s]dt$$

$$= J_1 + J_2.$$

$$J_1 = \int_0^{\frac{2}{3}}\left(\frac{1}{3}-\frac{t}{2}\right)[(1+t)^s+(1-t)^s]dt$$

$$= \int_0^{\frac{2}{3}}\left(\frac{1}{3}-\frac{t}{2}\right)(1+t)^s dt + \int_0^{\frac{2}{3}}\left(\frac{1}{3}-\frac{t}{2}\right)(1-t)^s dt$$

$$= \left(\frac{5(1+t)^{s+1}}{6(s+1)}-\frac{(1+t)^{s+2}}{2(s+2)}\right)\Bigg|_0^{\frac{2}{3}} + \left(\frac{5(1+t)^{s+1}}{6(s+1)}-\frac{(1+t)^{s+2}}{2(s+2)}\right)\Bigg|_0^{\frac{2}{3}}$$

$$= \frac{5^{s+2}-2\times 3^{s+2}+1}{2\times 3^{s+2}(s+1)(s+2)}.$$

$$J_2 = \int_{\frac{2}{3}}^1\left(\frac{t}{2}-\frac{1}{3}\right)[(1+t)^s+(1-t)^s]dt$$

$$= \int_{\frac{2}{3}}^1\left(\frac{t}{2}-\frac{1}{3}\right)(1+t)^s dt + \int_{\frac{2}{3}}^1\left(\frac{t}{2}-\frac{1}{3}\right)(1-t)^s dt$$

$$= \left(\frac{(1+t)^{s+2}}{2(s+2)}-\frac{5(1+t)^{s+1}}{6(s+1)}\right)\Bigg|_{\frac{2}{3}}^1 + \left(-\frac{(1+t)^{s+1}}{6(s+1)}+\frac{(1-t)^{s+2}}{2(s+2)}\right)\Bigg|_{\frac{2}{3}}^1$$

$$= \frac{(s-4)6^{s+1} + 5^{s+2} + 1}{2 \times 3^{s+2}(s+1)(s+2)}.$$

Corollary 1. If we take $s = 1$ in Theorem 6, then f^* is a multiplicatively convex function on $[a, b]$ and the inequality (5) reduces to the following inequality:

$$\left| \left((f(a)) \left(f\left(\frac{a+b}{2}\right) \right)^4 (f(b)) \right)^{\frac{1}{6}} \left(\int_a^b (f(x))^{dx} \right)^{\frac{1}{a-b}} \right| \leq \left((f^*(a))(f^*(b)) \right)^{\frac{5(b-a)}{72}}$$

Corollary 2. In Corollary 1, if $f(a) = f\left(\frac{a+b}{2}\right) = f(b)$, then we have

$$\left| \left(f\left(\frac{a+b}{2}\right) \right) \left(\int_a^b (f(x))^{dx} \right)^{\frac{1}{a-b}} \right| \leq \left(\left(f^*(a)\right)\left(f^*(b)\right) \right)^{\frac{5(b-a)}{72}} \tag{6}$$

Corollary 3. In Corollary 2, if $f^* \leq K$ then we have

$$\left| \left(f\left(\frac{a+b}{2}\right) \right) \left(\int_a^b (f(x))^{dx} \right)^{\frac{1}{a-b}} \right| \leq K^{\frac{5(b-a)}{36}}$$

Remark 2. We note that the obtained inequality (6) is better than the inequality in Theorem 3.3 in [16].

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A Note on Midpoint Type Inequalities for Multiplicative Integrals

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Abstract **–** In this study, we obtain a new generalized version for the right-hand side of the Hermite-Hadamard inequality. Using an identity for multiplicative differentiable functions, we establish a new midpoint type inequality in the setting of multiplicative calculus. The results we obtained can be reduced to multiplicative convex functions for s=1. By broadening these specific types of inequalities, the aim is to reveal new mathematical insights, properties, and relationships that can contribute to the development of more robust mathematical techniques. This research supports the advancement of mathematical tools across various scientific disciplines.

Keywords –Midpoint type inequalities, multiplicative integral, multiplicative calculus, multiplicative s-convex function

I. INTRODUCTION

Convex functions hold a crucial place in mathematical analysis, providing important insights into optimization, approximation, and variational calculus principles. Their importance spans numerous scientific and engineering fields, where they are essential tools for modeling complex systems and tackling difficult problems.

The exploration of convex functions has received considerable attention in recent years, with researchers investigating their theoretical basis, analytical characteristics, and practical applications in various areas. For example, in economics, convex functions are vital in modeling utility, production, and cost functions, offering understanding into consumer behavior, market equilibrium, and resource distribution [1]. Additionally, convex optimization methods are widely applied in finance for portfolio management, risk assessment, and option valuation, where convexity assumptions support many quantitative frameworks [2].

One of the crucial findings in convexity theory is the H–H inequality, introduced by C. Hermite and J. Hadamard. This inequality is a foundational element in the extensive domain of convexity and inequalities, playing a significant role in multiple scientific fields. It is formulated as follows [3-5]:

Theorem 1. Let $f: I \subseteq \mathbb{R} \to \mathbb{R}$ be a convex function and $a, b \in I$ with $a < b$. Then

$$f\left(\frac{a+b}{2}\right) \leq \frac{1}{b-a}\int_a^b \big(f(\varkappa)\big)d\varkappa \leq \frac{f(a)+f(b)}{2} \tag{1}$$

The Hermite-Hadamard inequality can be viewed as an enhancement of the concept of convexity. In recent times, several generalizations and extensions have been explored for classical convexity.

Additionally, numerous investigations have been dedicated to establishing new bounds for both the left and right-hand sides of inequality (2). For some illustrative instances, please refer the monographs [6-11].

Definition 1. [12] A function $f: I \to (0, \infty)$ is said to be multiplicatively convex, if

$$f((1-t)\varkappa + ty) \leq [f(\varkappa)]^{1-t}[f(y)]^{t} \tag{2}$$

for all $\varkappa, y \in I$ and $t \in [0,1]$.

Definition 2. [13] A function $f: I \to (0, \infty)$ is said to be multiplicatively s-convex, where $s \in (0,1]$, if

$$f((1-t)\varkappa + ty) \leq [f(\varkappa)]^{(1-t)^{s}}[f(y)]^{t^{s}} \tag{3}$$

for all $\varkappa, y \in I$ and $t \in [0,1]$.

It is obvious that for $s = 1$, the inequality (3) reduces to the inequality (2).

Definition 3. [14] Let $f: \mathbb{R} \to \mathbb{R}^{+}$be a positive function. The multiplicative derivative of the function f noted by f^{*} is defined as follows:

$$\frac{d^{*}f}{dt} = f^{*}(t) = \lim_{h \to 0} \left(\frac{f(t+h)}{f(t)}\right)^{\frac{1}{h}}$$

Remark 1. If f has positive values and is differentiable at t, then f^{*} exists and the relation between f^{*} and ordinary derivative f' is as follows:

$$f^{*}(t) = e^{(\ln f(t))'} = e^{\frac{f'(t)}{f(t)}}$$

The multiplicative derivative has the following properties:

Theorem 2. [14] Let f and g be multiplicatively differentiable functions, and c is arbitrary constant. Then functions cf, $fg, f+g, f/g$ and f^{g} are * differentiable and

1. $(cf)^{*}(t) = f^{*}(t)$,
2. $(fg)^{*}(t) = f^{*}(t)g^{*}(t)$,
3. $(f+g)^{*}(t) = f^{*}(t)^{\frac{f(t)}{f(t)+g(t)}}g^{*}(t)^{\frac{g(t)}{f(t)+g(t)}}$,
4. $\left(\frac{f}{g}\right)^{*}(t) = \frac{f^{*}(t)}{g^{*}(t)}$,
5. $(f^{g})^{*}(t) = f^{*}(t)^{g(t)}f(t)^{g'(t)}$.

Proposition 1. [14] If f is Riemann integrable on $[a, b]$, then f is * integrable on $[a, b]$ and

$$\int_{a}^{b} (f(\varkappa))^{d\varkappa} = e^{b}\ln\,(f(\varkappa))d\varkappa$$

Theorem 3. [14] Let f be a positive and Riemann integrable on $[a, b]$, then f is * integrable on $[a, b]$ and

1. $\int_a^b ((f(\varkappa))^p)^{d\varkappa} = \left(\int_a^b (f(\varkappa))^{d\varkappa}\right)^p$,

2. $\int_a^b (f(\varkappa)g(\varkappa))^{d\varkappa} = \int_a^b (f(\varkappa))^{d\varkappa} \int_a^b (g(\varkappa))^{d\varkappa}$,

3. $\int_a^b \left(\frac{f(\varkappa)}{g(\varkappa)}\right)^{d\varkappa} = \frac{\int_a^b (f(\varkappa))^{d\varkappa}}{\int_a^b (g(\varkappa))^{d\varkappa}}$,

4. $\int_a^b (f(\varkappa))^{d\varkappa} = \int_a^c (f(\varkappa))^{d\varkappa} \int_c^b (f(\varkappa))^{d\varkappa}, a < c < b$,

5. $\int_a^a (f(\varkappa))^{d\varkappa} = 1$ and $\int_a^b (f(\varkappa))^{d\varkappa} = \left(\int_b^a (f(\varkappa))^{d\varkappa}\right)^{-1}$.

*The multiplicative integration by parts is given as follows:

Theorem 4. [14] Let $f: [a, b] \to \mathbb{R}$ be multiplicative differentiable, let $g: [a, b] \to \mathbb{R}$ be differentiable so the function f^g is * integrable, and

$$\int_a^b \left(f^*(\varkappa)^{g(\varkappa)}\right)^{d\varkappa} = \frac{f(b)^{g(b)}}{f(a)^{g(a)}} \times \frac{1}{\int_a^b \left(f(\varkappa)^{g'(\varkappa)}\right)^{d\varkappa}}.$$

Lemma 1. [15] Let $f: [a, b] \to \mathbb{R}^+$be a^* differentiable mapping on $[a, b]$ with $a < b$. If f^* is * integrable on $[a, b]$, then

$$f\left(\frac{a+b}{2}\right)\left(\int_a^b (f(\varkappa))^{d\varkappa}\right)^{\frac{1}{a-b}} = \left(\int_0^1 \left(f^*\left((1-t)a + t\frac{a+b}{2}\right)^t\right)^{dt}\right)^{\frac{b-a}{4}} \left(\int_0^1 \left(f^*\left((1-t)\frac{a+b}{2} + tb\right)^{t-1}\right)^{dt}\right)^{\frac{b-a}{4}}.$$

II. MAIN RESULT

Theorem 5. Let $f: [a, b] \to \mathbb{R}^+$be a^* differentiable mapping on $[a, b]$ with $a < b$. If f^* is multiplicatively s-convex on $[a, b]$, then the following midpoint-type inequality holds:

$$\left|f\left(\frac{a+b}{2}\right)\left(\int_a^b (f(\varkappa))^{d\varkappa}\right)^{\frac{1}{a-b}}\right| \leq \left((f^*(a))\left(f^*\left(\frac{a+b}{2}\right)\right)^{2(s+1)}(f^*(b))\right)^{\frac{b-a}{4(s+1)(s+2)}}$$

$$\leq \left((f^*(a))(f^*(b))\right)^{\frac{(2^{2-s}+1)(b-a)}{4(s+1)(s+2)}} \quad (4)$$

Proof. From Lemma 1 and properties of * integral, we have

$$\left|f\left(\frac{a+b}{2}\right)\left(\int_a^b (f(\varkappa))^{d\varkappa}\right)^{\frac{1}{a-b}}\right|$$
$$\leq\left(\exp\frac{b-a}{4}\int_0^1\left|\ln\left(f^*\left((1-t)a+t\frac{a+b}{2}\right)^t\right)\right|dt\right)$$
$$\times\left(\exp\frac{b-a}{4}\int_0^1\left|\ln\left(f^*\left((1-t)\frac{a+b}{2}+tb\right)^{t-1}\right)\right|dt\right)$$
$$=\left(\exp\frac{b-a}{4}\int_0^1 t\left|\ln\left(f^*\left((1-t)a+t\frac{a+b}{2}\right)\right)\right|dt\right)$$
$$\times\left(\exp\frac{b-a}{4}\int_0^1 (1-t)\left|\ln\left(f^*\left((1-t)\frac{a+b}{2}+tb\right)\right)\right|dt\right)$$

By using the multiplicative s-convexity of f^*, we have

$$\left|f\left(\frac{a+b}{2}\right)\left(\int_a^b (f(\varkappa))^{d\varkappa}\right)^{\frac{1}{a-b}}\right|$$
$$\leq\left(\exp\frac{b-a}{4}\int_0^1 t\left|\ln(f^*(a))^{(1-t)^s}\left(f^*\left(\frac{a+b}{2}\right)\right)^{t^s}\right|dt\right)$$
$$\times\left(\exp\frac{b-a}{4}\int_0^1 (1-t)\left|\ln\left(f^*\left(\frac{a+b}{2}\right)\right)^{(1-t)^s}(f^*(b))^{s^s}\right|dt\right)$$
$$=\left(\exp\frac{b-a}{4}\int_0^1\left(t(1-t)^s\ln(f^*(a))+t^{s+1}\ln\left(f^*\left(\frac{a+b}{2}\right)\right)\right)dt\right)$$
$$=\left(\exp\frac{b-a}{4}\left(\ln(f^*(a))\int_0^1 t(1-t)^s dt+\ln\left(f^*\left(\frac{a+b}{2}\right)\right)\int_0^1 t^{s+1}dt\right)\right)$$
$$\times\left(\exp\frac{b-a}{4}\left(\ln\left(f^*\left(\frac{a+b}{2}\right)\right)\int_0^1 (1-t)^{s+1}dt+\ln(f^*(b))\int_0^1 t^s(1-t)dt\right)\right)$$
$$=\left(\exp\frac{b-a}{4}\left(\frac{1}{(s+1)(s+2)}\ln(f^*(a))+\frac{1}{s+2}\ln\left(f^*\left(\frac{a+b}{2}\right)\right)\right)\right)$$
$$\times\left(\exp\frac{b-a}{4}\left(\frac{1}{s+2}\ln\left(f^*\left(\frac{a+b}{2}\right)\right)+\frac{a+b}{(s+1)(s+2)}\right)+t^s(1-t)\ln(f^*(b))\right)dt\Bigg).$$

Thus we have,

$$\left|f\left(\frac{a+b}{2}\right)\left(\int_a^b (f(\varkappa))^{d\varkappa}\right)^{\frac{1}{a-b}}\right|\leq\left((f^*(a))^{\frac{1}{(s+1)(s+2)}}\left(f^*\left(\frac{a+b}{2}\right)\right)^{\frac{2}{s+2}}(f^*(b))^{\frac{1}{(s+1)(s+2)}}\right)^{\frac{b-a}{4}} \quad (5)$$

and the first inequality in (4) is proved. To prove the second inequality in (4), by using the multiplicative s-convexity of f^*, we get

$$\left(f^*\left(\frac{a+b}{2}\right)\right)^{2^{s-1}} \leq \left(\left(f^*(a)\right)\left(f^*(b)\right)\right)^{\frac{1}{s+1}} \tag{6}$$

A combination of (5) and (6) gives the inequality

$$\left|f\left(\frac{a+b}{2}\right)\left(\int_a^b (f(x))^{dx}\right)^{\frac{1}{a-b}}\right| \leq \left(\left(f^*(a)\right)\left(f^*\left(\frac{a+b}{2}\right)\right)^{2(s+1)}\left(f^*(b)\right)\right)^{\frac{b-a}{4(s+1)(s+2)}}$$

$$\leq \left(\left(f^*(a)\right)\left[\left(\left(f^*(a)\right)\left(f^*(b)\right)\right)^{\frac{1}{s+1}}\right]^{2(s+1)2^{1-s}}\left(f^*(b)\right)\right)^{\frac{b-a}{4(s+1)(s+2)}}$$

$$= \left(\left(f^*(a)\right)\left(f^*(b)\right)\right)^{\frac{(2^{2-s}+1)(b-a)}{4(s+1)(s+2)}}.$$

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SYNERGISTIC EFFECT OF ADDED MO AND TI ELEMENTS ON THE MICRO STRUCTURE AND WEAR PROPERTIES OF 316 L STAINLESS STEEL PRODUCED BY TM METHOD

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Abstract – The powder metallurgy (P/M) process allows the creation of high-performance and durable components using metal powders of different sizes. The properties of these components depend on the size, composition, compression and sintering properties of the powders used. The addition of elements such as chromium, nickel, copper, titanium, molybdenum, niobium, aluminum, nitrogen, silicon and sulfur significantly improves the properties of stainless steel. This study focuses on 316L stainless steel matrix processed with specific concentrations of titanium and molybdenum elemental powders using P/M technology, resulting in a powder mixture with the required composition. Powders were shaped into blocks using ASTM E8M powder metal drawing sample mold and cold pressed unidirectionally at 750 MPa compression pressure. After the pressing process, the samples were sintered in an atmosphere-controlled tube furnace at 1310°C for 6 hours to regain their original strength. The samples were subjected to microstructural examination and wear testing. This comprehensive research highlights the potential of powder metallurgy in producing high-quality stainless steel alloys with special properties through precise control of powder composition and processing parameters.

Keywords – 316L stainless steel, Microstructure, wear test, PM steel

I. INTRODUCTION

Materials are the building blocks that engineers use to create anything. Biomaterials are any materials that the body uses to repair or maintain tissues that function in a living environment and injured organs. A great deal of effort is invested in ensuring that components of biomedical goods adapt to biological systems without causing harm. Biocompatible, dependable, and effective biomaterials are materials used in the human body to support or carry out the functions of organs or tissues that come into contact with bodily fluids on a regular or continuous basis and that shouldn't result in cytotoxic reactions in the organism. Their significance and field of application are expanding every day [1].

Generally speaking, a biological material's performance is determined by two factors: bio functioning and biocompatibility. While biocompatibility evaluates a substance's suitability for the body, bio functioning indicates how effectively a device can perform its intended purpose. Some important characteristics of biomaterials make them desirable. Engineers are well-acquainted with mechanical performance, which includes tensile strength, deformation, bending, fatigue, toughness, and elasticity. They are also familiar with chemical stability, such as resistance to corrosion. Additionally, biological properties and bioinertity are traits that are of interest to disciplines in the biological and medical fields [2].

One of the minerals being examined in this research is chromium, which was given the moniker Siberian red lead after it was found in a Siberian gold mine in 1766. The discovery was first attributed to the French researcher Nicholas Louis Vauquelin, who identified it in Paris in 1798 [3]. The term "chromium" is derived from the Greek word "chroma," which translates to "color." The substance is now referred to as crocoite and belongs to the category of lead chromate [4]. This mineral may be found in several locations, including as Kazakhstan, South Africa, India, and Turkey.

Chromium is a bright, brittle, and inflexible metal. It might have a silver-gray hue and be very polished [5]. In air, it does not tarnish. The surface of the stainless steels becomes a thin, chemically stable coating of passive oxide when Cr is present. The oxide coating forms and heals itself when oxygen is present. The physical-chemical properties of this passive layer control the material's corrosion behavior, its bodily interactions, and its biocompatibility. Many in-vitro and in-vivo studies have been conducted on the corrosion of metal implants. However, the majority of in vitro studies employed physiologically realistic fluids such as Ringer's or Hanks' solutions. Reportedly, the amount of chromium in the protective coating processes that result in a coating significantly affects stainless steel's corrosion resistance [6].

The discovery that stainless steel, which is made of metalized chromium, may have been engineered to be very resistant to corrosion and discoloration, represented a dramatic shift in the production of steel. Eighty-five percent of industrial use is made up of stainless steel (chromium electroplating) and chrome coating combined. Chromium is added to steel to increase its resistance to oxidation. This resistance increases when more chromium is added. Chromium content in stainless steels must be at least 10.5% (usually 10.9 or 12.1%). This offers a notable level of overall abrasion resistance in comparison to steels that include less chromite. Stainless steel is resistant to corrosion because, as previously mentioned, its surface is coated with chromium oxide, which facilitates the material's passive self-healing properties. Stainless steel, which has a chromium concentration of more than 12% and provides better corrosion resistance, was used to manufacture the first orthopedic implants in the 1920s [7]. Owing to its superior machinability, cheap cost, enhanced ductility, and strong fatigue strength, type (AISI 316L) is frequently used in implanted devices, especially orthopedic implants [8]. Stainless steels are known for having a high level of corrosion resistance in a variety of circumstances [9]. Nonetheless, solutions containing 30% nitric acid demonstrate the exceptional corrosion resistance of chromium and chromium alloys [10].

This study aims to investigate the effects of Mo and Ti addition on the mechanical properties and microstructure of 316L stainless steels. It is thus thought that these steels produced using the new P/M can have improved mechanical properties. It is commonly recognized that if P/M is used to make these steels, the number of samples required will determine how much the production costs will decrease. The object that is formed will be guaranteed to have a high-quality surface, and some metals that are difficult to produce and process using traditional methods can be made.

II. MATERIALS AND METHOD

The investigation has developed innovative composite materials by incorporating stainless steel 316L with additions of titanium (Ti) and molybdenum (Mo). All samples were fabricated using P/M techniques. The sizes and purity levels of the powders used are detailed in Table 1.

Table 1. Sizes purities and density of the powders

	Elemental powders	**Size (µm)**	**Purity %**	**Density (g/cm³)**	**Supplied Company**
1	SS316L	<149	99.9	7.95	Höganas, USA
2	Ti	<45	96.5	4.54	Aldrich, Germany
3	Mo	<150	99.9	10.28	Aldrich, Germany

The size of particles in powders impacts their flowability, packing density, and sintering behavior. Titanium (Ti) has the smallest particle size (<45 μm), resulting in better sintering characteristics and surface finish in additive manufacturing processes. High purity levels (99.9% for SS316L and Mo) are critical for applications where material properties cannot be compromised by impurities. Titanium (96.5%) has lower purity due to refining difficulties or acceptable impurities. Density values show differences in material properties, with Molybdenum (Mo) having the highest density (10.28 g/cm³) for high mass and thermal stability, and Titanium (Ti) suitable for lightweight applications like aerospace components. Suppliers like Höganas and Aldrich ensure powders meet quality and consistency standards for research and industrial applications.

Figure 1 illustrates the step-by-step process employed in the fabrication of these samples.

Figure 1. The sequence of operations of this study

By following these steps, we can develop a thorough understanding of a material's properties and performance. Each step is crucial for ensuring the quality and reliability of the final product, from initial powder preparation to detailed microscopic analysis. This comprehensive approach enables the optimization of materials for specific applications, leading to improved products and innovations in various industries.

Table 2 lists the different compositions of 316L stainless steel with varying amounts of molybdenum (Mo) and titanium (Ti), all subjected to the same thermal treatment profile (1310°C for 6 hours in a neutral environment).

Table 2. Chemical compositions of powder metal steels.

Alloys number	Composition
1	316L
2	316L+0.1Mo
3	316L+0.2Mo
4	316L+0.2Mo+0.2Ti

By analyzing the results of mechanical testing and microscopic analysis for these different compositions, it is possible to optimize the material for specific uses, leading to better performance and longer lifespan in practical applications.

The preparation of the powders begins with precise weighing using a RADWAG AS-60-220 C/2 precision scale, known for its 0.0001 g measurement accuracy. This high level of precision is crucial for ensuring that each component of the powder mixture is measured accurately, thereby maintaining

consistency in the experimental results. Accurate weighing helps minimize variations, ensuring that the proportions of each element in the powder mixture are correct.

Following the precise weighing, the powders are blended using a TURBULA T2F device from Willy A. Bachofen AG, Muttenz, Switzerland. This blending device operates on the basis of three-dimensional motion and is used to meticulously mix the powder compositions over a period of one hour. The TURBULA T2F ensures that the powder particles are uniformly mixed, which is crucial for achieving homogeneity in the final product. Homogeneous mixing ensures that the desired enhancements in mechanical and chemical properties, such as those provided by alloying elements like molybdenum (Mo) and titanium (Ti), are uniformly distributed throughout the material.

The thorough blending process facilitated by the TURBULA T2F also plays a key role in process efficiency and property optimization. By ensuring a uniform distribution of the alloying elements within the base powder, the blending process helps achieve consistent properties in the final sintered product. This level of thoroughness is essential for subsequent steps such as compaction and sintering, which further enhance the material's properties. The meticulous preparation and blending of the powders lay a strong foundation for the entire material preparation process, ensuring reliability and reproducibility in the results.

As required by the ASTM E8M standards the powders were meticulously crushed and formed into the required shape for the tensile test specimens. This critical step was achieved using a robust 100-ton hydraulic press manufactured by Hidroliksan. The pressing process was executed with an impressive precision, setting the pressure to a remarkable 750 MPa. This high level of pressure ensures that the powders are compacted to the desired density and structural integrity, which is essential for accurate and reliable tensile testing.

Following the pressing process, the material was subjected to sintering in an argon environment, utilizing the device.The sintering process involved heating the material at a controlled rate of 5°C per minute until reaching a peak temperature of 1310°C, maintained for a duration of 6 hours. This careful control of the heating rate ensures uniform temperature distribution and optimal bonding between powder particles.

In the subsequent phase of the experiment, the samples were cooled at a controlled rate of 5°C per minute from the peak temperature down to room temperature. This controlled cooling rate is crucial to prevent thermal shocks and to maintain the material's structural integrity and desired properties. The entire sintering process, both heating and cooling, plays a vital role in achieving the final microstructure and mechanical properties of the material, making it suitable for its intended application.

The optical microscopy analysis was conducted using the highly accurate and excellent Nikon ECLIPSE L150 microscope, manufactured in Melville, New York, USA, as shown in Figure 4.11. The mean linear intercept method was employed to calculate the grain sizes of the composites [85].

A variety of abrasive paper meshes were used to prepare the samples for the wear test (400, 600, 800, 1000, 1500, 2000, and 2500 meshes, coarse to fine). The tribometer gadget, 4D-ECN type, was employed for wear tests. The wear test was performed with a stroke of 10 mm, a total of 100 meters of sliding distance for each load, and a sliding speed of 40 mm/s in an SBF solution at 37 °C under 20N loadsFor the wear test, 6mm-diameter alumina balls were utilized. Microstructure images of the samples produced with the PM technique were taken at 750 MPa pressure and sintered in an argon atmosphere at 1310◦C for 6 hours. Figure 6.1. To Figure 6.6. It shows optical microscope images of samples produced by the PM method before and after adding alloying elements (Ti and Mo).

III. RESULTS AND DISCUSSION

When 0.1% Mo, 0.2% Mo and 0.2% Mo + 0.2% Ti are added to 316L Stainless steel, respectively, the grain size in the microstructure increases. It has been observed that the grain size decreases depending on the amount of addition, and the grain size decrease gradually increases with double additions to see the synergistic effect.

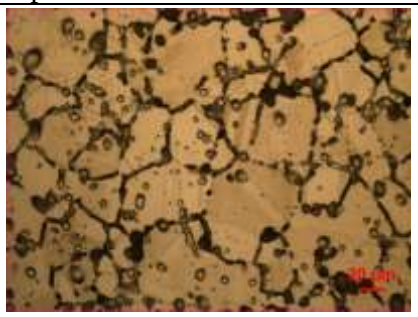
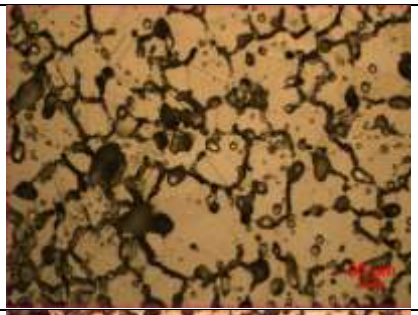
Number	Alloys	Optic Microstructure
1	316L	
2	316L-0.1Mo	
3	316L-0.2Mo	
4	316L-0.2Mo-0.2Ti	

Figure 2. Optical Microstructure of the samples.

Ti has a high affinity for carbon. Therefore, the formation of TiC (titanium carbide) can be observed with the addition of Ti. These carbides often precipitate at grain boundaries, and these precipitations can limit grain growth. Titanium can react with nickel to form intermetallic phases. These phases are generally hard and brittle, which can reduce the ductility of the material. With the addition of Ti, the precipitation hardening mechanism can be activated. In this case, the hardness and strength of the material may increase. Ti can precipitate at grain boundaries and inhibit grain growth. This can reduce the grain size of the material and increase microstructural homogeneity [11].

2D wear depth images taken from the surface profilometer device in the wear test performed under 20 N load are given in Figure 3. As can be seen from the figure, the highest wear depth was obtained in 316L stainless steel without any alloying elements. When 0.1% Mo is added to 316L stainless steel, there is a visible decrease in the corrosion depth. With the addition of 0.2% Mo, there is still a decrease in depth compared to the unalloyed material, although not as much as with the addition of 0.1% Mo. When it comes to the 316L+0.2%Ti+0.2%Mo alloy, where the synergistic effect will be seen, it is obvious that a clear decrease in the wear depth is observed. The wear depth seen in the last sample is less than the wear seen in all other samples. Both Mo and Ti tend to form carbides (carbides). These carbides act as hard phases that increase the wear resistance of the steel. Mo-carbide and Ti-carbide (TiC) particles improve wear resistance by increasing the surface hardness of the material. Ti precipitates at grain boundaries and prevents grain growth. This increases the overall hardness and wear resistance of the material. Mo has a similar effect and increases the hardness of the material by making dislocation motion more difficult [12].

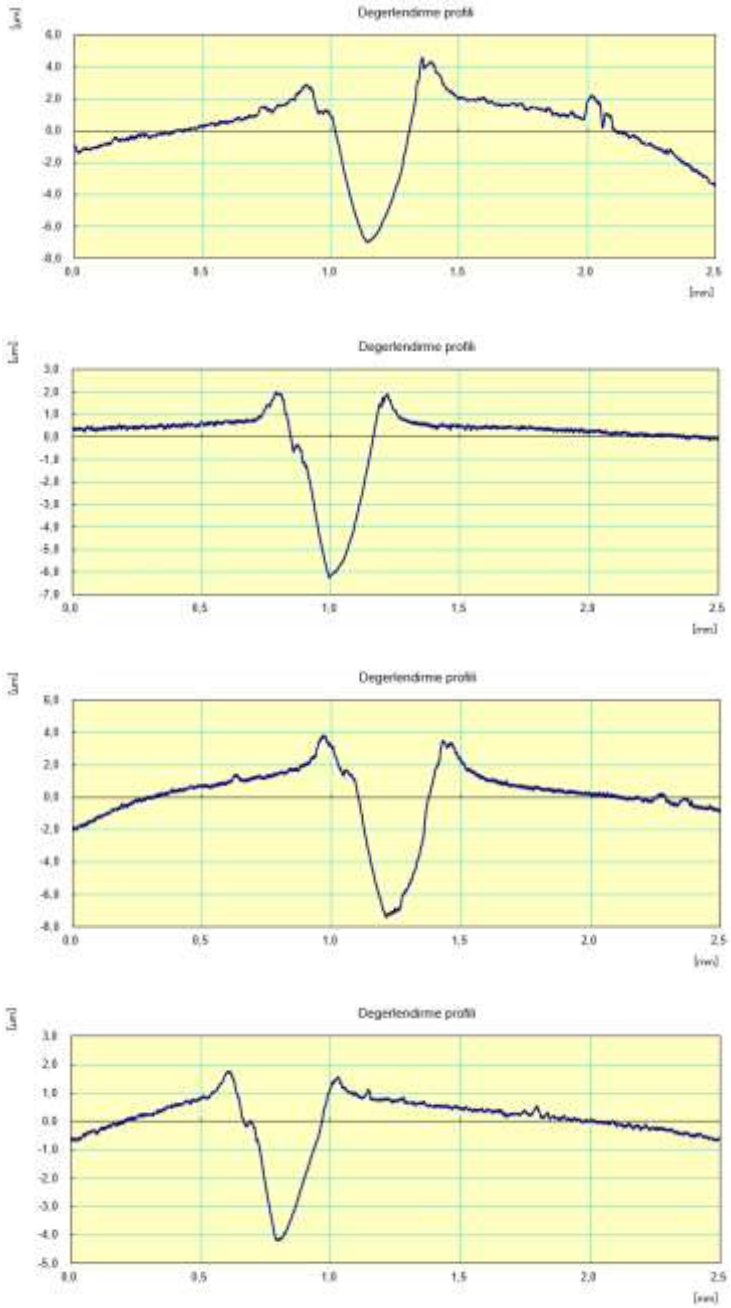


Figure 3. 2D depth values of the samples in the order given in Table 2.

IV. CONCLUSION

- With the alloying element added to 316L stainless steel, significant thinning occurred in its microstructure. This situation is thought to be due to the effect of the carbide-forming elements Mo and Ti.
- As can be seen from the microstructure images, the lowest grain size was seen in the 316L + 0.2% Mo + 0.2% Ti sample, where the synergistic effect was observed.
- When we look at the wear results under 20 N load, the lowest wear depth value was obtained in the 316L + 0.2% Mo + 0.2% Ti sample.

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Innovative Metamaterial-Based Antenna for Blood Glucose Measurement

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Abstract – Maintaining optimal blood glucose levels is vital for energy production and overall health, with deviations leading to serious conditions such as diabetes mellitus. Traditional glucose monitoring methods, although accurate, often involve invasive procedures that can be uncomfortable for patients. This has spurred interest in non-invasive techniques for glucose monitoring, which promise a more convenient and patient-friendly approach. Recent advancements in antenna-based sensor technology have shown potential for non-invasive glucose measurement. This study investigates a microwave sensor intended for blood glucose measurement that operates in the 8–12 GHz (X-band) frequency range. The sensor offers a painless substitute for traditional techniques by interacting with glucose molecules through the skin using electromagnetic waves. S-parameter measurements were used to analyze the sensor's performance, with particular attention paid to the S11 parameter in order to gauge the sensor's sensitivity and accuracy. Blood and skin phantoms were constructed with dielectric characteristics corresponding to varied glucose concentrations in order to replicate variable blood glucose levels. This method made it possible to thoroughly examine how the sensor distinguishes between different glucose levels depending on variations in the S11 parameter. The goal of the project is to advance non-invasive glucose monitoring technology, which will enable more effective and convenient diabetes care.

Keywords – Non-invasive blood glucose measurement, Microwave sensor, Microstrip antenna, Dielectric phantoms,Diabetes Management

I. INTRODUCTION

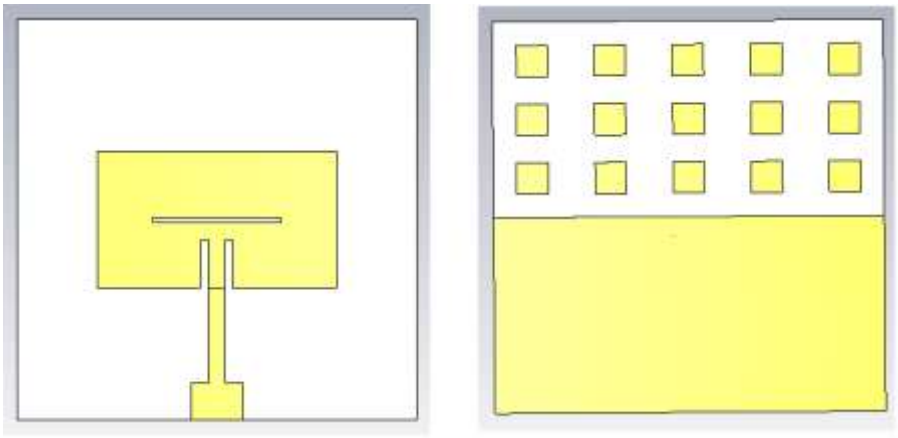
Blood glucose, or blood sugar, refers to the concentration of glucose in the bloodstream. Glucose is a crucial source of energy for the body's cells, and its levels are tightly regulated by hormonal mechanisms involving insulin and glucagon. Maintaining optimal blood glucose levels is essential for proper bodily function, including energy production, metabolism, and overall health[1]. Blood glucose levels can be broadly categorized into three main types[2, 3]. Normal blood glucose levels typically range from 70 to 99 mg/dL when fasting and up to 140 mg/dL two hours after eating[4]. These normal levels are crucial for maintaining metabolic health and preventing chronic conditions. Hyperglycemia, or high blood glucose, is characterized by elevated blood glucose levels, typically above 140 mg/dL. Chronic hyperglycemia is a hallmark of diabetes mellitus and can lead to severe complications if not managed properly[5]. Hypoglycemia, or low blood glucose, occurs when blood glucose levels fall below 70 mg/dL. Symptoms of this illness include lightheadedness, disorientation, and in extreme situations, unconsciousness. Hypoglycemia is a serious disorder that needs to be treated right away. For the millions of people worldwide who suffer from diabetes, blood glucose monitoring is essential to managing this common chronic illness. Good blood glucose control aids in avoiding consequences including kidney failure, nerve damage, cardiovascular disease, and eye issues. Additionally, by helping people with diabetes to better manage their illness, it enhances their quality of life. In recent years, non-invasive methods for blood glucose monitoring

have gained significant attention[6, 7]. One method that seems promising is antenna-based sensor technology[8]. This technique uses electromagnetic waves to probe the skin's glucose levels[9]. For this reason, a number of antenna design strategies are being investigated. Wearable devices can incorporate microstrip patch antennas due to their compact design [10]. Their working frequency are microwaves, which can interact with glucose molecules and pass through skin. The efficiency and simplicity of integration of planar inverted-F antennas (PIFA) into portable electronics are well-known[11]. PIFA's consistent performance throughout a broad frequency range makes them appropriate for use in non-invasive glucose monitoring systems. Antennas that are flexible and conformal are made to fit the shape of the human body.

The development of non-invasive blood glucose monitoring devices using advanced antenna designs represents a significant leap forward in diabetes management[12]. These technologies offer a painless and convenient alternative to traditional finger-prick methods, improving the ease and effectiveness of monitoring blood glucose levels. In this study, a microwave sensor was designed for non-invasive glucose measurement. The designed sensor took measurements for the range of 8-12 GHz (X-band) and the S-parameter was examined. For the S11 parameter, blood and skin phantom were created to examine the difference according to the sugar level. Blood phantoms, which were created by considering dielectric differences in accordance with different blood sugar levels, were tried and the results were shared.

II. Materials and Method

For the study, we first decided on the operation frequency range as 8-12 GHz. This specific range is a band with many usage ranges, also known as the X-band. In this study, microstrip antenna, which is a popular antenna type in antenna theory, was preferred. Microstrip antennas emit radiation at a certain frequency value depending on their size. FR-4 substrate, which has an epsilon value of 4.3 and a thickness of 1.52mm, was preferred as a substrate for the designed microstrip antenna due to reasons such as accessibility, cost and easy manufacturability.



a) b)

Figure.1 a) Front, b) back of the proposed antenna

The proposed microstrip antenna shown in Figure 1 has a size of 50x50 mm2. In order to improve the scattering parameters of the designed microstrip antenna, slots were removed from the patch part. In the soil structure, degraded soil structure (DGS) was used. Thanks to the squares used in the degraded soil structure, the capacitive effect is increased. Moreover, metamaterial unit cells are placed on the upper side of the soil part, thus aiming to increase the bandwidth.

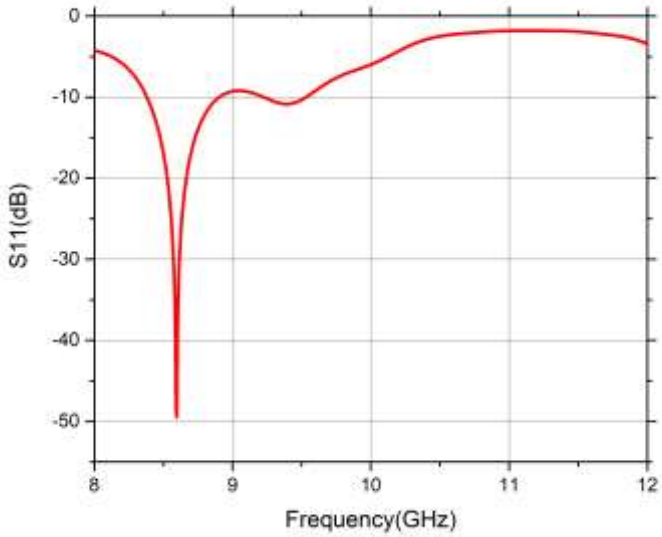
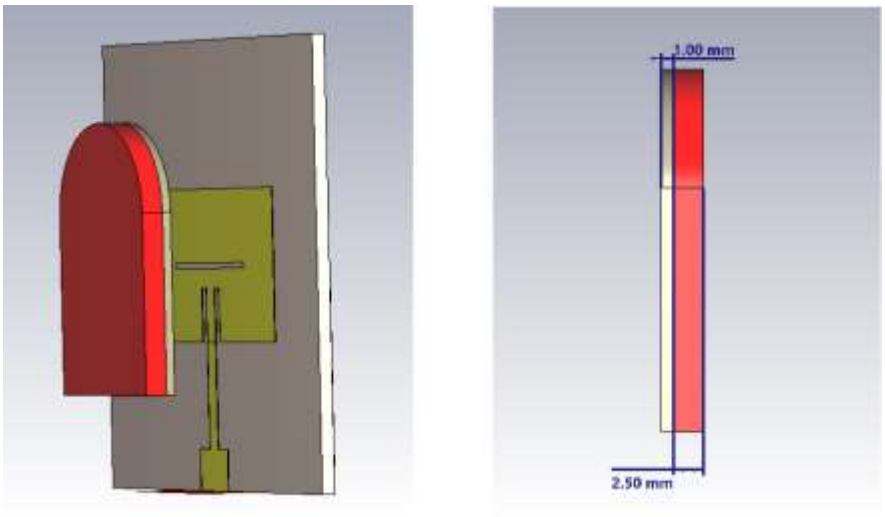


Figure.2 S11 results of the proposed antenna

As can be seen in Figure 2, the scattering parameters are at frequencies of 8.36-8.91 GHz below -10dB, which means 90% transmission. While simple microstrip antennas have a narrow bandwidth, a wide band gap has been obtained due to the microstrip antenna structure we propose, slotted structure and degraded soil structure. The proposed antenna structure reaches its peak value at a frequency of 8.569 GHz. This peak was intended to lead us in comparing materials with different dielectric values.



a) b)

Figure.3 a) Environment of blood glucose simulation b) designed blood-skin phantom

In Figure 3, a simplified skin-blood phantom is placed in front of the proposed antenna structure. The epsilon value of the skin phantom with a thickness of 1mm is 5.5 and the simulation results of the blood phantoms with a thickness of 2.5mm at different epsilon values are given in the next section.

III. RESULTS

Figure 4 shows the simulation results with the antenna structure we proposed for different blood phantoms of different blood glucose rates.

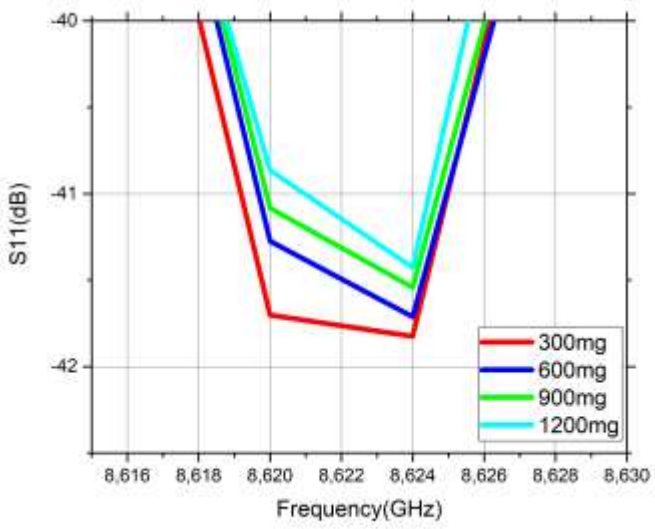


Figure 4. Measurement results of different blood glucose levels

In this study, it was observed that the largest dB difference of blood glucose differences was at 8.620 GHz. In line with this specific frequency, 300mg blood glucose was shown in red and it was seen that it had the lowest S11 value with -41.6969 in line with the simulation results. The blood phantom 600mg represented in blue was observed to be in second place with a blood glucose phantom of -41.2693, 900mg represented in green and 1200mg shown in light blue was observed to be -41.0786 and -40.8603, respectively. In the light of the results of this study, blood glucose differences were clearly determined by dB difference on four different phantoms.

IV. DISCUSSION

These findings highlight the potential and applicability of microwave sensors compared to existing non-invasive glucose measurement technologies in the literature. Previous studies have noted limitations and precision issues with some non-invasive techniques, in addition to traditional invasive methods. The antenna-based microwave sensor used in this study has the potential to address these issues, offering higher accuracy and comfort. This study represents a significant advancement in non-invasive glucose monitoring, providing a painless and practical alternative to conventional finger-prick methods. The results establish a promising foundation for future research and development in this technology. Testing the sensor's performance across a broader patient population and under various conditions will enhance confidence in the technology. Moreover, further comprehensive studies are needed to better understand the potential benefits of such technologies in clinical applications.

V. CONCLUSION

This study highlights the development and evaluation of a microwave sensor designed for non-invasive blood glucose measurement. The sensor operates in the X-band frequency range of 8-12 GHz, where the S-parameters, specifically the S11 parameter, were examined using blood and skin phantoms created to simulate different blood sugar levels. These phantoms were designed based on the dielectric differences corresponding to varying glucose concentrations. The results indicate that the proposed sensor can effectively differentiate glucose levels. The largest dB difference in blood glucose measurements was observed at 8.620 GHz. At this specific frequency, the simulation results showed that the 300 mg/dL blood glucose phantom had the lowest S11 value at -41.6969. The 600 mg/dL blood glucose phantom followed with an S11 value of -41.2693, while the 900 mg/dL and 1200 mg/dL phantoms had S11 values of -41.0786 and -40.8603, respectively. These findings demonstrate that the microwave sensor can clearly differentiate between various blood glucose levels based on dB differences across four different phantoms. This

advancement suggests significant potential for non-invasive blood glucose monitoring, offering a painless and convenient alternative to traditional finger-prick methods. The outcomes of this study provide a promising foundation for future research and development in the field of non-invasive glucose monitoring technology.

ACKNOWLEDGMENT

The authors declare no conflict of interest.

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Derin Öğrenme ile Yolcu Duraklarında İnsan Yoğunluğunun Tahmin Edilmesi

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Özet **–** Yapay zekâ ve görüntü işleme yöntemleri ile insanların belirli bir alanda sayılabilmesi insan yoğunluklarının tespit edilmesinde kullanılmaktadır. Toplu ulaşım alanlarında yolcu yoğunluğuna göre toplu taşıma araçlarının sefer sıklığının belirlenmesinin önemli olacağı düşünülmektedir. Böylelikle taşıma maliyetlerin yolcu sayılarına göre düzenlenen seferlere göre azaltılacağı öngörülmektedir. Yolcu yoğunluğunun doğru ve hızlı bir şekilde tespit edilmesi, toplu taşıma sistemlerinin etkin yönetimi ve planlanması açısından büyük önem taşımaktadır. Mevcut sistemlerde kullanılan geleneksel yöntemler, düşük doğruluk oranları ve yavaş işlem süreleri nedeniyle yetersiz kalmaktadır. Derin öğrenme yöntemlerinin sağladığı yüksek doğruluk ve hız, toplu taşıma duraklarında gerçek zamanlı izleme ve yönetim için bu alanda büyük bir potansiyel sunmaktadır. Bu çalışmada derin öğrenme yöntemlerinden YOLOv5, YOLOv8, YOLOv9 ve izleme algoritması Deep SORT kullanılarak insan yoğunluğu tespiti gerçekleştirilmiştir. Çalışmada kullanılan en başarılı sonucu YOLOv9 algoritması ile geliştirilen yapay zekâ modeli ile mAP %97,1 başarı değeri elde edilmiştir. Geliştirilen yapay zekâ destekli yazılımın otobüs duraklarında bir sabit kamera ile kullanılması ile yolcu yoğunluğunun hesaplanarak toplu taşıma sefer saatlerinin ihtiyaca göre düzenleneceği düşünülmektedir. Çalışma, hem akademik alanda hem de pratik uygulamalarda kullanılabilecek yenilikçi ve etkili bir çözüm sunmaktadır. Gelecekte, bu tür algoritmaların daha da geliştirilmesi ve çeşitli veri setleriyle test edilmesi ile toplu taşıma sistemlerinin daha da etkin ve verimli hale getirilmesine yardımcı olacaktır.

Anahtar Kelimeler – YOLO, Deep SORT, derin öğrenme, insan yoğunluğu, toplu taşıma

I. GİRİŞ

2008 yılında yapılan bir çalışmada insanların yoğun olduğu bir videoda yayaların takip işlemlerini yaptıkları görülmüştür [1].

Yapılan bir çalışmada insan sayısının arttığı noktalarda insan sayısının videolarda ölçülmesinin önemli bir problem olarak görmüşlerdir [2].

2010 yılında yapılan farklı bir çalışmada kalabalıklar içinden insan sayısı tespiti yapılan bir çalışmada K-ortalamalar, Haar Dalgacık dönüşümü, Gaussian tekniklerinin kullanıldığı görülmüştür [3].

Kalabalıklarda insan sayısının tespit edildiği bir çalışmada insan kafalarının ilgili noktalar olarak gradyan oryantasyonu ile belirlendiği ve yerel ikili örüntüler yön teminlerini kullandıkları görülmektedir [4].

2015 yılında derin evrişimli sinir ağı modeli ile sahne kalabalığı saymanın önerildiği görülmüştür [5].

Derin öğrenme yöntemlerinin kullanıldığı bir çalışmada, insan vücut parçalarını tespit etmek için geliştirilmiş bir model geliştirildiği görülmüştür [6].

Derin Öğrenme yöntemleri ile yapılan farklı bir çalışmada insan ve hareketlerinin pozlarının tespit edildiği görülmüştür [7].

Çok sütunlu evrimşimli sinir ağları kullanılan bir çalışmada tek bir görüntü üzerinde her açıdan insan sayısının tahmin edildiği görülmüştür [8].

Video üzerinde kalabalıkların sayım işlemlerinin zorluklarından bahseden çalışmada DRC-ConvLSTM ağı kullanılarak kalabalık yoğunluğunun hesaplandığı aktarılmıştır [9].

Yapılan farklı bir çalışmada görüntülerde insan kafalarının sayma işlemlerinde kullanıldığında tespit edilecek nesnenin görüntü üzerindeki toplam piksel değerine oranı değeri olan Average Pixel Occupied değerinin derin öğrenme ağının performansını etkilediği ifade edilmiştir [10].

İnsan pozisyonlarının tespit edildiği bir çalışmada YOLOv4 ve YOLOv-tiny algoritmaları ile sırasıyla %99,04 ve %97,91 mAP50 değerleri ile insanlara ait oturma, ayakta ve düşme pozisyonlarının tespiti gerçekleştirilmiştir [11].

Kapalı mekânlarda insanlar arasında fiziksel mesafenin korunmasına fiziksel mesafe tahminine yönelik bir çalışmada YOLOv3 algoritması ile %89,91 mAP başarı oranına erişildiği görülmüştür [12].

Kalabalık görüntüler üzerinde tespit edilen nesnelerin hareket etmesi durumlarında dahi diğer nesnelerde ayırabilen DeepSORT tekniğinin kullanıldığı bir çalışmada YOLOv3 algoritması ile beraber kullanıldığı ve insanlar arası sosyal mesafenin tahmin edildiği görülmüştür [13].

Bu çalışmada YOLOv9 derin öğrenme algoritması ve Deep SORT izleme algoritması kullanılarak insan yoğunluğunun hesaplanabilmesi için önerdiğimiz yazılım ile kalabalıklar içinde insanların sayılması önerilmektedir.YOLOv9 algoritması ile geliştirilen yapay zekâ modelinin mAP başarı değeri %97,1 olarak elde edilmiştir.

Çalışma şu şekilde organize edilmiştir. Bölüm 2'de çalışmada kullanılan veri seti açıklanmıştır ve Bölüm 3'te önerilen sistem sunulmaktadır. Bölüm 4' te, çalışmada elde edilen deneysel sonuçlar paylaşılmıştır. Son olarak ise, yapılan çalışmanın sonuçları sunulmuştur.

II. MATERYAL VE YÖNTEM

A. Materyal

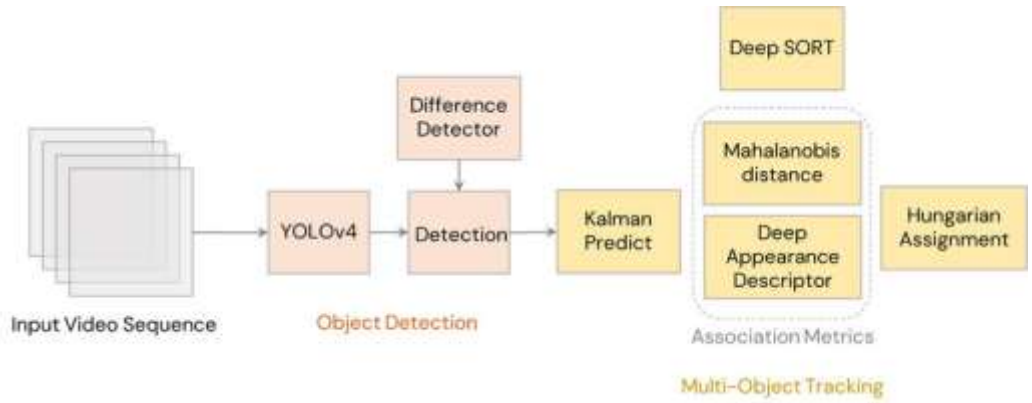
Bu bölümde, araç içi kameradan alınan yol görüntüleri üzerinde oluşturulan veri seti RGB görüntüleri tanıtılmaktadır. Şekil 1' de çalışmada kullanılan veri setinden bir bölüm sunulmuştur. Veri setinde yer alan görüntüler Kaggle web sistesinde yer alan "People Image Dataset" isimli veri setinden seçilen 795 RGB görüntüden elde edilmiştir [14]. Veri setinin %70' lik bölümü eğitim, %20' lik bölümü doğrulama ve %10'luk kısmı test verisi için bölümlendirilerek yapay zekâ model eğitimlerinde kullanılmıştır. Eğitim verileri olarak ayrılan bölümde yatay yönde aynalama ve saat yönünde 90 derece döndürme teknikleri kullanılarak eğitim verileri 1670 sayısına ulaştırılmıştır. Veri setinde yer alan tüm görüntüler 640x640 çözünürlüğe tekrar boyutlandırılarak kullanılmıştır.

Şekil 1. Çalışmada kullanılan veri setinden bir bölüm.

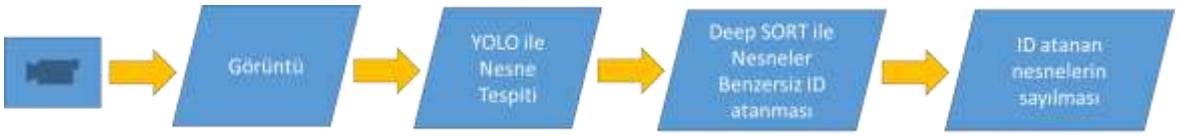
B. Yöntem

Bu bölümde çalışmada oluşturulan yapay zekâ modellerinin eğitim süreçleri, üretilen yazılımlar açıklanmaktadır. Oluşturulan veri seti python dili kullanılarak Google Colab web hizmeti üzerinde

eğitilmiştir. Veri seti YOLOv5, YOLOv8 ve YOLOv9 derin öğrenme algoritmaları kullanılarak eğitilmiştir. Çalışmada belirlenen tüm derin öğrenme algoritmaları ile 100 iterasyon olarak eğitimler gerçekleştirilmiştir. Geliştirilen yapay zekâ modellerinin performans değerlendirilmesi için karışıklık matrisi, mAP50 (tüm sınıflara ait ortalama hassasiyet değerinin %50 eşik değerinin üzerindeki tüm değerlerin ortalaması), mAP50-95 (ortalama hassasiyet değerinin %50 ile %95 arasındaki ortalama değerleri), precision (kesinlik), recall (geri çağırma) değerleri kullanılmıştır. Belirlenen bu metriklerin derin öğrenme algoritmalarında başarı metrikleri olarak kullanıldığı görülmüştür [15]. Geliştirilen derin öğrenme modelleri OpenCV, NumPy, torch kütüphaneleri kullanılarak kameradan gelen görüntü kareleri üzerinde nesne tespiti yapmaktadır. Kameradan gelen her bir kare için, nesne tespiti yapılır ve bu tespitler nesne takibi algoritması olan DeepSort' a iletilmektedir. DeepSort, takip edilen nesneleler için benzersiz bir ID atar. Böylelikle aynı karede tespit edilen insan sınıfına ait kişiler sadece birer kez sayılmış olur. Şekil 2' de YOLOv4 ağının Deep SORT mimarisinde kullanımı görülmektedir. Şekil 3' de kalabalıklarda insan sayısının hesaplanması için önerdiğimiz sistemin işlem basamakları yer almaktadır.



Şekil 2. Deep SORT algoritmasının yapısı [16].

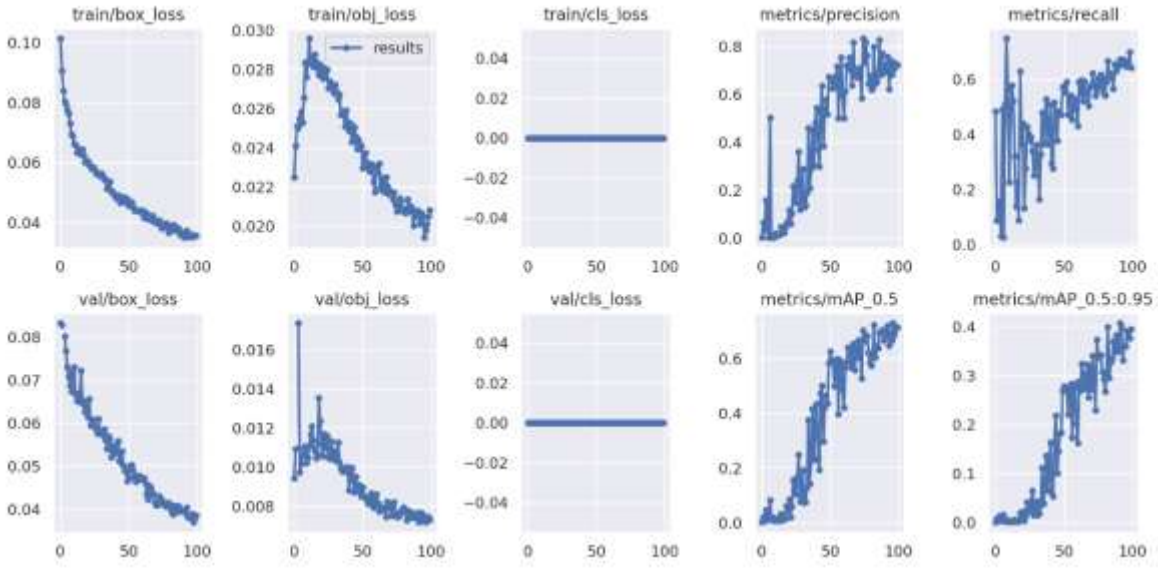


Şekil 3. YOLO ve Deep SORT ile nesne sayılması.

III. BULGULAR

Bu bölümde, yapay zekâ model eğitimlerinde elde edilen başarı metriklerine ait değerler, grafikler ve test sürecinde elde edilen bulgular yer almaktadır.

YOLOv5 derin öğrenme algoritması ile recall %67,3, precision %70, 1, mAP50 %69,6, mAP50-95 %40,5 değerleri elde edilmiştir. Şekil 4' te YOLOv5 algoritması ile eğitilen modele ait başarı grafikleri görülmektedir. 100 iterasyon boyunca eğitim ve doğrulama box_loss değerinin düştüğü görülmektedir. mAP50 ve mAP50-95 hassasiyet değerlerini gösteren grafiklerinin de eğitim boyunca arttığı görülmektedir.



Şekil 4. YOLOv5 ile eğitilen modele ait başarı grafikleri.

YOLOv5 algoritması ile eğitilen modele ait sınıflandırma başarısını gösteren karışıklık matrisine ait grafik Tablo 1' de gösterilmiştir. Karışıklık matrisinde doğrulama verileri üzerinde 111 insan sınıfının doğru tahmin edildiği, 48 tahminin yanlış yapıldığı görülmektedir.

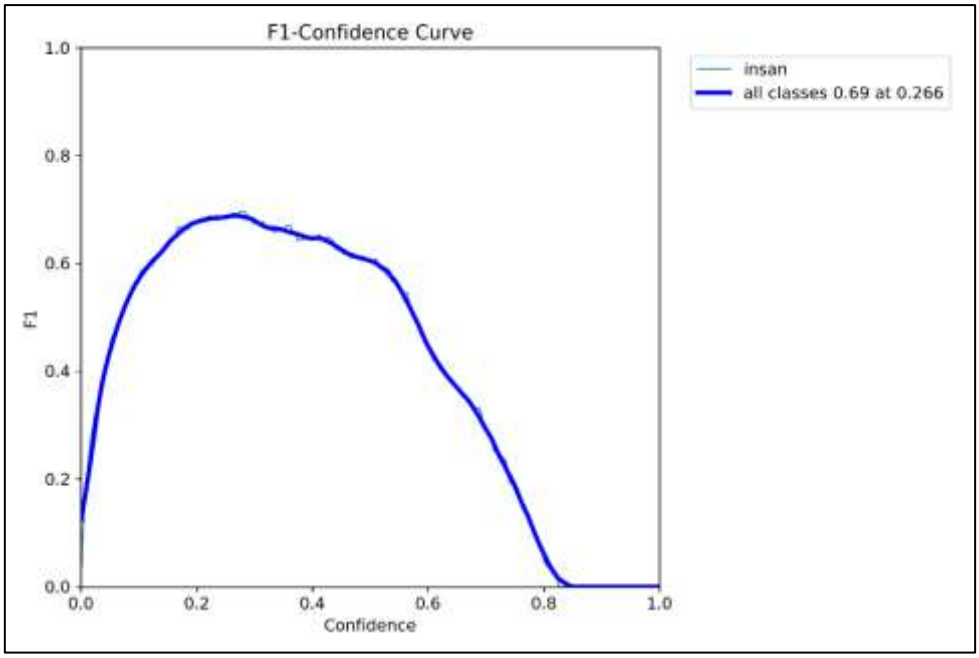
Tablo 1. YOLOv5 algoritması ile geliştirilen modelin karışıklık matrisi.

İNSAN	111 (%70)	31 (%100)
ARKAPLAN	48 (%30)	
	İNSAN	**ARKAPLAN**

YOLOv5 algoritması ile eğitilen modele ait farklı güven seviyelerinde (thresholds) F1 skoru performansını gösteren eğri Şekil 5' de gösterilmiştir. F1 skoru denklem 1' e göre hesaplanmaktadır [17].

$$F1 = 2 \times \frac{\text{Hassasiyet} \times \text{Duyarlılık}}{\text{Hassasiyet} + \text{Duyarlılık}}$$

Denklem 1

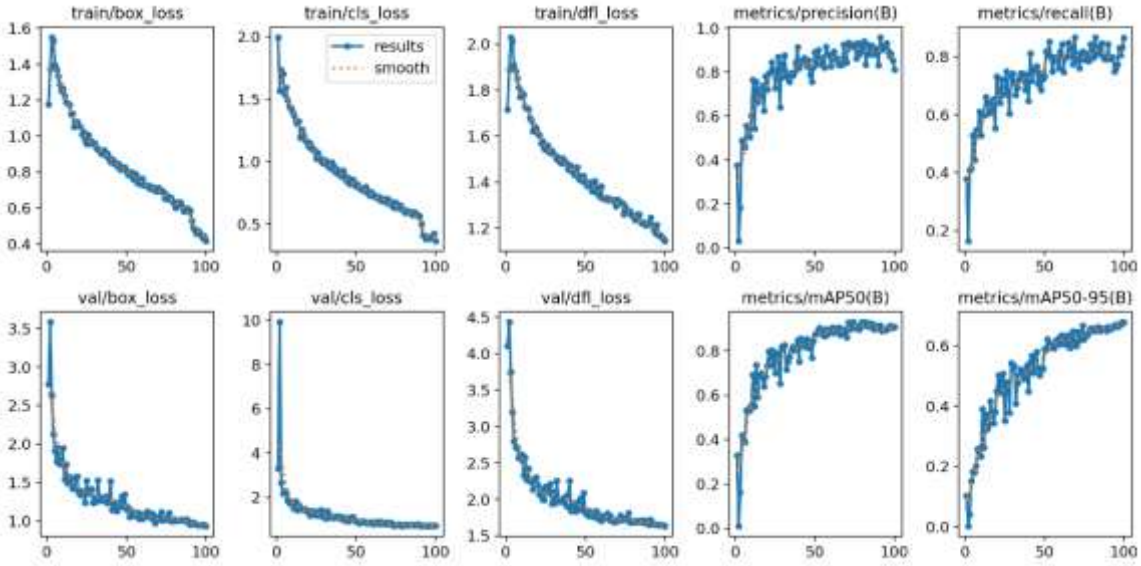


Şekil 5. YOLOv5 ile eğitilen modele ait F1 skoru güven eğrisi.

YOLOv5 ile geliştirilen modelin test verileri üzerinde gerçekleştirdiği tahminler Şekil 6' da sunulmuştur.

Şekil 6. YOLOv8 ile eğitilen modele ait tahmin sonuçları.

YOLOv8 derin öğrenme algoritması ile %83,3 recall, precision %85, 2, mAP50 %90,5, mAP50-95 %67,9 değerleri elde edilmiştir. Şekil 7' de YOLOv8 algoritması ile eğitilen modele ait başarı grafikleri görülmektedir. 100 iterasyon boyunca eğitim ve doğrulama box_loss değerinin düştüğü görülmektedir. mAP50 ve mAP50-95 hassasiyet değerlerini gösteren grafiklerinin de eğitim boyunca arttığı görülmektedir.



Şekil 7. YOLOv8 ile eğitilen modele ait başarı grafikleri.

YOLOv8 algoritması ile eğitilen modele ait sınıflandırma başarısını gösteren karışıklık matrisine ait grafik Tablo 2' de gösterilmiştir. Karışıklık matrisinde doğrulama verileri üzerinde 142 insan sınıfının doğru tahmin edildiği, 17 tahminin yanlış yapıldığı görülmektedir.

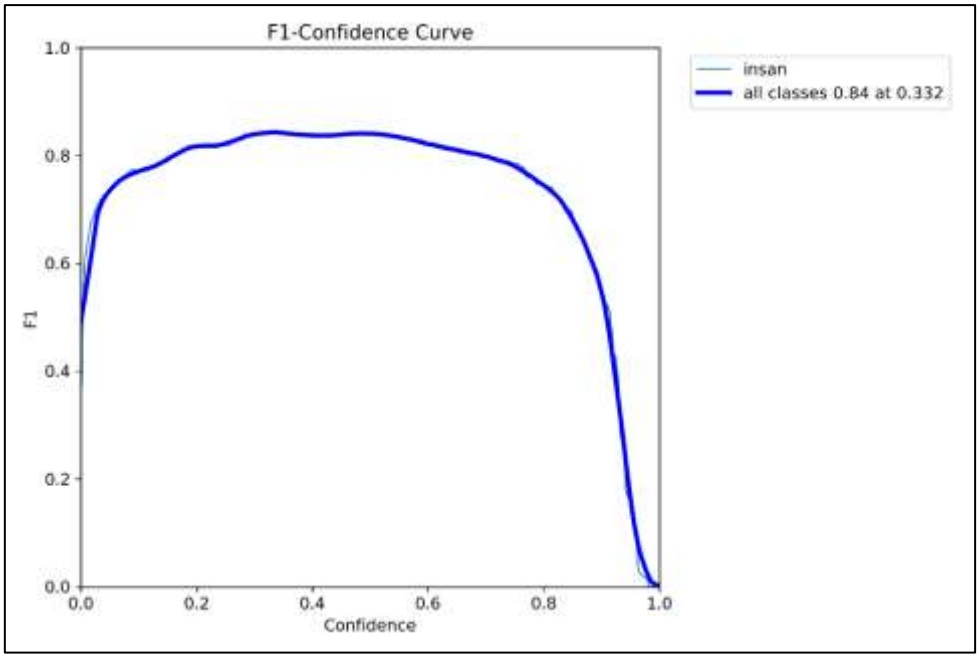
Tablo 2. YOLOv8 algoritması ile geliştirilen modelin karışıklık matrisi.

İNSAN	142 (%89)	31 (%100)
ARKAPLAN	17 (%11)	
	İNSAN	**ARKAPLAN**

YOLOv8 algoritması ile eğitilen modele ait farklı güven seviyelerinde (thresholds) F1 skoru performansını gösteren eğri Şekil 8' de gösterilmiştir.

$$F1 = 2 \times \frac{\text{Hassasiyet} \times \text{Duyarlılık}}{\text{Hassasiyet} + \text{Duyarlılık}}$$

Denklem 1

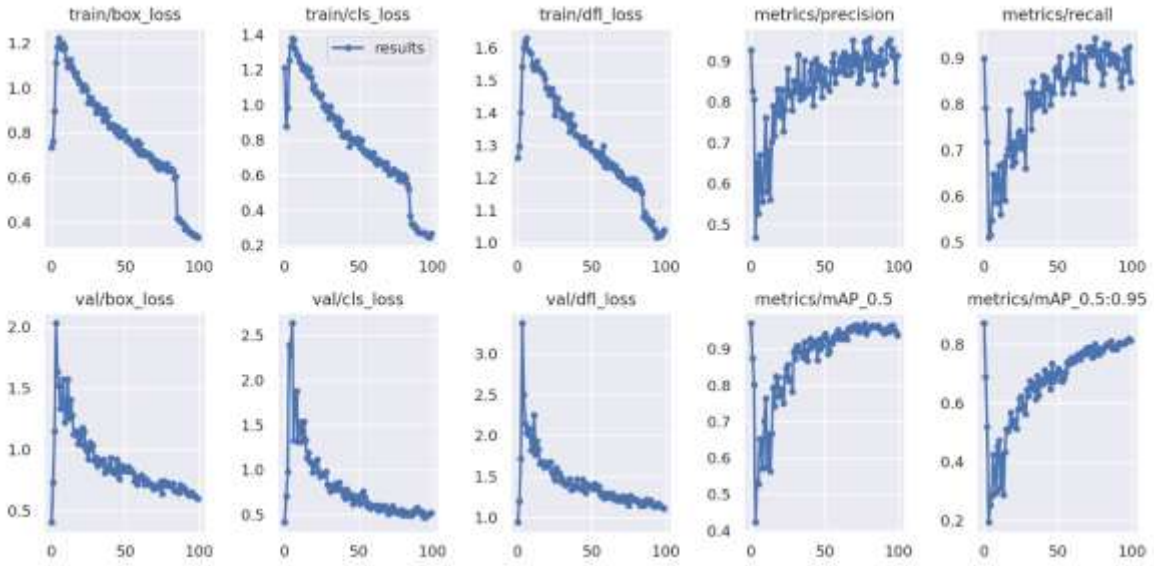


Şekil 8. YOLOv8 ile eğitilen modele ait F1 skoru güven eğrisi.

YOLOv8 ile geliştirilen modelin test verileri üzerinde gerçekleştirdiği tahminler Şekil 9' da sunulmuştur.

Şekil 9. YOLOv8 ile eğitilen modele ait tahmin sonuçları.

YOLOv9 derin öğrenme algoritması ile %91,2 recall, precision %92, mAP50 %97,1, mAP50-95 %87,2 değerleri elde edilmiştir. Şekil 10' da YOLOv9 algoritması ile eğitilen modele ait başarı grafikleri görülmektedir. 100 iterasyon boyunca eğitim ve doğrulama box_loss değerinin düştüğü görülmektedir. mAP50 ve mAP50-95 hassasiyet değerlerini gösteren grafiklerinin de eğitim boyunca arttığı görülmektedir.



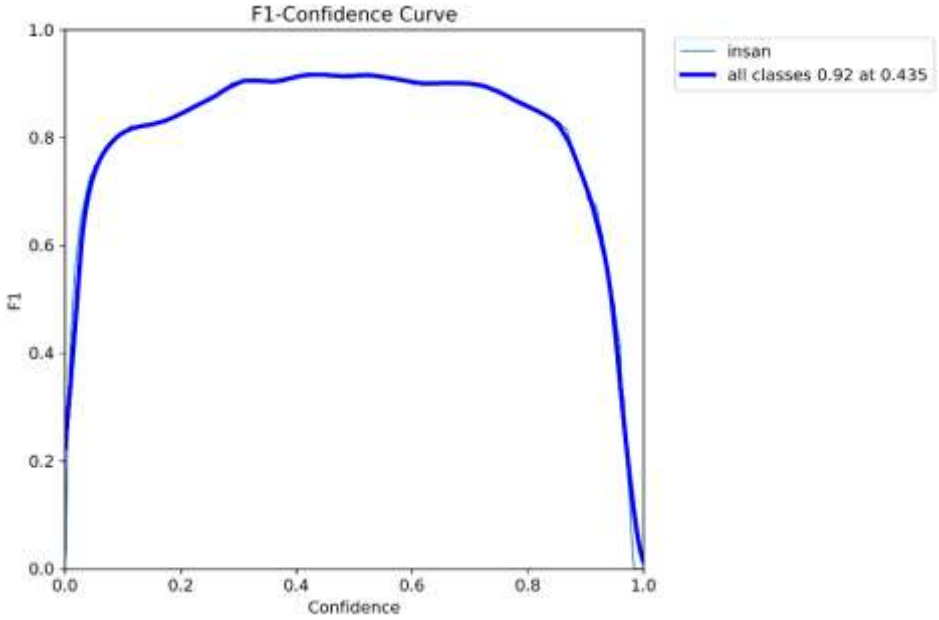
Şekil 10. YOLOv9 ile eğitilen modele ait başarı grafikleri.

YOLOv9 algoritması ile eğitilen modele ait sınıflandırma başarısını gösteren karışıklık matrisine ait grafik Tablo 3' de gösterilmiştir. Karışıklık matrisinde doğrulama verileri üzerinde 149 insan sınıfının doğru tahmin edildiği, 10 tahminin yanlış yapıldığı görülmektedir.

Tablo 3. YOLOv9 algoritması ile geliştirilen modelin karışıklık matrisi.

İNSAN	149 (%94)	31 (%100)
ARKAPLAN	10 (%4)	
	İNSAN	**ARKAPLAN**

YOLOv9 algoritması ile eğitilen modele ait farklı güven seviyelerinde (thresholds) F1 skoru performansını gösteren eğri Şekil 11' de gösterilmiştir.



Şekil 11. YOLOv9 ile eğitilen modele ait F1 skoru güven eğrisi.

YOLOv9 ile geliştirilen modelin test verileri üzerinde gerçekleştirdiği tahminler Şekil 12' de sunulmuştur.

Şekil 12. YOLOv9 ile eğitilen modele ait tahmin sonuçları.

Şekil 13' de çalışmada önerilen sistemin bir video üzerinde insan yoğunluğunun tespit edildiği görüntü yer almaktadır. Tespit işlemi Lenovo V15 G2 bilgisayar üzerinde gerçekleştirilmiştir [18].

Şekil 13. Video üzerinde önerilen sistemin uygulanması.

IV. TARTIŞMA

Bu çalışma toplu taşıma duraklarında yolcu yoğunluğunun tespiti ve yönetimi açısından büyük bir öneme sahiptir. Derin öğrenme yöntemleri kullanılarak elde edilen sonuçlar, toplu taşıma yolculuklarının planlaması ve maliyet yönetimi için değerli veriler sunmaktadır. Üzerinde çalıştığımız YOLOv5, YOLOv8, YOLOv9 ve Deep SORT algoritmalarının performansı, literatürdeki diğer çalışmalarla karşılaştırıldığında oldukça rekabetçi ve yenilikçidir. Önceki çalışmalar genellikle YOLOv3 ve diğer eski sürümleri kullanarak insan tespiti ve takip işlemlerini gerçekleştirmişlerdir. Zhang ve arkadaşları [5], YOLOv3 kullanarak kalabalık analizinde belirli başarılar elde etmiştir. Ancak, çalışmamızda kullanılan YOLOv8 ve YOLOv9 algoritmaları, daha gelişmiş mimarileri sayesinde daha yüksek doğruluk oranları ve daha hızlı işlem süreleri sunmaktadır.

V. SONUÇLAR

Kalabalıklarda insanların tespit edilebilmesi için 3 adet yapay zekâ modeli geliştirilmiştir. Ek olarak yapay zekâ modelleri ile beraber kullanılan Deep Sort algoritması ile kalabalıklarda insan yoğunluğunun tespitinin gerçekleştirildiği bir yazılım gerçekleştirilmiştir. Bu yazılım ile otobüs duraklarında yer alan yolcu sayılarının tespit edilerek yolcu yoğunluğu tespiti gerçekleştirilmiştir. Yolcu yoğunluğunun hesaplanması ile aynı hat üzerinde yer alan otobüslerin sefer sıklığının ihtiyaca göre belirleneceği öngörülmüştür. Böylelikle ihtiyaca göre otobüs seferleri düzenlenerek ulaşım maliyetlerinde tasarruf sağlanacağı düşünülmektedir. YOLOv5, YOLOv8 ve YOLOv9 derin öğrenme yöntemleri geliştirilen yapay zekâ modellerinin mAP başarı değerleri sırasıyla %69,6, %90,5, %97,1 olarak elde edilmiştir. Bu çalışmada YOLOv9 algoritması ile geliştirilen modelin diğer iki algoritmaya göre daha başarılı olduğu görülmektedir.

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Proposed Smart School System with Fiber-to-the-x Network

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Abstract – The goal of the Smart School program is to use information and communication technology (ICT) to transform the educational system in our country. A Smart School system with conventional technologies has difficulties, such as a slow data rate, erratic internet connectivity, and unexpected server outages. Consequently, a fiber-based network with many benefits was unveiled. Universal Basic Education planned the first Smart School program in 2023, however, the need for more reliable internet access was a major impediment to this program. In order to examine the viability of installing a fiber optic-based network in schools in Kano State, Nigeria, the physical layer performance of the passive optical network is assessed in this article using an Optisystem simulation. These include increasing the downstream bit rate potentially extending the fiber's reach. The results of the simulation indicate that the downstream bit rate and maximum fiber distance are 2.75 Gbps and 38 km, respectively. At an average bandwidth of 10 Mbps, up to 256 schools can be accommodated, taking into account the highest downstream bit rate that has been attained.

Keywords – FTTX, PON, Optical Access Network

I. INTRODUCTION

In January 2023, the Nigerian government launched Smart Schools as part of the Universal Basic Education (UBE) programme, with the aim of implementing ICT-based learning systems in a few chosen government schools [1]. However, one issue with internet access is that unpredictable internet connectivity is a result of insufficient high-speed data rates. One of the biggest problems with implementing smart schools is unexpected server outages, as more educational institutions use video conferencing and e-learning systems to facilitate instruction [2]. The legacy copper-based asynchronous digital subscriber line (ADSL) internet can only deliver a maximum bandwidth of 6 Mbps, which is insufficient to meet the intended key performance requirements of 8 Mbps to 20 Mbps.

These days, the development of fiber-based networks targets not only long-distance connections but also the "last mile," or the area closest to the end user. This new domain, known as an optical access network, involves the implementation of these networks. Under Fiber-to-the-x (FTTX) technology, various types of buildings and places can be reached by the optical fiber. Because it is more affordable, passive optical networks (PONs) are the chosen technology for FTTX deployment. Since 2013, FTTX networks have been installed in Lagos state's residential and business districts of Ikeja, Apapa, and Surulere in Nigeria [3].

Due to its quick spread and greater take-up rate of approximately 93,021 KM of broadband links, the deployment of fiber optic cables will expand to 120,000 KM by July 2024. The FTTX is regarded as a successful deployment. Because FTTX has so many advantages over its alternatives, it is becoming the technology of choice for school networks. Through the terrestrial fiber optic project, the Nigerian federal government hopes to solve the country's eight undersea cables' current 10% utilisation rate. It is anticipated that more fiber optic lines will be installed, leading to an approximately 60% price reduction and improved internet quality. Over the following four years, this investment is expected to help Nigeria's GDP increase by 1.5% [3].

According to government officials, the project will have a major impact on Nigeria's digital economy and technology startups by connecting over 200,000 government buildings, educational institutions, and critical infrastructures like hospitals that are currently unconnected. It also aims to close the non-consumption gap in connectivity. An assessment of the deployment of the fiber-based network's performance was carried out, and it was successful in providing the schools in Nigeria with the necessary bandwidth. Nonetheless, it is thought that this network has bright futures. Thus, the purpose of this research is to examine the feasibility of a FTTX network field trial in Kano State's metropolitan schools.

The remainder of the paper is organised as follows. Section 2 includes a description of PON. Section 3 discusses the simulation setup and parameters. Section 4 discusses the simulation results. The paper concludes at Section 5.

II. Passive Optical Network based on FTTX architecture

PON is a cabling system that implements a point-to-multipoint (P2MP) fiber-based access architecture, which overcomes the limitations of point-to-point (P2P) architecture by employing an active optical network concept that necessitates more fiber cables and central office equipment [4]. PON employs optical splitters rather than electrically driven switching equipment to split a single input signal and disseminate it to numerous users. PON is less expensive to build and maintain than ADSL because it requires fewer electrical parts at the signal's source and receiving ends. As a result, the benefits of PON make it the best solution for FTTX system technology [5].

A PON is made up of three components: an Optical Line Terminal (OLT) located at the Central Office (CO), a Fiber Distribution Hub (FDH), and an Optical Network Unit. The single input signal is carried by a "feeder fiber" cable that travels from CO in OLT to ONU. The input signal from the feeder fiber is split into numerous signals when it travels through the optical splitter. The split signals are then distributed to individual subscribers via "distribution fiber" cables. GPON delivers a downstream throughput of roughly 2.5 Gbps from OLT to ONU and an upstream rate of about 1.25 Gbps from ONU to OLT. The wavelength of the downstream signal is 1490 nm, while the upstream signal is 1310 nm.

A. PON Splitting Ratio

The cost and bandwidth of OLT are divided among ONUs via an optical splitter, making it less expensive. The number of ONUs is determined by the splitting ratio of the passive optical splitter. The existing network architecture allows for a variety of splitting options. The fundamental form is a single-stage splitting method, as seen in Fig. 1(a). Fig.1 (b) shows a cascaded stage splitting method. In rare circumstances, the feeder fiber can form an optical bus and connect ONUs at multiple sites along its journey using 1:2 optical splitters, as shown in Fig.1 (c).

The splitting architecture should be determined depending on the user demographics and the expense of managing many splitters. Among these three solutions, the single-stage splitter is the simplest and uses the fewest connectors, making splicing easier and reducing connector and splicing losses. Assume that all splitters in a bus or tree architecture have the same power of splitting ratio; the distance between the

ONT/ONU and the OLT increases the splitting and transmission loss. This problem can be overcome by utilising optical splitters with irregular splitting ratios to improve the overall power margin; however, management will face difficulties because non-uniform splitters must be provided.

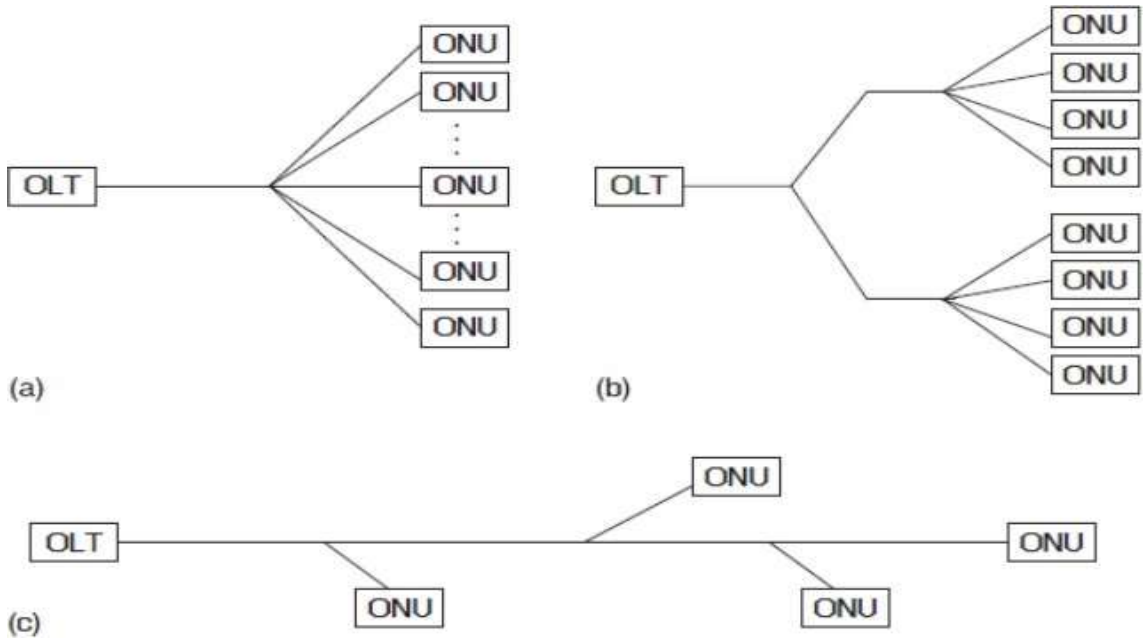
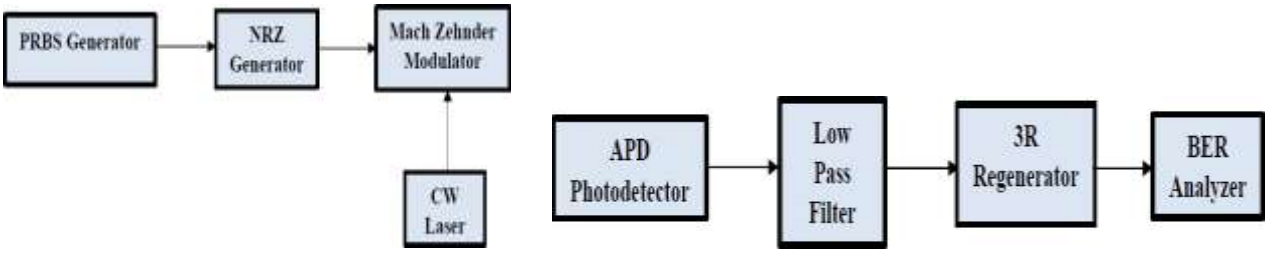


Fig. 1 Splitting Strategies in PON (a) single-stage splitting, (b) cascaded-stage splitting and (c) optical bus [6]

The most popular splitting ratios for commercial PON systems are 1:16, 1:32 and 1:64. The higher the splitting ratio, the more subscribers share the cost, making it cheaper. However, increasing the splitting ratio increases the transmission loss, as the optimal splitting loss for a 1:N splitter is 10 $\log_{10}$ N dB. Higher transmission loss indicates a shorter distance based on the link power budget. As a result, a system with a high splitting ratio requires more launching power at the transmitter, a more sensitive receiver, and low-loss optical components. A higher splitting ratio also means that there is less account for transmission fiber loss and a narrower safety margin for other system degradations and fluctuations. As a result, there is a trade-off between the choice of splitting ratio and system performance. An optimal splitting ratio is defined as up to a specific point. A larger splitting ratio will result in unfavourable results. Furthermore, the higher the splitting ratio, the more users share the OLT capacity, resulting in less bandwidth available for each user. To compensate for system noise and achieve a specific bit error rate (BER) performance, a minimum energy per bit is necessary. As a result, boosting the bit rate at the OLT to accommodate more users necessitates an increase in transmission power. Nonetheless, transmission power is limited by existing laser technology (in communication, lasers typically operate at 0 to 10 dBm output power) and safety regulations imposed by the relevant authorities [6].

III. PON SIMULATION

The simulated PON design makes advantage of more complex splitting configurations, such as cascaded splitting methods. Fig.2 (a) and (b) show the block diagrams of the built PON system's transmitter and receiver. Meanwhile, the channel comprises of two 1:8 splitters, one 1:4 splitter, a PON extender (optical amplifier), and three fiber wires. The fiber cable utilised in the system is single mode fiber (SMF). Fig.3 depicts the FTTX simulation network layout. The designed system includes an upstream link (OLT), an optical distribution network (ODN), a channel, and a receiver (ONU).



(a) Transmitter (b) Receiver

Fig. 2 Block diagram of the system

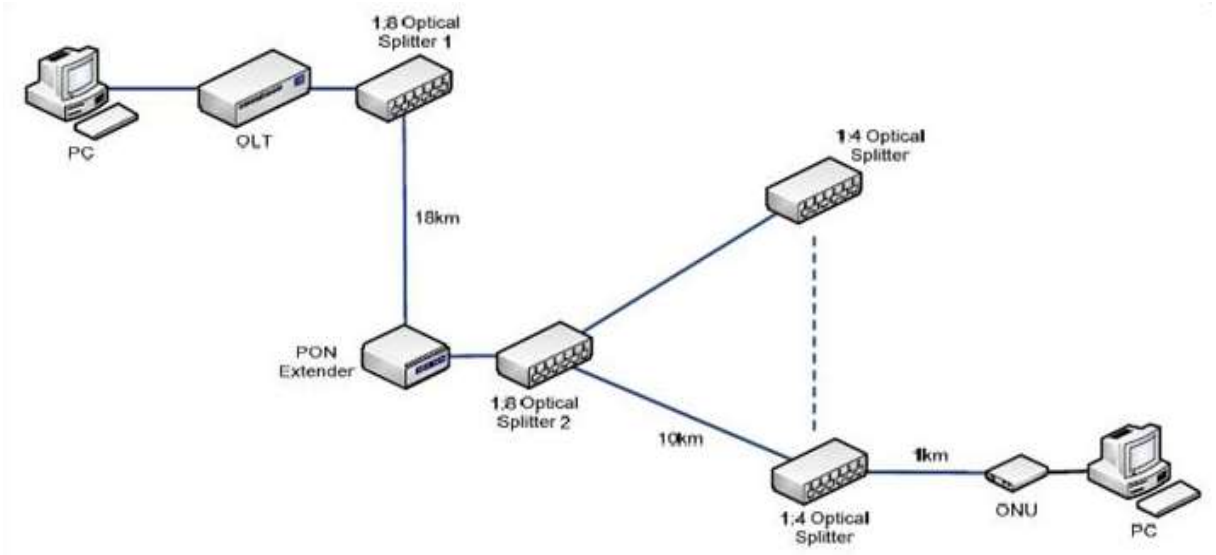


Fig. 3 FTTX Simulation Network layout [7]

Table 1. Simulation setup parameters [8]

Parameters	Unit
Downstream bit rate	1.25 -5 Gbps
Upstream bit rate	1.25 Gbps
Downstream signal optical power	+4 dBm
Upstream signal optical power	+0.7 dBm
Downstream wavelength	1490 nm
Upstream wavelength	1310 nm
Fiber optic cable length (from OLT to optical amplifier)	18 km
Fiber optic cable length (from optical amplifier to 1:4 splitter)	0 - 60 km
Fiber optic cable length (from 1:4 splitter to ONU)	1 km
Total split	256
Fiber attenuation	0.2 dB/km
Connector loss	0.1 dB
Splitter loss	1:8 (9 dB), 1:4 (6 dB)
Receiver sensitivity	-28 dBm
BER Threshold	10^{-12}
Min. Q factor	6.53

In this work, two scenarios will be explored (varying fiber length and downstream rate), and simulation will be performed to determine the minimum BER and maximum Q factor. To begin, the length of the fiber line (from optical amplifier to 1:4 splitter) is altered between 10 and 60 km at 10-kilometer intervals, while the power launched, bit rate, and wavelength of the downstream signal remain constant. Next, the downstream data rate is modified between 1.25 and 5.5 Gbps with 0.5 Gbps intervals, while the power launched, wavelength, and length of fiber cable remain constant.

IV. Result and Discussion

Fig. 4 shows a graph of $\log_{10}$ BER vs fiber cable length. In Fig. 4, the straight line displays the maximum allowed BER for the system, which is 10^{-12}, while the curved line represents the BER for different fiber distance. The BER produced from the simulated results must be less than or equal to the maximum permissible BER for the PON system to function satisfactorily. Overall, BER performance declines as distance increases. Based on the graph, the maximum bit rate for downstream signals in this system is predicted to be 2.75 Gbps, as the two lines overlap at this number. The figure is in line with the calculated rise time of 2.7 Gbps.

According to the graph, the intersection of these two lines is around 38 km, indicating that the system's maximum fiber cable length is 38 km at the desired BER. Meanwhile, Fig. 5 depicts the Q Factor performance versus fiber distance. Similarly, as distance rises, performance degrades. The Q Factor at BER is around 6.5, which corresponds to approximately 38 km.

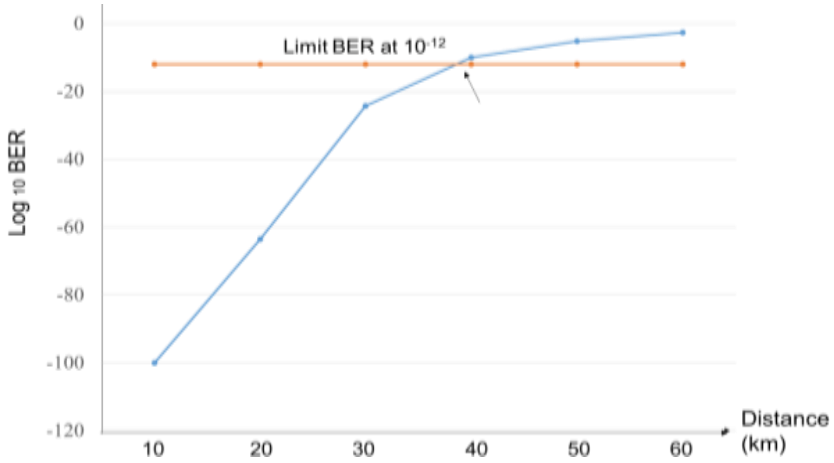


Fig. 4 BER performance vs Fiber length

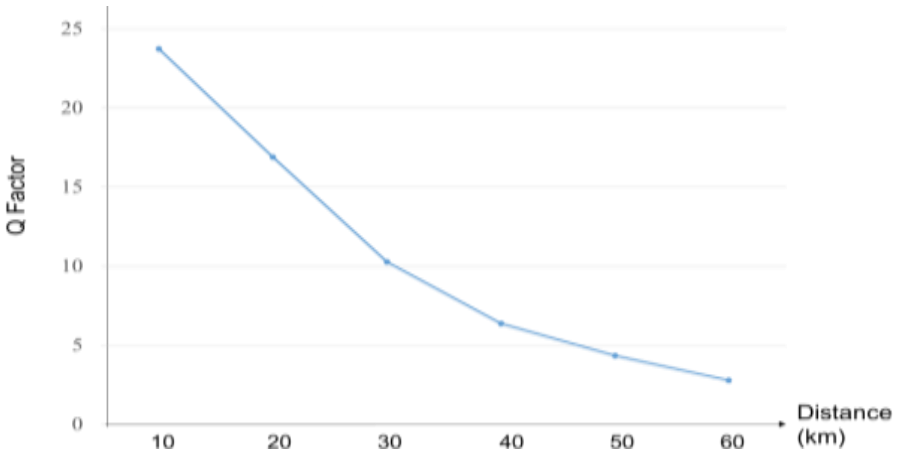


Fig. 5 Q-Factor vs Fiber length

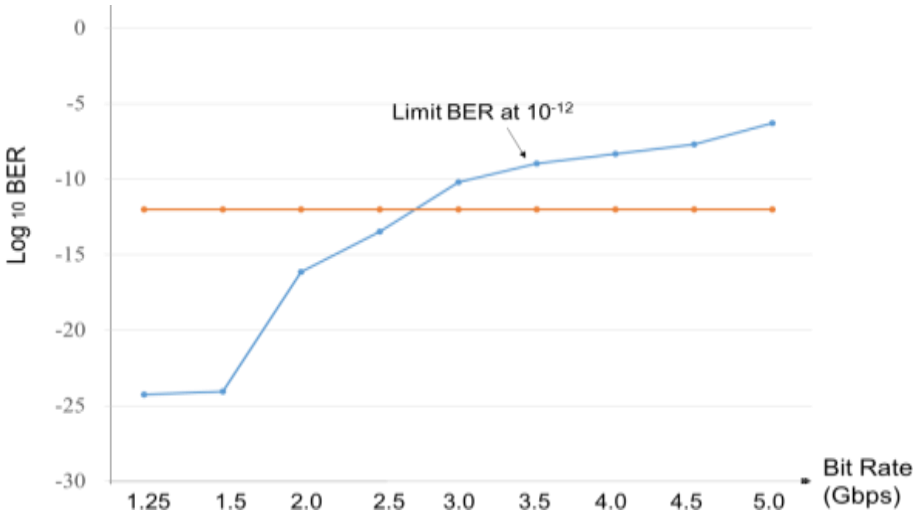


Fig. 6 BER vs downstream data rate

Based on the simulated results for various optical fiber lengths and downstream data rates, the maximum fiber cable length and downstream signal bit rate available for this system are 38 km and 2.75 Gbps, respectively. The simulated maximum distance is less than the theoretically calculated maximum fiber optic length of 53.5 kilometres. The simulated and estimated rising times demonstrate good agreement. Because sounds from other amplifiers and components are not included in the computation, the calculated power budget result understates the impacts if they are longer than the simulated result. Because Optisystem is a system-level simulator that uses the true model of optical components, it produces more accurate results that are closer to the real world. The average bandwidth for each school in the system is determined using the maximum available downstream data rate obtained from the simulation, which was 2.75 Gbps. The GPON system has a total split of 256, which means that up to 256 ONUs/users can connect to it. The bandwidth available for each user is computed using the following formula.

$$BW\ per\ school\ = \frac{maximum\ downstream\ bit\ rate}{total\ split\ ratio}$$

$$BW\ per\ school\ = \frac{2.75 \times 10^9}{256} = 10Mbps$$

As a result, the estimated bandwidth that can be delivered to each user in the system is 10 Mbps, and the system has a coverage area of up to 38 km with an optical amplifier with a gain of 30 decibels.

V. CONCLUSION

This paper investigates the potential deployment and field trial of FTTX networks in Nigerian schools. The physical layer simulation analysis establishes a threshold BER of 10^{-12} with a receiver sensitivity of -28 dBm, which falls within the system performance limit. The simulation results show that the fiber length can be expanded up to 38 km and the maximum data rate up to 2.75 Gbps. Based on the maximum downstream bit rate available for the PON system and the 1:256 splitting ratio, the average bandwidth for each school in the system is determined to be 10Mbps.

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Investigation of the Electrochemical Performance of Silver-Coated Copper Alloy

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Abstract **–** This study investigates the electrochemical performance of silver-coated copper alloy by focusing on the effects of PVD surface treatment and aging processes. The experimental procedures include the preparation of Cu-Cr-Zr alloy samples, followed by solution treatment, artificial aging, and coating the surface with silver using the physical vapor deposition (PVD) method. The samples were subjected to corrosion tests using potentiodynamic techniques in a 3.5% NaCl solution. X-ray diffraction (XRD) analysis revealed the presence of both silver and copper phases on the surface of the coated samples. Additionally, it was found that the corrosion resistance of the coated samples, particularly those held at 500 °C for 4 hours before silver coating, was superior. This thermal treatment increased the corrosion resistance by inducing favorable changes in the alloy's microstructure. The results demonstrate that silver-coated Cu-Cr-Zr alloy exhibits higher corrosion resistance compared to untreated samples, with the best performance observed after specific aging and coating processes. Specifically, the protective effect of the silver coating reaches its maximum under certain thermal and coating conditions. This study aims to contribute to the field of protective coating technologies by providing valuable insights into the electrochemical behavior of silver-coated copper alloys.

Keywords – Cu-Cr-Zr, PVD, Corrosion, SEM, XRD.

I. INTRODUCTION

Copper and copper alloys are among the most important commercial metals. In terms of production and ease of consumption, they rank third after iron and aluminum. Pure copper is favored for its high electrical and thermal conductivity as well as its resistance to corrosion. (Jiang et al., 2021; Jadhay et al., 2019; Ikeshoji et al., 2018). Especially, recent developments in the electronics industry have drawn researchers' attention to developing copper-based alloys with good electrical conductivity and high strength. In most studies in the literature, various alloying elements (such as Zr, Co, Ag, and Cr) have been added to the pure copper matrix. These traditional strengthening approaches cause various structural defects in the copper matrix, increasing the scattering of conductive electrons and resulting in losses in electrical conductivity. In this context, achieving high strength while maintaining good electrical conductivity in copper alloys poses opposing challenges. (Wei et al., 2011).

The understanding of the positive effects of the presence of a second phase on the mechanical properties of metallic materials has sparked interest among many researchers in the future development and use of alloyed commercial metals for a wide range of applications, and it continues to be of interest for many metals today (Caldwell and Wert, 1988; Qi et al., 2003). One of these metals is copper. Copper is

frequently preferred in relevant engineering applications due to its particularly high electrical conductivity and its lower cost compared to other metals that conduct electricity well. In addition to electrical conductivity, the strength values must also be at a certain level, so binary Cu-Cr and ternary Cu-Cr-Zr alloys can be preferred for the desired applications (Iždinský et al., 2005; Vinogradov et al., 2004).

As mentioned above, the Cu-Cr-Zr alloy is known for its various advantages, providing a diverse array of applications. The surface of this alloy is typically smooth and homogeneous. This feature significantly facilitates the processing and application of the alloy. A smooth surface enhances the aesthetic appearance of the final product and increases efficiency during the machining process. Its high thermal conductivity (Guschlbauer et al., 2018) makes the alloy ideal for temperature control. This property is especially important in applications involving high-temperature environments or frequent thermal fluctuations. High thermal conductivity allows the alloy to heat and cool uniformly, enhancing durability and performance. The strength of the Cu-Cr-Zr alloy is also quite impressive (Bai et al., 2021; Feng et al., 2013), making it durable under various mechanical loads. This property makes the alloy particularly suitable for industrial or heavy-duty applications. Additionally, the alloy has good machinability (Brotzu et al., 2020). This means that the alloy can undergo various shaping and processing methods to suit different applications. The machinability feature ensures that the alloy can be used in a wide range of industries and applications, meeting various requirements. The combination of all these properties makes the Cu-Cr-Zr alloy an ideal choice for a wide range of applications. This alloy is preferred in many applications across various industries due to its durability, machinability, and thermal performance.

In this study, a conductive silver coating was deposited onto the Cu-Cr-Zr alloy., which achieved a strength increase of approximately 2-3 times through aging, using the PVD method. This approach allowed for a significant increase in strength without substantial loss in bulk electrical conductivity, while the surface coating provided a corrosion-resistant and conductive layer. In summary, the Cu-Cr-Zr alloy, strengthened by aging and enhanced with a suitable conductive coating, emerges as a candidate material for the fabrication of micro-metal forming applications and micro-electromechanical (MEM) components.

II. EXPERIMENTAL STUDIES

As the experimental material, Cu-Cr-Zr copper alloy samples with dimensions of 15x15x3 mm^3 were used. The solution treatment was conducted at 1000 °C for a duration of 30 minutes, in accordance with previous research. As a result of this process, the samples were rapidly quenched in water to obtain supersaturated copper alloys. Artificial aging was performed at 500 °C for two different durations, specifically for 2 hours and 4 hours, in a thermal processing furnace (Qi et al., 2003; Celik and Yuksel, 2023). After the aging process, the samples were cooled in air. These methods were carefully selected and applied to achieve the desired properties of the alloy.

Following the aging processes, the Cu-Cr-Zr copper alloy samples were polished sequentially using 60, 400, 800, 1200, and 2000 SiC sandpapers. At each intermediate stage, the specimens were washed with distilled water for cleaning purposes. After the final polishing, specimens were rinsed with ethanol and then dried using a hot air fan. These steps were meticulously applied to ensure the homogeneous preparation of the samples and to produce reliable results in the experiment.

Samples aged under different conditions were subjected to coating processes to improve their surface properties. Thermal evaporation was used as the PVD coating method. During this process, atoms were evaporated from an Ag target to form a thin film layer on the surface of the Cu-Cr-Zr copper alloy substrates. The coating process was conducted under a vacuum of 10^{-6} Torr. The coating procedures were carried out using the PVD device at the Advanced Technology Research and Application Center of Ondokuz Mayıs University (OMÜ). The samples were coated with silver.

Electrochemical tests were conducted to determine the corrosion behaviors of the surface-treated copper alloys after the coating process. The corrosion experiments were conducted in a 3.5 % NaCl solution using the potentiostatic technique with OCP (open circuit potential). Polarization measurements were carried out using a three-electrode setup in a corrosion cell, employing an Ag/AgCl reference electrode (RE), a graphite rod as the counter electrode (CE), and the test specimen as the working electrode (WE). First, the open circuit potential changes of the samples were measured (OCP, potential-time curves). The open circuit potential refers to the potential difference between the working electrode and the reference electrode when no potential or current is applied to the corrosion cell. Sufficient polarization must occur for corrosion to initiate. Therefore, the OCP technique was applied to the samples before performing potentiodynamic polarization measurements.

XRD (X-ray Diffraction) measurements were conducted to analyze the crystal structures of the samples. The analysis was conducted within the range of 2θ= 20-80° with a scanning rate of 2 degrees per minute. This allowed for a detailed examination of the changes in the crystal structures of the samples and the effects of the coating process on the material.

Cross-sectional images, surface topographies, and images of corrosion products of the coated samples were obtained using a Jeol JSM 7001 SEM (Scanning Electron Microscope) device. The SEM device, with its high resolution, enabled a detailed examination of the surface morphologies of the samples. Cross-sectional images were used to evaluate the thickness of the coating layers. Surface topographies were examined to determine the homogeneity of the coating and identify any potential surface defects. Additionally, the distribution and structure of corrosion products on the surface of the samples after corrosion tests were analyzed using SEM images.

III. RESULT AND DISCUSSION

The XRD spectrum of the Cu-Cr-Zr alloy is presented in Fig. 1. Upon examining the spectrum, Cu crystal peaks were detected at 2θ= 43.45°, 2θ= 50.46°, and 2θ= 74.20° (Zhang et al., 2013). When analyzing the XRD spectrum of the silver-coated samples, peaks corresponding to Ag crystal planes were observed at 2θ= 38.19°, 2θ= 44.48°, 2θ= 64.88°, and 2θ= 77.79° (Saravanan et al., 2017). It can also be seen that the peaks corresponding to the base material are reflected on the graph.

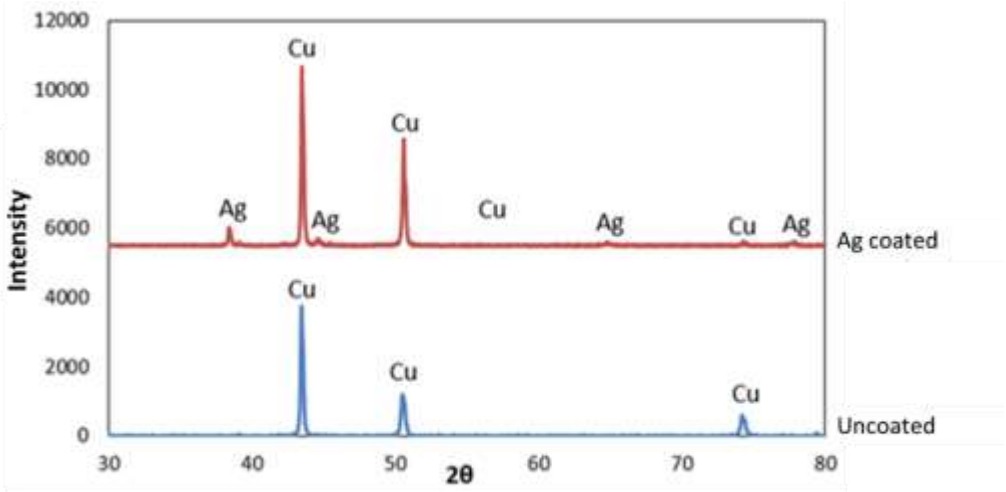

Fig. 1. XRD graph of uncoated and silver-coated Cu-Cr-Zr samples.

Fig. 2 presents a cross-sectional image of the silver coating layer obtained using the PVD method, captured with an SEM device. Upon detailed examination of the cross-sectional image, it is evident that a homogeneous coating layer with uniform thickness was achieved on the material surface as a result of the coating process. This homogeneous coating layer is evenly distributed across the entire surface of the material. Measurements indicate that a coating layer with a thickness of approximately 2.5 μm was obtained on the surfaces of the materials. These results demonstrate that silver coating using the PVD method was effectively and homogeneously performed.

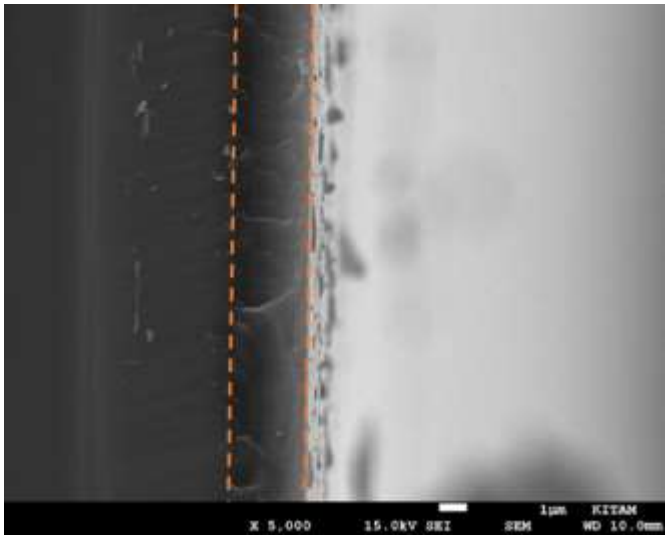

Fig. 2. The cross-sectional image of the silver-coated Cu-Cr-Zr alloy.

The current density-potential curves of Cu-Cr-Zr samples aged for 2 hours at 500 °C, aged for 4 hours at 500 °C, aged for 2 hours at 500°C and silver-coated, and aged for 4 hours at 500°C and silver-coated are presented in Fig. 3. According to the results of corrosion experiments, it can be stated that the silver coating exhibits a more cathodic character compared to the Cu-Cr-Zr alloy. Indeed, coatings exhibit either anodic or cathodic properties relative to the base material in corrosion tests (Tezdogan and Demirel, 2014; Margarit and Mattos, 1998; Bulbul et al., 2012). If the applied coating exhibits cathodic properties, it plays a more dominant role in providing protection to the base material. Coatings showing such properties should ideally not have defects such as pores or cracks, as in the case of cathodic coatings, if such defects exist, corrosive liquids or gases in the aggressive environment will affect the base material, which is more active than the coating, and the corrosion will rapidly damage the base material. However, the situation is different for coatings exhibiting anodic properties. Defects such as cracks or pores in these coatings do not adversely affect the base material because these coatings, being more active than the base material in the corrosive environment, do not harm the base material even if the aggressive environment reaches the base material through these defects. As a result, coatings exhibiting anodic properties continue to protect the coated base material cathodically. According to the data obtained from corrosion tests, the silver-coated surfaces exhibit a more cathodic character compared to the base material. The results of the corrosion experiments are presented in Table 1.

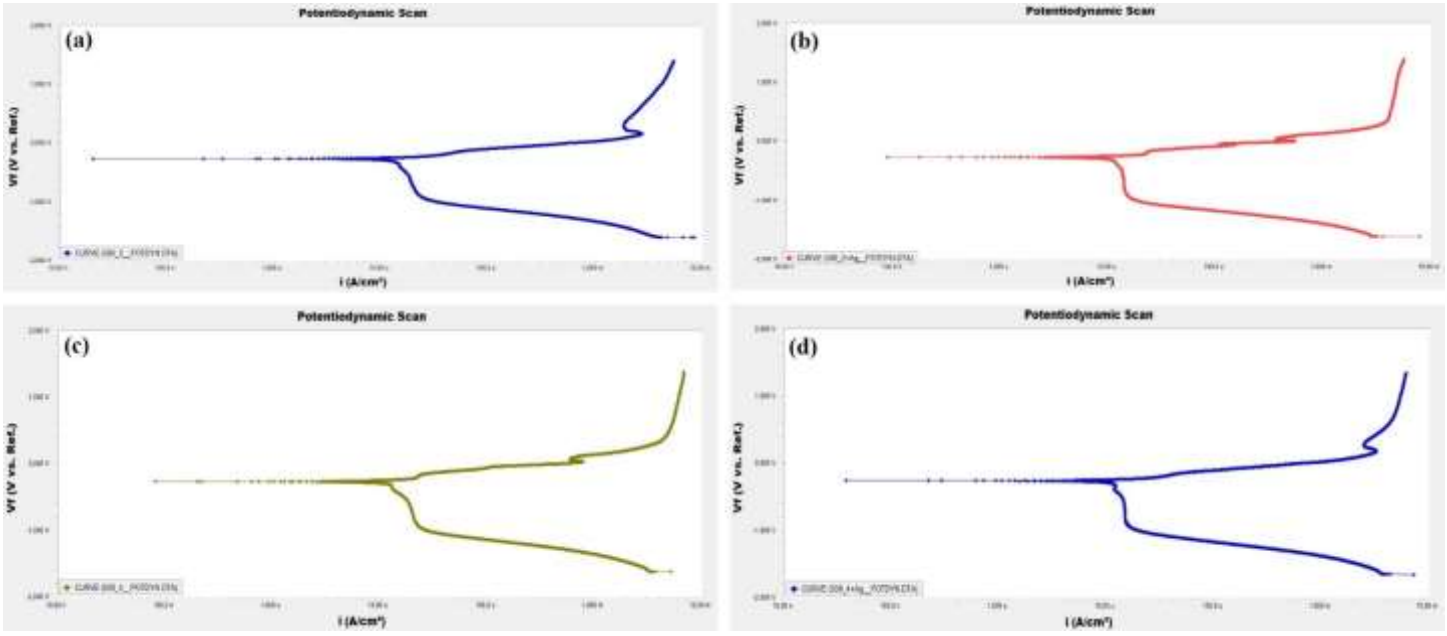

Fig. 3. Current density-potential curves of Cu-Cr-Zr samples aged and silver-coated under different conditions: (a) 500_2, (b) 500_2+Ag, (c) 500_4, and (d) 500_4+Ag.

Table 1. Polarization results of untreated and silver-coated Cu-Cr-Zr samples.

Sample Name	Icorr (µA)	Ecorr (mV)	Corrosion Rate (mpy)
500_2	19.12	-265	17.41
500_4	12.78	-266	11.64
500_2+Ag	9.91	-267	9.02
500_4+Ag	8.22	-259	7.48

In Fig. 4, a mapped EDS analysis of a corroded portion of the surface of the Cu-Cr-Zr alloy aged for 2 hours at 500 °C is provided. According to the EDS analysis, chlorine (Cl) and oxygen (O) elements are present on the corroded surface. Examination of the corrosion surface of the Cu-Cr-Zr alloy aged for 2 hours at 500 °C reveals that pitting corrosion is an active damage mechanism.

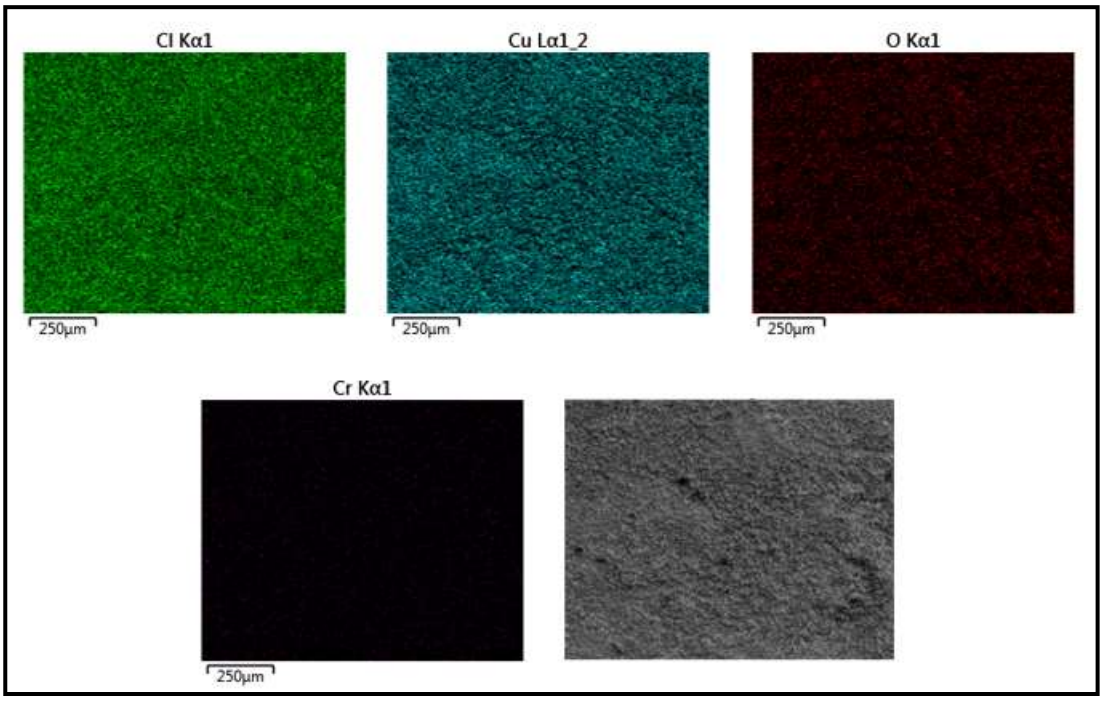

Fig. 4. X-ray diffraction map of Cu-Cr-Zr alloy aged at 500°C for 2 hours.

In Fig. 5, an SEM image of the corroded surface of the Cu-Cr-Zr alloy aged for 4 hours at 500 °C is provided. Upon detailed examination of the corrosion surface, it can be observed that pitting corrosion is also an active damage mechanism here.

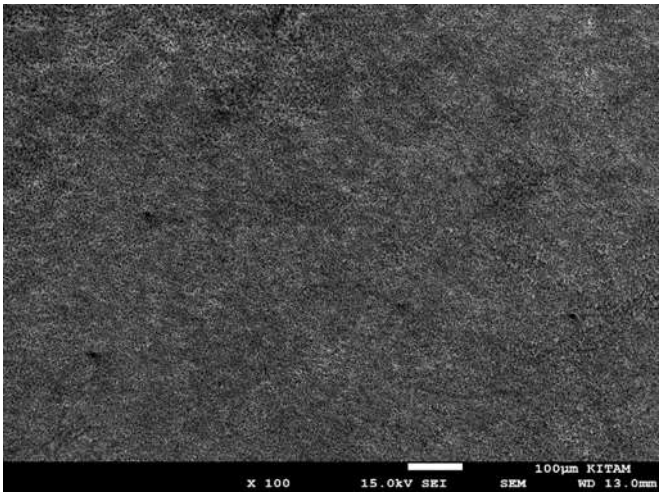

Fig. 5. SEM image of the corroded surface of the sample aged at 500°C for 4 hours.

The EDS analysis graph of the corroded surface of the Cu-Cr-Zr alloy aged for 4 hours at 500 °C is presented in Fig. 6. Upon examination of the EDS analysis results, it is determined that chlorine (Cl), the active substance of the corrosive environment, is present on the corroded sample surface. Additionally, the presence of oxygen (O) on the surface is also noted.

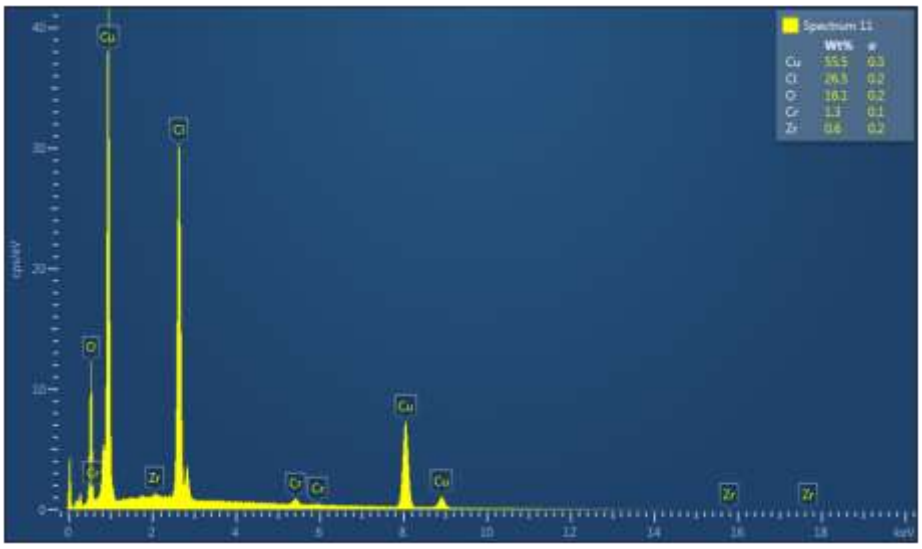

Fig. 6. EDS analysis of the corroded surface of the sample aged at 500°C for 4 hours.

The SEM image of the corroded surface of the Cu-Cr-Zr alloy, which was silver-coated after aging for 2 hours at 500 °C, is provided in Fig. 7. The formation of pit corrosion is notable on the corrosion surfaces. According to the data obtained from corrosion tests, the corrosion current density of the sample is determined to be 9.91 µA. In comparison, the corrosion current density of the uncoated sample is at levels of 19.12 µA. Based on the corrosion test results, it can be observed that improvement in corrosion resistance of the material is achieved after coating.

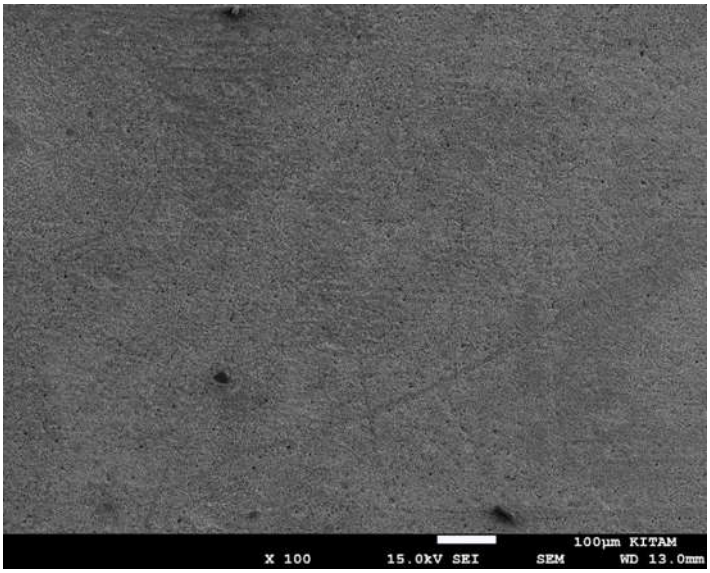

Fig. 7. SEM image of the corroded surface of the sample aged at 500°C for 2 hours and coated with Ag.

Fig. 8 shows the mapped EDS analysis of a portion of the corroded surface of the Cu-Cr-Zr alloy, which was silver-coated after aging for 4 hours at 500°C. According to the EDS analysis, chlorine (Cl) and oxygen (O) elements are present on the corroded surface. Additionally, it is observed that coating layer products (Ag) are also present on the surface, indicating that the coating attempts to maintain its stability against the corrosive environment. Reflections from the base material products are also found in the EDS X-ray distribution map. According to the capacity of the device used in the EDS analysis, X-rays analyze approximately up to a depth of 5 µm. Since the thickness of the coating we obtained is approximately 2.5 µm, reflections from the base material are also captured.

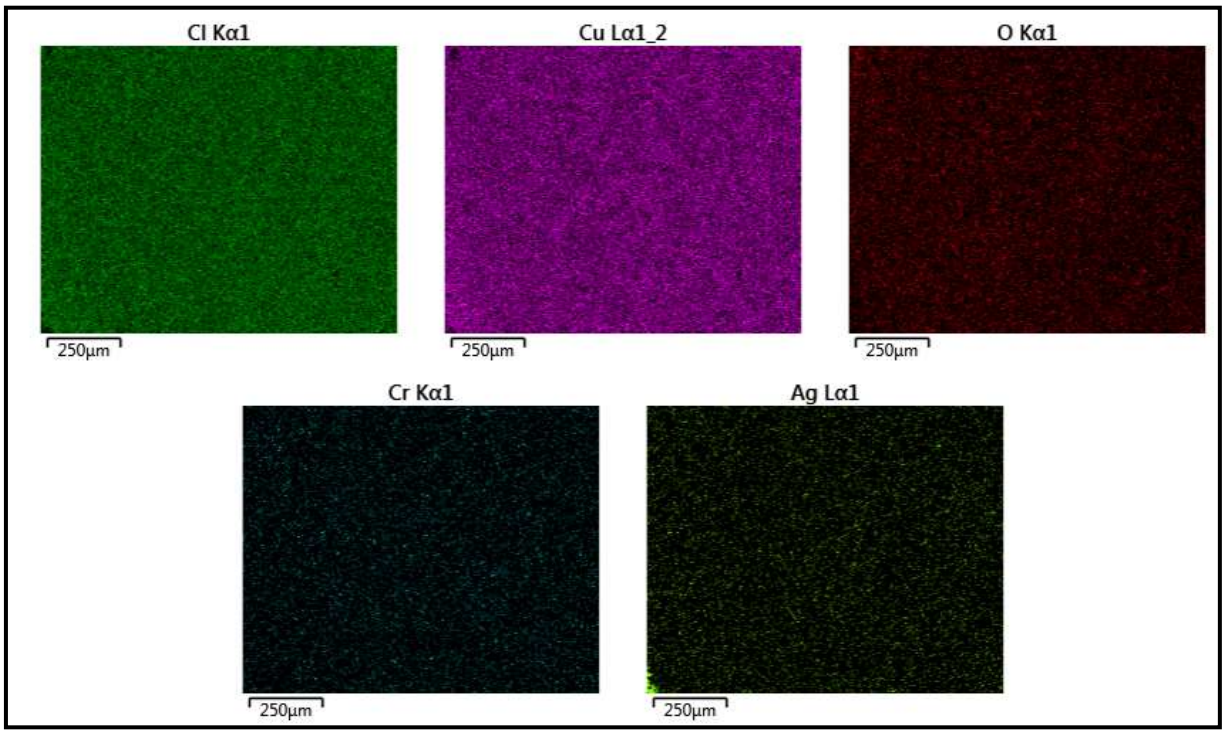

Fig. 8. EDS analysis of the corroded surface of the sample aged at 500°C for 4 hours and coated with Ag.

IV.CONCLUSION

In this research, Cu-Cr-Zr copper alloy specimens were treated with aging at 500 °C for 2 and 4 hours. Subsequently, the aged Cu-Cr-Zr specimens were surface-treated with Ag coating using the PVD method. The structural and electrochemical characteristics of both aged and coated Cu-Cr-Zr alloys were examined. The findings from the analyses are outlined below:

- XRD data indicated the presence of peaks corresponding to the silver phase in the silver-coated sample, along with peaks of Cu. Peaks of the Cu reflected from the submaterial were detected due to the relatively low thickness of the coating layer formed after the coating process. The detected peaks were consistent with studies in the literature.

- As a result of the coating process, samples achieved a coating layer with homogeneous thickness on their surfaces. A coating layer of approximately 2.5 μm thickness was obtained on the surfaces of the materials.

- Corrosion tests revealed that silver-coated samples exhibited better corrosion resistance. The best performance in terms of corrosion resistance was observed in the Cu-Cr-Zr alloy silver-coated after aging for 4 hours at 500°C.

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Civic Participation in Local Governance – a Case from an Albanian Municipality

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Abstract – There are different forms of citizen participation in local governance, ranging from general consultations and sending comments on Municipality Council draft decisions through e-mail to direct negotiations based on strategic partnership agreements. This paper aims to present a short history of citizen activity in participatory democracy, presenting its different levels and forms, through a brief overview of the main documents in international and European level, which serve as guides for local legislation. In addition, a survey was conducted in a middle-sized Albanian municipality on the perception of the impact of citizen participation and transparency in local council decision-making. Results show rather low level of public awareness and reluctancy in participation level, despite some efforts from local civic society organizations.

Keywords – good governance, local governance, civic participation, municipality, Albania

I. INTRODUCTION

Participation in the decision-making process means opportunities for citizens, civil society organizations and other interested actors to influence the development of policies and legal acts that affect them. It is important to note that participatory democracy does not suspend the constitutional and legal powers of the representatives of the executive and legislative power in the procedure of approving and implementing laws, as well as public policy instruments; but rather enables the authorities to implement these powers more efficiently. Consultations between authorities and stakeholders help address some of the shortcomings in political representation in modern parliamentary democracies.

CSOs play a dual role in this process: on the one hand, CSOs are mechanisms that enable citizens to organize and express their legitimate interests more effectively, while on the other hand, they are also legitimate parties in the process. (at least, as regards some of the human rights, from which the right to participate derives, which also apply to CSOs, e.g. freedom of speech, freedom of association, freedom of unimpeded access to information, etc. (Golubovic, 2010).

The European Commission's White Paper on European Governance (2001) aimed to strengthen the culture of consultation and dialogue at the EU level, and thus increase the legitimacy of decisions. The document highlights the five principles of 'good governance': transparency, participation, effectiveness and coherence, which not only "support democracy and the rule of law in EU member states, but they apply to all levels of governance - global, European, national, regional and local". Through the White Paper, changes are recommended in several directions, and the European Commission is obliged to undertake actions for their implementation. As one of the results, the European Commission adopted the General Principles and Minimum Standards for Stakeholder Consultation (2002). The document emphasizes the importance of

providing clear documents for consultation, consulting all relevant target groups, allowing sufficient time for participation, publishing results and informing participants of the results of their comments.

The European Parliament approved the resolution on the prospects for the development of civil dialogue within the framework of the Treaty of Lisbon (2009). The resolution reinforces the importance of consultations and calls for EU institutions to adopt binding guidelines regarding the appointment of civil society representatives, the methods of organizing consultations and their funding, and the requirements for them to maintain CSO registers active. Furthermore, the resolution calls on EU institutions and its member states to make the most of legal provisions and best practices to "increase dialogue with citizens and CSOs", and specifically in those regions and sectors, where the dialogue is not fully developed. The resolution also foresees that dialogue with citizens at all levels requires certain financial resources and, therefore, invites all interested parties and responsible bodies to ensure adequate funding of that dialogue.

The issue of participation has been addressed in several recommendations of the Council of Europe. Recommendation CM/Rec (2007) 14: "Government mechanisms and agencies should ensure effective and non-discriminatory participation of NGOs at all levels regarding dialogue and consultation on public policy objectives and decisions." This participation should ensure the free expression of the diversity of people's opinions regarding the functioning of society. This participation and cooperation should be supported by ensuring the provision of official information or proper access to it; NGOs should be consulted during the drafting of legislation and by-laws that affect their status, funding and spheres of operation. Recommendation Rec (2018)4 outlines basic principles of democratic participation policy at the local level. Based on these principles, the Recommendation identifies specific steps and measures to encourage and strengthen citizens' participation in local public life.

As for local participation, the other basic document is the European Charter for Local Self-Government (1988), which is the first binding international treaty that guarantees the rights of communities and their elected authorities, as well as defining the principle of subsidiarity. By signing the European Charter, states undertake to respect the basic principles, among others, the right of citizens to participate in the management of public affairs. Although it is not binding, it is also worth mentioning the Code of Good Practice on Citizen Participation in the Decision-Making Process (2009), through which the general principles, instructions, instruments and mechanisms for citizen participation are defined, in order to implement at the local, regional and state level.

II. Materials and Method

The methodology consists in the use of a community-based monitoring tool (Community Based Scorecards) which is a hybrid of social audit techniques, community monitoring and citizen reporting formats. Being a very flexible methodology, which makes it quite usable, "decision-makers" were used in this monitoring process as the unit of analysis and the focus is placed on monitoring at the local level of decision-making units. This method aims to address and improve the quality, efficiency, and accountability of the services that decision-making authorities provide to the community through the direct ascertainment and monitoring of council meetings.

The evaluations are based on the observation of the works of the Municipal Council. At the same time, in this monitoring process the "community" has been also used as a unit of analysis through the questionnaire, in order to monitor and evaluate the performance of the services, projects and work of the administrative units of government, from the point of view of the community itself. As part of the primary research, a total of 72 questionnaires were distributed, where only 55 resulted in valid answers. In total, the questionnaire has 25 questions. The questions abouts metrics in the first section are followed by those with issues that are directly related to the topic of how involved the citizens feel in local decision-making, how open are the meetings of the municipal council, how informed are the citizens, etc.

The study was carried out in a medium-sized municipality in the south of Albania. The questionnaire has been handed over to the citizens for self-administration. At the same time, explanations were given for any ambiguity that the participants had regarding the meaning of the questions. At the beginning of each questionnaire, citizens were informed about the purpose of the study and were advised about self-

administration. The data obtained from the questionnaires were processed electronically with the Microsoft Excel program. In order to protect the rights of the participants in the study and guarantee the anonymity when giving answers, the following actions were taken: a) the objectives of the study were explained to the participants, b) each participant was informed about the method of collection of the data, c) their approval was obtained in advance and no other identifying data was requested, d) the respondents were guaranteed that the name of their municipality would not be mentioned in the study.

III. RESULTS AND DISCUSSION

During the study period, the website of the Municipality and the local television media were regularly monitored, since these means of information are the most accessible by citizens. From the monitoring, we found that announcements about the date and time of the Municipal Council meetings were made public on the official website of the Municipality about 3-4 days before the organization of the meeting, as well as on the public notice stand near the municipality. The announcement was also made in the local TV media, one day before the organization of the meeting. The media has been present at all meetings of the Municipal Council, which makes the meeting accessible to many citizens, but the session wasn't fully broadcast. From the monitoring of the media, it was found that a 5 - 7 minutes report is dedicated to the municipal council meetings in the news editions. However, this does not show data on the number of citizens who are informed about the municipal council meetings and the issues that are discussed. The study developed the aspect of monitoring in another form, through the questionnaire, the main findings of which will be presented below.

There were citizens present at the meeting in almost all the monitored sessions. There are no real structures for the involvement of citizens, except in cases where citizens participate in the meeting on their own initiative after hearing the announcement of the meeting in the local media or from announcements at the municipality's stand. In the monitored councils, at the beginning of the session, after the presentation of the agenda, the chairman of the council asked the present citizens to express their concerns and problems, which were answered directly by the mayor or the council members. In general, citizens' concerns were related to the economic assistance scheme and their involvement as beneficiaries.

When asked "who makes the decisions in local government?", 47% of the interviewees answered "the Municipal Council", and 51% answered "the Mayor". Practically, the meetings of the Municipal Council take place no less than once a month according to the decision made by the Council itself and are considered valid when at least more than 50% of the total number of members of the Council participate in it. But it turns out that a significant part of the interviewees, 41%, do not know how often the Municipal Council meets, while 52% of the interviewees answered "once a month". The meetings of the Council are legally open to the public and every citizen is allowed to attend these meetings, in accordance with the legislation.

When asked if council meetings are open, 49% answered YES, 16% answered NO and 35% answered I Don't Know. In general, the public is notified of Council meetings by the Secretary of the Council, and in his absence by the Chairman or Vice-Chairman. The notice contains the date, place, time and agenda of the meeting. The Secretary notifies all those persons or organizations who have submitted a request to receive regular notice of each meeting of the Municipal Council.

Regarding the question about physical participation in the meeting, 28% said YES and 72% said NO. Their main reasons had to do with the lack of interest mostly, the lack of information and because of the citizens' perception that those meetings are only formalities. In a context where the consolidation of democratic policy-making institutions still remains a challenge and their performance is still weak, the involvement of citizens themselves in decision-making through appropriate models would not only increase the transparency of local structures in the eyes of the public but it would break the existing stereotypes about the local governing structures and the lack of trust towards them on the part of the citizens.

Based on the Albanian legislation on local government, it is within the competence of the local government bodies to establish various structural elements, as well as to establish clear communication reports between them when deemed necessary. This is particularly important in the case of consultative meetings that the Municipality must hold with community groups for the budget. From the conducted survey, more than 50% of the interviewees have no information if the municipality has held consultative

meetings for the budget, 36% have expressed "never" and only 6% have stated that the municipality has held consultative meetings every year.

IV. CONCLUSION

Based on what was discussed during the paper, it can be concluded that the level of community participation in the reviewed municipality is not satisfactory, being rather modest. There are many reasons for this. The lack of tradition of participation, the lack of information about the importance of participation, the unwillingness of state institutions to engage communities, etc.

In order to increase the level of community participation, it might be necessary to take the following steps:

- Organize campaigns to raise community awareness of the importance of participation and the role they might play in the decision-making process.
- To raise the awareness of the representatives of the institutions that the participation of the community in the drafting of policies makes their implementation easier.
- Attracting more foreign expertise and donations, in order to help create a culture of more active community participation in issues that are directly related to them.
- Increased transparency in the process of communication with the public is needed to strengthen the credibility of the institutions.
- The website of the local government units should be regularly updated with information on the budget, the annual plan, the activities of the departments, the various projects as well as the meetings of the Municipal Council or the various consultations and their agenda.
- Various actors / educational institutions should be engaged in educating mostly young generations on the functions of the municipality and simultaneously cooperating with this institution to make practical acquaintance with it possible (e.g. visits to the municipality, inviting municipality officials to schools etc.)
- Youth and non-profit organizations should intensify initiatives to educate young people on the role of the municipality and the importance of citizen involvement through the constant organization of trainings, competitions, and internship programs.
- More media attention is required in the launch of positive initiatives in this direction or various activities of the municipality, dedicating more space to information on these issues.
- Engagement of all actors of society, starting from the family, school, community and media in educating and raising awareness of citizens about their potential, thus promoting civic activism.

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Good agricultural practices in the function of sustainable agriculture

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Abstract- The integration of Good Agricultural Practices (GAP) is key to promoting sustainable agriculture. This paper explores the role of GAP in promoting environmentally friendly farming techniques, improving food security and ensuring the socio-economic well-being of farming communities. Through a comprehensive review of existing literature and case studies from different agricultural regions, this paper highlights the basic principles of GAP, such as soil health management, water conservation, crop rotation and integrated pest management. Findings show that adoption of GAP leads to increased crop yields, reduced environmental impact and increased resilience to climate change. Furthermore, GAP implementation encourages biodiversity, reduces dependence on chemical inputs and promotes efficient use of natural resources. By aligning agricultural practices with sustainable development goals, GAP serves as a bridge between traditional agricultural methods and modern sustainable practices. Recommendations are made for policy makers, farmers and stakeholders to support the widespread adoption of GAP through education, financial incentives and collaborative efforts. Emphasizing the importance of a holistic approach, this paper highlights the potential of GAP to transform agriculture into a more sustainable and resilient sector, contributing to global food security and environmental sustainability.

Keywords: Good Agricultural Practices (GAP), sustainable agriculture, natural resource efficiency, sustainable development goals, agricultural innovation, farming techniques.

MATERIAL AND METHOD

A structured survey questionnaire was used for data collection. The quantitative results obtained from the survey questionnaire were processed in a computer-statistics program Excell, while the qualitative data were descriptively presented.

The research includes individual farmers of the municipality of Prilep, R. North Macedonia in order to identify different approaches and aspects in the agricultural sector. 30 individual farmers participated in the research, and the response to the survey questionnaire was 100%. Data collection was done personally by administering the survey questionnaires. After all the necessary data were collected, statistical processing of the same for analysis and interpretation was started, which follows in the following text. In general, the research has an operational character, quite current in time and aimed at understanding the situations in a real and current period of operation.

INTRODUCTION

Sustainable agriculture is increasingly recognized as a critical component in addressing global food security, environmental degradation, and climate change. At the heart of sustainable agriculture lies the concept of Good Agricultural Practices (GAP), which encompass a suite of methods aimed at improving agricultural efficiency while minimizing negative environmental impacts. GAP includes practices such as soil health management, water conservation, crop rotation, and integrated pest management. These practices are designed to enhance crop productivity, protect natural resources, and promote the socio-economic well-being of farming communities.

The importance of GAP extends beyond mere agricultural productivity; it plays a vital role in fostering resilience against climate variability and extreme weather events. By implementing GAP, farmers can achieve more sustainable and resilient agricultural systems, reduce reliance on chemical inputs, and improve biodiversity. Furthermore, GAP contributes to the goals of sustainable development by ensuring the long-term viability of agricultural lands, supporting rural livelihoods, and providing safe and nutritious food for growing populations.

This paper aims to explore the function of GAP within the framework of sustainable agriculture. Through an examination of existing literature, case studies, and empirical data, this study will elucidate how GAP can be effectively implemented and scaled to achieve broader sustainability objectives in agriculture.

The concept of good agricultural practices (GAP)

Good agricultural practices (GAP) represent a set of principles, regulations and technical recommendations aimed at ensuring the safety, quality and sustainability of agricultural production. GAP is designed to address critical components of agriculture that affect food security, environmental health and farmers' socio-economic conditions. Key aspects of GAP include soil health management, water conservation, crop rotation and integrated pest management.

GAP soil health management focuses on maintaining and improving soil fertility through organic matter amendments, cover crops and reduced tillage. Water conservation strategies aim to optimize water use efficiency, reduce waste and conserve water resources through practices such as drip irrigation and rainwater harvesting. Crop rotation and diversification help break pest and disease cycles, improve soil health and increase biodiversity. Integrated Pest Management (IPM) emphasizes the use of biological control methods and the reduction of chemical pesticides, promoting a healthier ecosystem.

GAP also includes guidelines for safe and hygienic food production, addressing issues such as proper product handling and storage, worker health and safety, and the use of clean and safe inputs. Adopting GAP helps farmers produce high-quality, safe food while protecting the environment and improving their

livelihoods. By integrating these practices, GAP serves as a foundation for sustainable agriculture, aligning agricultural practices with broader environmental and social goals.

Overview of Sustainable Agriculture

Sustainable agriculture is an approach to farming that focuses on producing food, fiber, and other plant and animal products in a way that maintains and enhances the health of ecosystems, supports farmer livelihoods, and meets the needs of present and future generations. It aims to achieve a balance between environmental health, economic profitability, and social equity.

Key principles of sustainable agriculture include the conservation of resources, such as soil, water, and biodiversity, to ensure their availability for future generations. Practices like crop rotation, cover cropping, and agroforestry enhance soil fertility, reduce erosion, and promote biodiversity. Water management strategies, including efficient irrigation and rainwater harvesting, help conserve water and protect aquatic ecosystems.

Economic viability is another critical component, ensuring that farming remains profitable for farmers and rural communities. Sustainable agriculture promotes the use of local inputs, value-added products, and diversified farming systems to enhance economic resilience.

Social aspects of sustainable agriculture emphasize the well-being of farm workers and communities. This includes fair labor practices, community engagement, and access to resources and markets. Education and training are crucial for empowering farmers with the knowledge and skills needed to implement sustainable practices.

Sustainable agriculture seeks to create a resilient agricultural system that can withstand environmental challenges, support rural economies, and provide nutritious food for a growing global population.

Principles of Good Agricultural Practices

Good Agricultural Practices (GAP) encompass a set of guidelines and strategies designed to enhance the efficiency, sustainability, and safety of agricultural production. These principles focus on optimizing resource use, protecting the environment, and ensuring the socio-economic well-being of farmers and their communities. Central to GAP are practices that improve soil health, conserve water, manage nutrients effectively, and reduce dependency on chemical inputs. By adhering to GAP principles, farmers can achieve higher yields, maintain ecological balance, and contribute to sustainable development goals. The following sections outline the core principles of GAP, including soil health management, water conservation, crop rotation, integrated pest management, nutrient management, and conservation tillage.

1. **Soil Health Management**

Soil health management is fundamental to GAP, focusing on maintaining and improving soil fertility and structure. Practices such as using organic amendments (e.g., compost and manure), implementing cover cropping, and practicing crop rotation help maintain soil organic matter and nutrient levels. Reduced tillage and contour farming prevent soil erosion and degradation, promoting a healthy, resilient soil ecosystem that supports robust plant growth and microbial activity.

2. **Water Conservation**

Efficient water use is critical for sustainable agriculture. GAP emphasizes techniques like drip irrigation, which delivers water directly to plant roots, minimizing evaporation and runoff. Rainwater harvesting and the use of drought-resistant crop varieties help reduce dependency on external water sources. Maintaining proper soil structure improve water retention, ensuring crops receive adequate moisture while conserving water resources.

3. **Crop Rotation**

Crop rotation involves growing different types of crops in the same area in sequential seasons. This practice breaks pest and disease cycles, reduces soil depletion, and improves soil structure and fertility. By alternating crops with different nutrient needs and root structures, farmers can optimize nutrient use and reduce the risk of crop failure due to pests and diseases.

4. **Integrated Pest Management**

Integrated Pest Management (IPM) is a holistic approach to controlling pests and diseases using a combination of biological, cultural, physical, and chemical methods. IPM emphasizes the use of natural predators, crop rotation, resistant crop varieties, and targeted chemical applications only when necessary. This reduces the reliance on chemical pesticides, minimizes environmental impact, and promotes a balanced ecosystem.

5. **Nutrient Management**

Proper nutrient management ensures that crops receive the right amount of nutrients at the right time, minimizing waste and environmental impact. GAP recommends soil testing and monitoring to tailor fertilization practices to specific crop needs. The use of organic fertilizers, green manures, and precision farming techniques help maintain soil fertility and prevent nutrient runoff, protecting water quality.

6. **Conservation Tillage**

Conservation tillage practices, such as no-till or reduced-till farming, minimize soil disturbance, preserving soil structure and moisture. These practices reduce erosion, enhance water infiltration, and promote the buildup of organic matter. Conservation tillage supports beneficial soil organisms, improves soil health, and reduces the carbon footprint of farming by decreasing fuel use and carbon emissions associated with conventional tillage.

By integrating these principles, Good Agricultural Practices promote sustainable, productive, and resilient farming systems that benefit both farmers and the environment.

Aligning good agricultural practices (GAP) with Sustainable Development Goals (SDGs)

Aligning good agricultural practices (GAP) with Sustainable Development Goals (SDGs) is crucial for achieving a sustainable future. GAP encompasses a range of practices aimed at ensuring food safety, enhancing agricultural productivity, and promoting environmental sustainability. By aligning GAP with SDGs, we can address several interconnected challenges.

Firstly, GAP supports SDG 2 (Zero Hunger) by promoting efficient use of resources, enhancing crop yields, and reducing post-harvest losses. Sustainable farming techniques, such as crop rotation, organic farming, and integrated pest management, improve soil health and boost productivity, thereby contributing to food security.

Secondly, GAP contributes to SDG 13 (Climate Action) by mitigating climate change impacts. Practices like conservation tillage, agroforestry, and precision agriculture reduce greenhouse gas emissions and enhance carbon sequestration. Sustainable water management techniques, such as drip irrigation and rainwater harvesting, help conserve water resources, addressing SDG 6 (Clean Water and Sanitation).

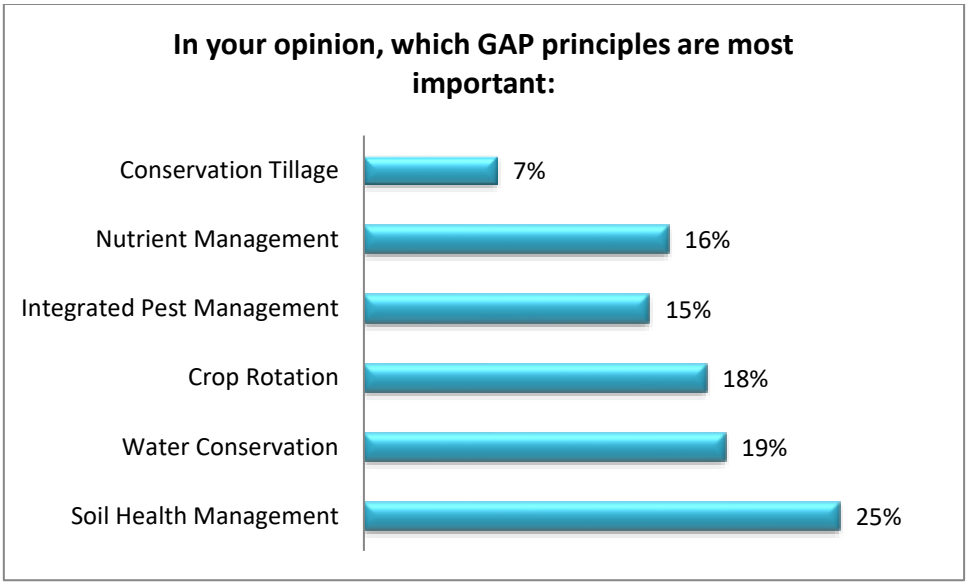
Moreover, GAP fosters biodiversity (SDG 15: Life on Land) by promoting the use of diverse crop varieties and sustainable land management practices. It also supports SDG 12 (Responsible Consumption and Production) by reducing the use of harmful chemicals, minimizing waste, and encouraging recycling.

Socially, GAP aligns with SDG 1 (No Poverty) and SDG 8 (Decent Work and Economic Growth) by improving farmers' livelihoods through increased productivity and access to markets. It promotes fair labor practices and ensures safe working conditions, enhancing social equity (SDG 10: Reduced Inequalities).

Integrating GAP with SDGs offers a holistic approach to sustainable agriculture, addressing environmental, economic, and social dimensions. This alignment not only ensures a resilient agricultural sector but also contributes to broader sustainable development objectives, fostering a healthier planet and more equitable societies.

RESULTS AND DISCUSSION

Figure 1:



Source: author's research

The survey question "In your opinion, which GAP principles are most important" reveals preferences for various Good Agricultural Practices (GAP). Here's a detailed analysis of the responses:

Soil Health Management (25%):

Soil health management is considered the most important GAP principle, with 25% of respondents prioritizing it. This indicates a strong awareness of the foundational role that soil health plays in sustainable agriculture. Healthy soil supports crop growth, improves water retention, and enhances nutrient availability. Practices under soil health management may include maintaining soil organic matter, using cover crops, minimizing soil disturbance, and ensuring proper soil pH levels.

Water Conservation (19%):

Water conservation is the second most important principle, with 19% of the responses. This highlights the critical role of efficient water use in agriculture, especially in regions facing water scarcity. Techniques for water conservation include drip irrigation, rainwater harvesting, scheduling irrigation based on crop needs, and using drought-resistant crop varieties.

Crop Rotation (18%):

Crop rotation is deemed important by 18% of respondents. This practice is vital for breaking pest and disease cycles, improving soil structure, and enhancing nutrient cycling. Typical crop rotation plans involve alternating different types of crops on the same land across seasons or years, such as rotating legumes with cereals.

Nutrient Management (16%):

Nutrient management, with 16% of the responses, is crucial for ensuring that crops receive the right balance of nutrients for optimal growth while minimizing environmental impacts. Effective nutrient management includes soil testing, using organic and inorganic fertilizers appropriately, and implementing precision agriculture techniques to apply nutrients efficiently.

Integrated Pest Management (15%):

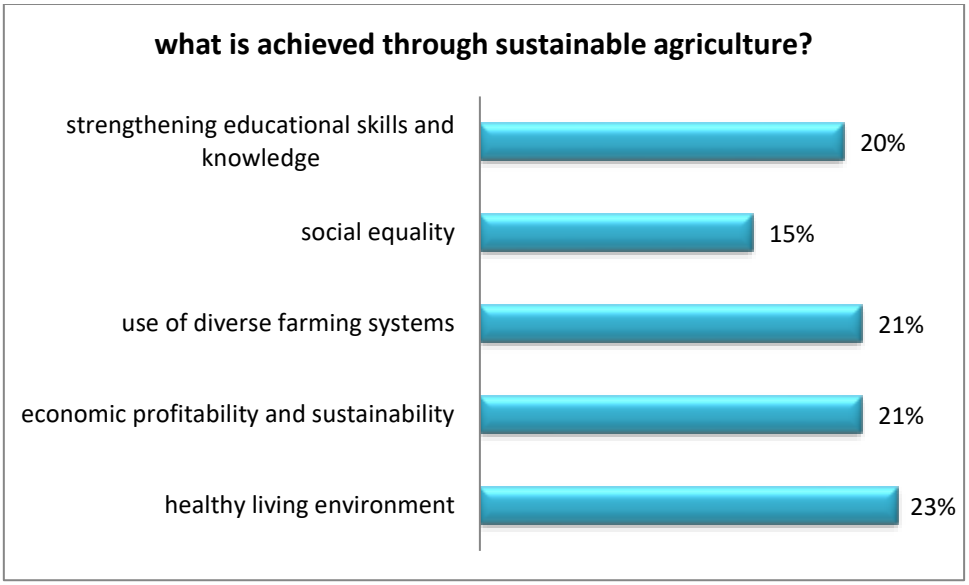
With 15% of respondents prioritizing it, integrated pest management (IPM) is recognized for its role in reducing the reliance on chemical pesticides, thus promoting environmental and human health. IPM involves a combination of biological, cultural, mechanical, and chemical control methods to manage pest populations in an economically and ecologically sound manner.

Conservation Tillage (7%):

Conservation tillage is considered the least important among the listed principles, with only 7% of respondents highlighting it. Despite this, conservation tillage is key for reducing soil erosion, improving water infiltration, and preserving soil structure. Conservation tillage methods include no-till, strip-till, and reduced-till systems, which aim to minimize soil disturbance compared to conventional tillage.

The survey results indicate a diverse range of priorities among respondents concerning Good Agricultural Practices. Soil health management emerges as the top priority, reflecting its fundamental role in sustainable farming. Water conservation, crop rotation, nutrient management, and integrated pest management also receive significant attention, emphasizing a balanced approach to maintaining agricultural productivity and environmental health. Conservation tillage, while least prioritized, remains an important practice for long-term soil sustainability.

Figure 2:



Source: author's research

The survey question "What is achieved with sustainable agriculture?" provides insight into the perceived benefits of sustainable agricultural practices through an analysis of responses:

Healthy environment (23%):

The largest percentage of respondents (23%) believe that sustainable agriculture primarily achieves a healthy environment. This indicates a strong recognition of how sustainable practices can lead to cleaner air, water and soil, thereby improving overall ecosystem health and human well-being.Sustainable agriculture reduces pollution, preserves biodiversity and mitigates climate change, contributing to a healthier environment.

Economic profitability and sustainability (21%):

With 21% of responses, economic profitability and sustainability are considered the main achievements of sustainable agriculture. This highlights the importance of financial sustainability and long-term economic resilience in agriculture. Sustainable practices can reduce input costs, improve yield stability and open up market opportunities for sustainably produced goods, ensuring agriculture remains profitable and sustainable over time.

Use of different agricultural systems (21%):

Another 21% of respondents highlight the use of different farming systems as a key achievement. This reflects an understanding of the benefits of agricultural diversity, including improved pest and disease resistance, improved soil health and greater overall farm productivity. Different agricultural systems, such

as polycultures, agroforestry and crop rotation, promote ecological balance and reduce dependence on single crops, leading to more sustainable and resilient agricultural practices.

Strengthening educational skills and knowledge (20%):

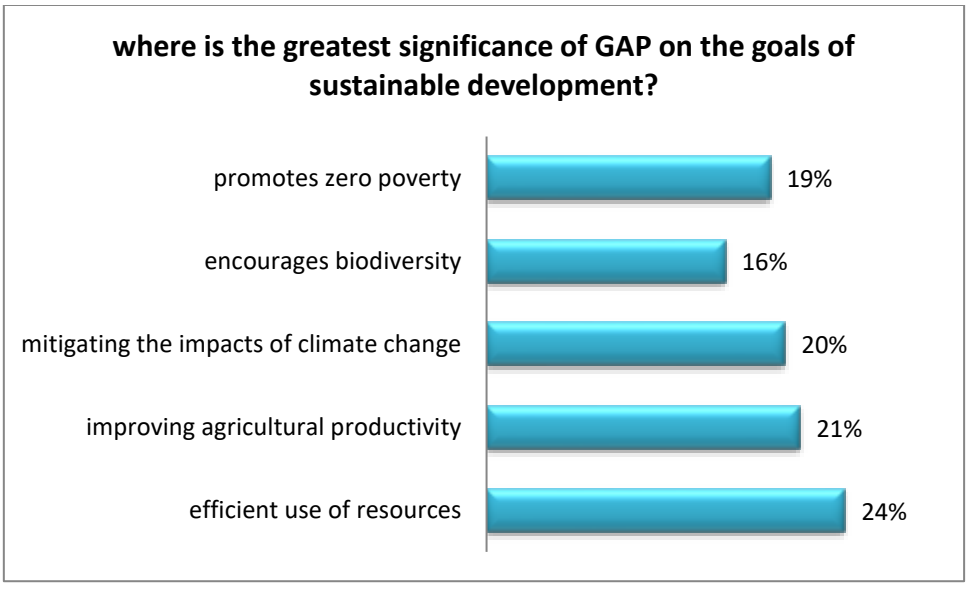
Strengthening educational skills and knowledge is considered important by 20% of respondents. This indicates that sustainable agriculture is also seen as a means of improving farmers' skills, knowledge and innovation capacity. Education and dissemination of knowledge in sustainable agriculture can lead to the adoption of better practices, improved farm management and increased community awareness of sustainability issues.

Social equality (15%):

Social equity is seen as an achievement by 15% of respondents, highlighting the role of sustainable agriculture in promoting fairness and equity in farming communities and society at large. Sustainable agricultural practices can support smallholders, improve access to resources, reduce rural poverty and ensure fair working conditions, contributing to greater social equity and inclusion.

Research results show that sustainable agriculture is valued for its multifaceted benefits. A healthy environment is considered the most significant achievement, followed by economic profitability and the use of different farming systems. Strengthening educational skills and knowledge is also highly valued, while social equity, although slightly less prioritized, remains an important outcome of sustainable agricultural practices. These responses reflect a comprehensive understanding of sustainability, encompassing environmental, economic, social and educational dimensions.

Figure 3:



Source: author's research

The survey question "Where is the greatest significance of GAP on the goals of sustainable development?" provides insights into the perceived impact of Good Agricultural Practices (GAP) on sustainable development goals. Here's a detailed analysis of the responses:

Efficient Use of Resources (24%):
The highest percentage of respondents (24%) believe that the greatest significance of GAP is the efficient use of resources. This indicates a strong recognition of how GAP can optimize the use of water, soil, nutrients, and energy in agricultural practices, reducing waste and increasing efficiency. Efficient resource use leads to lower input costs, higher productivity, and reduced environmental impact, contributing to sustainable agricultural systems.

Improving Agricultural Productivity (21%):
With 21% of responses, improving agricultural productivity is seen as a major significance of GAP. This highlights the role of GAP in enhancing crop yields and farm outputs through better management practices. Higher productivity ensures food security, increases farm incomes, and supports the growing global population, aligning with sustainable development goals.

Mitigating the Impacts of Climate Change (20%):
20% of respondents highlight mitigating the impacts of climate change as a key significance of GAP. This reflects an understanding of how sustainable practices can help reduce greenhouse gas emissions and improve resilience to climate variability. Practices such as carbon sequestration, reduced tillage, and efficient water use contribute to climate change mitigation and adaptation, supporting long-term sustainability.

Promotes Zero Poverty (19%):
Promoting zero poverty is considered important by 19% of respondents. This indicates the recognition of GAP's potential to improve livelihoods and reduce poverty among farming communities. GAP can increase agricultural productivity and profitability, provide employment opportunities, and improve access to markets, thereby contributing to poverty reduction and economic development.

Encourages Biodiversity (16%):
Encouraging biodiversity is seen as a significant outcome by 16% of respondents. This shows an awareness of the importance of maintaining diverse ecosystems within agricultural landscapes.

Biodiversity enhances ecosystem services such as pollination, pest control, and soil fertility, and ensures the resilience of agricultural systems against pests, diseases, and environmental changes.

The survey results demonstrate that respondents recognize multiple significant impacts of Good Agricultural Practices on sustainable development goals. The efficient use of resources is viewed as the most critical, followed closely by improving agricultural productivity and mitigating climate change impacts. Promoting zero poverty and encouraging biodiversity are also seen as important outcomes. These responses reflect a holistic understanding of how GAP can contribute to various dimensions of sustainability, including economic, environmental, and social aspects.

CONCLUSION

This study, underscores the integral role that GAP plays in advancing sustainable agricultural goals. Analysis of survey responses highlights several key areas where GAP significantly contributes to sustainability. The foremost achievement is the efficient use of resources, with 24% of respondents recognizing its critical role. By optimizing water, soil, nutrient, and energy use, GAP minimizes waste and maximizes productivity, directly aligning with sustainable agriculture's goals.

Improving agricultural productivity, acknowledged by 21% of respondents, is another crucial benefit of GAP. Through enhanced crop management and innovative farming techniques, GAP ensures higher yields and stable food supply, which are essential for food security and economic stability. Additionally, 20% of respondents emphasize GAP's role in mitigating climate change impacts. Practices like reduced tillage, carbon sequestration, and water conservation are vital in reducing greenhouse gas emissions and enhancing the resilience of farming systems to climatic variations.

The study also reveals that GAP promotes zero poverty, as indicated by 19% of participants. By increasing farm productivity and profitability, GAP provides better livelihoods and reduces poverty among rural communities. Furthermore, 16% of respondents recognize the importance of GAP in encouraging biodiversity. Diverse farming systems foster ecological balance, enhance ecosystem services, and ensure long-term agricultural sustainability.

Good Agricultural Practices are pivotal in achieving sustainable agriculture by addressing critical aspects such as resource efficiency, productivity enhancement, climate change mitigation, poverty reduction, and biodiversity conservation. This comprehensive approach not only supports the immediate needs of farmers but also ensures the sustainability of agricultural systems for future generations. The insights gained from this study highlight the multifaceted benefits of GAP and reinforce its importance in the pursuit of sustainable development.

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SUSTAINABILITY AND INNOVATIVE PERFORMANCE OF NIGERIAN MULTINATIONAL ENTERPRISES

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Abstract **-** The study investigated the relationship between sustainability and innovative performance of multinational enterprises in Nigeria. The made use of expo-facto research design to collected secondary data from six (6) quoted multinational consumer goods companies as at 31st December, 2019 in the Nigeria Stock Exchange for the period of 2014 to 2019 through simple random sampling technique. The simple model regression technique was adopted in the analysis of data through SPSS version 21.0. The results from the simple regression model revealed that sustainability practice is positively associated with innovative performance while firm resources utilization is not a sustainability parameter that influences innovative performance in the long-run. The study recommended that management should constantly embrace sustainability practice in order to drive performance of the multinational enterprises through the dynamic power of innovation. It was suggested that future research should consider other potential factors of sustainability strategies that can directly drive innovative performance among quoted multinational enterprise in Nigeria.

Keywords: *Firm Resources Utilisation, Innovative Performance, Multinational Enterprises, Simple Model Regression Technique.*

1. INTRODUCTION

Multinational corporations are a dynamic business environment where business organisations heavily in internationalization process for growth and expansion. Therefore, multinational corporations are business organizations which operate strategically on an international scale (Udoka, 2015). Innovative performance is an antecedent of innovativeness which is the process of adopted new business strategy, new process and new product required for customer satisfaction (Kamaruddeen, Yusof & Said, 2010). Dasí, Iborra and Safón (2015) argued that larger multinational companies with high level of reputation are

often benchmarks for gaining acceptance in the international market and smaller firms with proven products and services possessed dynamic strengths in assessing and meeting customer demands.

Proactive sustainability strategies enable managers of business firms to address social and environmental issues within their business environments to achieve innovative performance (Engert & Baumgartner, 2016).

Available literatures in Nigeria emerging economy mainly focused on sustainability reporting and corporate governance (Oba & Fodio, 2012; Uwuigbe, 2011; Arong, Ezugwu & Egbere, 2014) while others examine innovative determinants from organisational performance (Ngwakwe, 2009; Nwobu, 2017; Olayemi, Okonji, Oghojafor & Orekoya, 2020). Besides, multinational companies are citedal of internationalization process which play significant role in the development of the Nigerian economy through the process of industrialization and innovation policies. Studies of developed and emerging economy settings have overlooked innovation performance of multinational enterprises. In the area of innovative studies, the sustainability practice variable has been examined against innovative performance. Hence, the relationships between sustainability practice and innovation performance of multinational enterprises in Nigeria have not been fully researched.

1.2 Research Objectives

The main aim of the study is investigate the relationship between sustainability and innovative performance of multinational enterprises in Nigeria. Hence, the specific objectives are to:

(i) Investigate the effects relationship between sustainability practice and innovative performance of multinational enterprises in Nigeria.

(ii) Determine the relationship between firm resource utilisation and innovative performance of multinational enterprises in Nigeria.

2. THEORETICAL BACKGROUND AND HYPOTHESES

2.1 Innovative Performance of Multinational Firm

Scholars in accounting profession have carried out different studies on innovative capacity and its relationship to organisational performance. Multinational corporations play an indispensable role in global business organisation and also promising in an emerging economy like Nigeria (Kumar, 2015). The consistent growth of multinational enterprises (MNEs) and the internationalization of firms in emerging economies has been an arguments that successful internationalization process of firm requires a well-established institutional framework, firm or country-specific resources and favourable market conditions (Buckley, Doh & Benischke, 2017). Santos and Brito (2012) argued that innovative performance is a un-idimensional and multi-dimensional construct of management research. Innovative performance is a good indicator of financial propensity of business organisation which include profitability, market value, and growth while the social indicator include employee and customer satisfaction, environmental and environmental audit performance (Selvam, Gayathri, Vasanth, Lingaraja & Marxiaoli, 2016). Innovation is very essential for organizations' success and competitiveness. Al-Juboori, Singh, Mansor, Kakar, Zulfiga and Pitchy (2021) defined innovative performance as the ability of firm to identify new ideas and knowledge, introducing new products/services in meeting customer satisfaction. In the view of Hafeez (2013), innovative performance is the enhancement of product quality for better customer satisfaction. The level of innovativeness is characterized by the introduction of new and improved products in driving a competitive business environment.

2.2 Sustainability Practice and Innovative Performance

Sustainability is driven by three main factors such as social, economic and environmental. According to Filho (2000:133), sustainability practice defined as the "ability of a nation to attain developmental process economically and socially without negative influence on the environmental resources thereby adhering to ethically acceptable, morally fair and financially sound". Proactive sustainability practices deal with

timely evaluation of the market to spot out threats and opportunities of the social and environmental constraints facing the market (Wijethilake, 2017). Sustainability practices components are social economic and financial. Bergmiller et al., (2009) describes sustainability as environmental practices that are geared towards improving proficiency, shortening reaction time, cutting down energy consumption, reducing waste and toxic material usage, improving resource utilization, and reducing production costs in order to enhancing environmental performance through innovative measures. Boso, Danso, Leonidou, Uddin, Adeola & Hultman, (2017) maintained that management must ensure they commit huge investment on sustainability strategies to pioneer innovative products for future social and environmental market demands for increasing the efficient delivering of goods and services that meet customer satisfaction in the future (Boso, et al, 2017).

Kucukoglu and Pinar (2015:1232), did a empirical study on the "positive influences of green innovation on company performance, and found out that sustainability practices of committing to green manufacturing applications exert a positive effect on innovation and environmental performance". Masocha (2018:1), carried out an empirical study in South Africa on "the relationship between environmental sustainability and firm innovative performance where cross-sectional research design employed through the distribution of 208 self-administered questionnaires to SME owners and managers". The results from the structural equation modelling (SEM) regression show that environmental sustainability exerts a significant positive relationship with innovative performance. Another study by Sezen and Yildiz (2013:154), on the effects of "green manufacturing and eco-innovation on sustainability performance revealed that sustainability practice and innovative performance is positively and significantly related,". This indicates that proactive sustainability practice is driven by high level of innovative performance. Similarly, Theyel and Hofmann (2012:1110), conducted a study on the "relationship between stakeholder relations and sustainability practices of US small and medium-sized manufacturers and found out environmental sustainability exhibit a significant positive effect on innovation performance at p-value < 0.05". Sound sustainability practices under gone in the social,

economic and environment of doing business has the tendency of improving innovative performance of multinational enterprises. Hence:

H1: Sustainability practices are positively related to innovative performance of multinational enterprises.

2.3 Firm Resource Utilisation and Innovative Performance

Lee, Wang and Ho (2019) stressed that firm financial resources is the mechanism for sustaining the survival and growth of firms. Ombaka, Machuki and Mahasi (2015) maintained that firm resources are vital instrument of strategic management function that enhance production and management of business environment. Nwoba, Boso and Robson (2021) defined firm resource utilistion is the efficient assessment, deployment of financial capital by top-level managers to achieve the set goals and objectives of business organisation. Besides, firm resource utilization is the availability of capital of net profit after deducting discretionary expenses and taxes. In Zimbabwe, Sibanda, Hove-Sibanda, and Shava (2018) used survey research design through structured questionnaire to examine the impact of SMEs access to finance and performance on exporting behaviour of multinational enterprises at firm level. The regression results showed that firm resources has a direct impact on innovative performance. This indicates that a firm resource is a major determinant of internationalization and innovative performance. Demirkan, (2018:672), investigate the influence of firm resources on innovative performance in US by adopting panel data research for the period of 1990 to 2006 where 306 firms from the biotechnology industry were sampled". The empirical evidence revealed that firm resource and innovative performance is significantly related. Hence, firm resources bring about innovativeness and market competitiveness for sustained performance. It is thus propose that:

H2: Firm resource utilistion is positively related to innovative performance of multinational enterprises.

The Theory of Innovative Behaviour

The study was driven by the theory of innovative behaviour which is developed by Midgley and Dowling (1978). The study is based on the inter-personal communication between individual's behaviour and organisational settings. The theory stressed that tedious nation of communication do experience in

business organisation at times can be reduce with the use of innovativeness in the processes of communication. Sustainability and innovative performance of multinational is a multinational mechanism of business organistions operating in a global dynamic environment. This is represented in the diagram below:

Figure: 1

Source: Researchers' Conceptual framework, (2021)

3. METHODOLOGY

3.1 Research Design

The study adopted expo-facto research design to investigate the relationship between sustainability and innovative performance of multinational enterprises in Nigeria. The population consisted of quoted multinational companies as at 31st December, 2019 in the Nigeria Stock Exchange (NSE, 2019). The quoted companies must possess the status of multinational corporations among the twenty-one (21) Consumer Goods Firm in Nigeria. Each multinational company in the population must have finished its obligation in delivering annual reports for six (6) consecutive years (2014-2019). Nevertheless, in order to avoid bias, simple random sampling technique was used to select six (6) consumer goods companies that status of multinational corporations in Nigeria.

3.2 Model Specification and Measurement of Variables

In this study, single linear regression technique was specified as shown below:

$INPF_{it} = \beta_0 + \beta_1 SPR_{it} + \beta_2 FRU_{it} + \varepsilon$ …… (1)

Where;

B_1-β_2 = coefficient of the variables

i,t = firm i, time t

$INPF_{it}$ = Innovative performance

SPR_{it} = Sustainability practice

FRU_{it} = Firm resource utilisation

The measurement of the variables was presented in table 1 below:

Table 1: Measurement of Variables

S/N	Variables	Measurement	Apriori sign
1.	Innovative performance (dependent variable)	Innovative performance was measured by ratio of intangible asset to total gross revenue.	
2.	Sustainability practice (independent variable)	Sustainability practice was measured by the ratio of corporate social donation to total revenue	+
3.	Firm resource utilisation (independent variable)	Firm resource utilisation was measured by logarithms of retained earnings.	+

Researcher's Compilation (2021)

3.3 Method of Data Analysis

This study used single regressions technique to examine the relationship between sustainability and innovative performance of multinational enterprises. The study analysis was conducted using SPSS 21.0 econometric software.

4. SIMPLE MODEL ESTIMATION AND RESULTS

To test the hypotheses of the study, a simple regression is adopted. The relationship between innovative performance and sustainability practice, and it was presented in Table 2 below;

Table 2: Relationship between innovative performance and sustainability practice

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.330[a]	.109	.083	.00611	.958

a. Predictors: (Constant), SPR

b. Dependent Variable: INPF

The R-square value of 0.109 account for about 11% systemic variation in innovative performance which was potentially explained by sustainability practice. This was supported by the adjusted R-square value of 8%. The linearity between innovative performance and sustainability practice was denoted by R-model of 33%. This implies that the simple model has a moderate predictive power. The Durbin-Watson statistic value of 0.958 revealed the presence of serial correlation in the model but it irrelevant to the study due to the nature of data employed.

To test for the significant relationship between innovative performance and sustainability practice was presented in Table 3 below;

Table 3: Test of Hypothesis One: Sustainability practices are positively related to innovative performance of multinational enterprises

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.006	.001		4.757	.000
	SPR	3.339	1.636	.330	2.042	.049

a. Dependent Variable: INPF

It was observed from Table 3 above that sustainability practices (coefficient=3.339, t-statistic=2.042 and p-value =0.049). This indicates that sustainability practices were positively and significantly related to innovative performance of multinational enterprises at 5% level of significance. This in other words means that multinational enterprises adopting sustainability practices would positively drive innovative performance in the area of new product introduction and new strategy of doing business. The finding was supported by the findings of Kucukoglu and Pinar (2015), Sezen and Yildiz (2013) and Theyel and Hofmann (2012) that sustainability exhibit a significant positive effect on innovation performance. It means that the hypothesis was therefore accepted that sustainability practices were positively related to innovative performance of multinational enterprises.

A simple regression was employed to investigate the relationship between innovative performance and sustainability practice, and it was presented in Table 4 below;

Table 4: Relationship between innovative performance and firm resources utilization

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.063[a]	.004	-.025	.00646	.708

a. Predictors: (Constant), FRU

b. Dependent Variable: INPF

The R-square value of 0.004 account for about 1% systemic variation in innovative performance which was explained by firm resource utilistion. The linearity between innovative performance and firm resource utilistion was denoted by R-model of 6%. This implies that the simple model has a weak predictive power. The Durbin-Watson statistic value of 0.708 revealed the presence of serial correlation in the model but it irrelevant to the study due to the nature of data employed.

To test for the significant relationship between innovative performance and sustainability practice was presented in Table 5 below;

Table 4: Test of Hypothesis Two: Firm resource utilistion is positively related to innovative performance of multinational enterprises

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.013	.018		.759	.453
	FRU	-.001	.002	-.063	-.365	.717

a. Dependent Variable: INPF

It was deduced from Table 5 above that firm resource utilistion (coefficient=-0.001, t-statistic=-0.365 and p-value =0.717). This implies that firm resource utilistion exert an insignificant negative relationship with innovative performance of multinational enterprises at p-value < 0.05. This indicates that ineffective utilistion of firm resource would adversely affect innovative performance over time. The finding was contrary to the findings of Sibanda, Hove-Sibanda, and Shava (2018) and Demirkan, (2018) that firm resource and innovative performance is significantly related. It therefore means that the hypothesis was rejected that firm resource utilistion was not positively related to innovative performance of multinational enterprises.

5. PRACTICAL IMPLICATIONS

5.1 Implications for Top Managers

Due to the challenges of external environment couple with the non-compliance sustainability strategies and ethics by multinational enterprises, rapid globalisation, and under-developed market structures in Nigeria. Hence, the study emphases the importance of innovative drive of the work process in Nigeria by top-level manager to embrace sustainability initiatives for innovative performance. In addition, the findings revealed the essence of top-level managers to commit to sustainability strategies for birthing out new policy formulation that are innovative based. The idea of innovativeness exhibit by top-level managers enables them to enhance local market information, knowledge driven, social and environmental challenges resolved by proactive and responsive sustainability practices.

Finally, the finding that firm resource utilization is one of the paths of sustainability strategies to innovative performance. It might prove that top-level manager's neglect and ineffective use of firm resources negatively affect innovative performance of the multinational enterprises.

5.2 Conclusion

The study mainly focused on sustainability and innovative performance of multinational enterprise in Nigeria. It is interestingly for top-level managers to know that level of innovativeness is the barometer of firm's financial propensity such as profitability level, market value, and growth through responsive sustainability strategies. It was concluded from the simple regression model that sustainability practice is positively associated with innovative performance while firm resources utilization is not a sustainability parameter that influence innovative performance in the long-run. The study therefore recommended that management should constantly embrace sustainability practice in order to drive performance of the multinational enterprises through the dynamic power of innovation.

5.3 Limitations and future research

In most empirical studies, there are limitations associated which create room for future research. First, the study only considered the multinational enterprise among listed consumer goods in Nigeria. Based on this

premise, it would be useful for future empirical studies to investigate how innovative parameters influence sustainability practice. Second, as emerging economies like Nigeria is moving slowly toward a developed market system, it is imperative for future research to investigate whether sustainability strategies are constantly implemented by multinational enterprise with reference to the level of innovativeness. Future research should consider other potential factors of sustainability strategies that can directly drive innovative performance among quoted multinational enterprise in Nigeria.

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RISK UNDER CONTROL: INTERACTIVE CASE TECHNOLOGIES IN LIFE SAFETY EDUCATION

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Abstract: This article explores the organization of student training using the case study method combined with heuristic tasks in the "Life Safety" discipline. A significant advantage of this innovative pedagogical approach is the enhancement of both universal and core professional competencies, the creation of educational products by students, and the development of their personal qualities. These skills are fundamental for cultivating a culture of life safety in future specialists, which is essential across all professional fields.

Keywords: sustainable development, safety, danger, risk, interactive case technologies.

I.INTRODUCTION

The sustainable development of society and security are two interconnected concepts crucial for setting goals and determining methods to achieve both material and spiritual prosperity for people. Sustainable development refers to progress that addresses the current global needs, amid the shifting spheres of influence among world powers, without compromising the ability of future generations to fulfill their natural needs. This term was internationally recognized at the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. Following the conference's recommendations, which outlined the principles for a coordinated policy on sustainable development and biosphere conservation, Uzbekistan formulated the "Concept of National Security of the Republic of Uzbekistan" (Decree of the President of the Republic of Uzbekistan No. 467-I, August 29, 1997) and the "Concept and National Strategy for Sustainable Development of the Republic of Uzbekistan" (1998).

II. MAIN PART

The sustainable development of society and security are two interconnected concepts crucial for setting goals and determining methods to achieve both material and spiritual prosperity for people. Sustainable development refers to progress that addresses the current global needs, amid the shifting spheres of influence among world powers, without compromising the ability of future generations to fulfill their natural needs.

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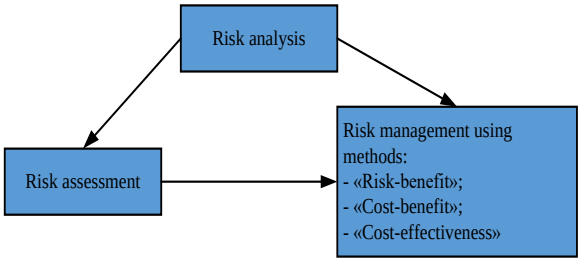

Fig.1. Hazard Source Risk Analysis

The method of risk management is influenced by numerous factors, including economic considerations. A contemporary approach to risk analysis is the "hazard-based" analysis method.

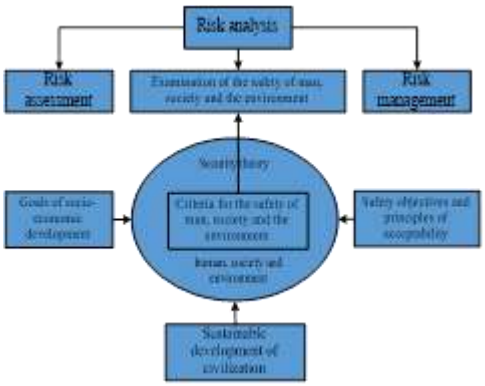

Fig.2. Risk analysis method based on the hazard object

Three primary sources of danger can be identified: individuals, the natural environment, and society (the state). Individuals are indifferent to the source of the danger (e.g., a car, a machine, or their own negligence). Given the same duration and intensity of impact, an individual can suffer fatal injuries. This scenario is similar in cases of explosions (e.g., gas cylinder explosions, technological installation malfunctions, or explosives), penetrating radiation (e.g., radiography, nuclear reactor explosions, or working with radiation sources), and toxic effects (e.g., vehicle emissions, power plant emissions, chemical accidents, or chemical weapons).

The difference between the "hazard source" risk analysis method and risk management lies in the basis of management on safety expertise, which uses human, environmental, and social safety criteria. Security criteria are established based on the concept of sustainable development, socio-economic development goals ("everything for the benefit of humans," the enrichment of oligarchs, the "golden billion" theory, etc.), and the goals and principles of acceptable safety (acceptable risks). A security criterion is a specific parameter that limits the negative impact of hazardous and harmful environmental factors on the danger object, ensuring its condition does not deviate more than a specified amount (usually 5%) from the existing state. For an individual (as a danger object), there is an individual safety criterion; for society, there are social, legal, demographic, technical, and other safety criteria; for the natural environment, there are biological, ecological, landscape, geographical, and other safety criteria. Individual safety criteria (medical or sanitary) limit the negative environmental impact on humans from above. Known values are used as specific individual safety criteria, such as maximum permissible concentration (limiting toxic exposure to hazardous chemicals and dust), effective radiation dose Eeff (radiation exposure), noise intensity LA (acoustic exposure), and so on. When selecting a technical safety criterion, different approaches can be applied depending on the priority: human health (in the UK, the inadmissibility of accidents causing more than 100 deaths), incidents negatively affecting more than 5% of different animal species, technical systems (accidents leading to reactor core meltdown ("beyond design basis" radiation accidents), explosions, etc.).

To enhance security measures, investments can be allocated in three main ways:

1. Improving technical systems and infrastructure;
2. Training and educating personnel;
3. Enhancing emergency management capabilities.

In the first two cases, funds are directed towards reducing the likelihood of accidents, whereas in the third case, the focus is on minimizing their impact should they occur. Upon analyzing the effectiveness of capital investments, it becomes evident that in many instances, the risk to the population can be significantly mitigated by prioritizing actions in response to accidents over solely focusing on technical systems for prevention, which do not guarantee absolute safety.

Risk management employs technical, organizational, and administrative methods in conjunction with economic approaches such as insurance, financial compensation for damages, and risk payments. The decision-making process in risk management involves assessing costs versus benefits associated with risk reduction measures.

To better comprehend risk reduction strategies, interactive case studies have been integrated into the curriculum of "Life Safety." This method involves situational scenarios that stimulate intellectual and creative engagement among students. Through case study activities, students update their theoretical knowledge, enhance practical skills, and deepen their understanding of life safety issues.

The case study method integrates individual student development and group training techniques, fostering teamwork and personal growth. It employs project-based learning, centered on real-life scenarios for problem-solving tasks. Key to its success is active student participation, motivating them through recognition of achievements and fostering healthy competition.

At the core of this method is its role in teaching students to tackle complex problems that resist straightforward analytical solutions, emphasizing collaborative information exchange among group members. Facilitators utilize tools that immerse students in scenarios, guiding discussions to stimulate exploration and discovery.

Case analysis sharpens analytical skills, while group discussions refine communication abilities, enabling participants to collectively analyze diverse scenarios from everyday incidents to industrial emergencies and natural disasters.

The case study method encompasses various types of situations:

1. Real-life examples where participants attempt to find solutions or assess the current situation.
2. Critical analysis of management decisions already made, with students acting as external observers.
3. Practical exercises where complex situations are explored in-depth.
4. Application of best practices to solve recurring problems.

These exercises are often categorized by complexity:

- Illustrative cases serve as examples to guide decision-making.
- Training programs delve into specific situations, requiring participants to make informed decisions.
- Learning situations challenge students to identify and solve problems using available resources.
- Practical exercises involve participants in finding solutions to assigned tasks.

Cases vary in format, ranging from extensive documents to concise summaries, typically distributed in print or electronic formats, and sometimes via video or audio media.

Creating cases involves several steps:

1. Defining educational objectives.
2. Establishing goals and outlining tasks.
3. Identifying a relevant scenario for the case study.
4. Mapping out the program structure based on defined theses.
5. Researching and gathering necessary information.
6. Selecting a suitable organizational model or example.
7. Defining the genre and writing the case study text.
8. Evaluating program effectiveness through diagnostics.
9. Finalizing and implementing the case study program.
10. Preparing methodological recommendations and discussion questions.

In the context of "Life Safety," the case study unfolds through these stages:

1. Introduction to the emergency situation, understanding its origins and causes.
2. Identification of the core problem and assessment of potential risks to students' life and health.
3. Brainstorming to generate ideas and solutions.
4. Analysis of decision consequences or proposed solutions.
5. Proposing optimal action sequences, evaluating alternatives, identifying potential issues, and suggesting preventive measures or solutions.

III. CONCLUSION

Based on accumulated global experience in addressing emergency risk management issues, as well as analysis of current conditions and future projections, it is evident that this problem has rightfully become a critical component of state policies concerning sustainable development of national security and global security overall. Utilizing the case study method for diagnosing hazards, understanding risk factors, and developing predictive capabilities are crucial elements in training specialists in safety, including educators in life safety.

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ENERGY SOAR: UZBEKISTAN ON THE PATH TO CLEAN ENERGY

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Abstract: The article explores the prospects of developing alternative energy sources in Uzbekistan. The main focus is on the potential of solar and wind energy, as well as the necessity of innovation and sustainable development in the energy sector. The author emphasizes the importance of utilizing clean energy sources to ensure energy security and sustainable economic development of the country.

Keywords: Uzbekistan, alternative energy sources, solar energy, wind energy, innovation, sustainable development.

I.INTRODUCTION

In the modern world, energy issues are becoming increasingly critical and strategically important for many countries, including Uzbekistan. In the face of global challenges such as climate change and the depletion of traditional energy sources, the need to develop alternative energy sources has become an integral part of sustainable development strategies. In this article, we will explore Uzbekistan's potential in the field of alternative energy sources, as well as possible pathways for their development and integration into the national energy system. Let's delve into the world of innovations and perspectives that the future of energy opens up.

II. MAIN PART

President of Uzbekistan, Shavkat Mirziyoyev, has approved the Strategy for the country's transition to a "green" economy for the period 2019-2030. The document highlights the low level of energy efficiency in the economy, suboptimal use of natural resources, technological lag, and insufficient involvement of small businesses in applying innovative solutions for the development of the "green" economy.

One of the main goals of the strategy is to reduce greenhouse gas emissions per unit of gross domestic product by 10% from the 2010 level, as well as to increase the share of renewable energy sources to 25% of the total electricity generation and more. It also includes ensuring modern, accessible, and reliable energy supply for 100% of the population and economic sectors, expanding the production and use of energy-efficient and environmentally friendly fuels for transport, developing electric transport, introducing drip irrigation, and increasing crop yields by 20-40%.

Like many other countries, Uzbekistan aims to develop its energy infrastructure, including the use of alternative energy sources. Recommendations for selecting specific sources depend on various factors, including climatic conditions, geography, available resources, technical capabilities, and economic feasibility. Below are several alternative energy sources that could be recommended for application in Uzbekistan:

Solar Energy: Uzbekistan possesses extensive solar resources due to its sunny climate. Using solar panels for electricity generation on large and small-scale installations could be an effective option.

Wind Energy: Some regions of Uzbekistan may also have potential for wind energy, especially in areas with high wind speeds.

Hydropower: Uzbekistan has rivers and reservoirs, making hydropower potentially beneficial, although this may be limited by technical and environmental factors.

Biomass Energy: Agricultural waste and other biomass can be used for energy production, which could be particularly useful in regions with developed agriculture.

Geothermal Energy: If suitable geological conditions exist, geothermal energy could also be an option.

These renewable energy sources present opportunities for Uzbekistan to diversify its energy mix, enhance energy security, and contribute to global efforts in combating climate change. As Uzbekistan continues to implement its green economy strategy, harnessing these alternatives will be crucial for sustainable development and long-term economic growth.

Choosing the optimal energy source for Uzbekistan requires comprehensive analysis and planning, considering both technical and economic aspects, as well as potential environmental consequences. Let's look at recent trends in alternative energy:

Innovative Work in Solar Panels:

1. Perovskite Solar Cells: Perovskites are a new class of materials promising significant improvements in efficiency and cost reduction for solar panels. They have high light absorption coefficients and can be manufactured on flexible substrates.

2. Tandem Solar Cells: Tandem solar cells consist of two or more layers of different materials, each absorbing different ranges of light. This allows for higher overall solar cell efficiency.

3. Amorphous Silicon (a-Si:H) Solar Panels: This technology enables the production of thin and flexible solar panels, making them suitable for various applications.

4. Nanostructured Solar Cells: These solar cells use nanostructured materials to increase light absorption surface area, thereby enhancing light-to-electricity conversion efficiency.

5. Optimization Technologies: Various optimization schemes and technologies like microinverters and Maximum Power Point Tracking (MPPT) optimizers can improve solar system performance through better management and control.

These new schemes and technologies make solar panels more efficient, accessible, and versatile for different applications, contributing to wider adoption and use.

Innovations in Wind Energy:

1. Direct Drive Wind Turbines: Direct drive technology reduces the number of mechanical components and increases generator efficiency, ultimately reducing maintenance costs and enhancing reliability.

2. Floating Wind Turbines: These turbines can be deployed at sea on special floating platforms, tapping into wind resources in open waters where wind speeds are typically higher than on land.

3. Vertical Axis Wind Turbines: Unlike traditional horizontal axis wind turbines, these turbines have a vertical axis of rotation, making them more compact, easier to install, and less affected by wind direction changes.

4. Smart Management and Forecasting Systems: Utilizing modern management systems and analytics optimizes wind turbine operations, considering wind variability, thereby improving their performance and economic efficiency.

5. Integration with Energy Storage: Wind turbines are increasingly integrated with energy storage systems such as batteries or hydrogen-based storage, smoothing out energy production fluctuations and enhancing system flexibility.

These advancements in both solar and wind energy technologies represent significant opportunities for Uzbekistan to enhance its energy infrastructure, improve energy security, and contribute to global efforts in combating climate change. Each technology presents unique benefits and considerations that should be evaluated based on local conditions and long-term strategic goals.

These new schemes and technologies help make wind turbines more efficient, reliable, and economically viable, thereby promoting their wider acceptance and use in various regions around the world.

In Hydroelectric Energy:

1. Floating Hydroelectric Power Stations: These stations can be deployed on open water surfaces such as seas, lakes, or rivers. They may be less dependent on specific locations and offer the opportunity to harness hydro energy where it was previously inaccessible.

2. Micro Hydro Power: This concept refers to small-scale hydroelectric power stations that can be installed on small rivers or canals. They can provide power for remote areas or small communities.

3. Tidal Energy Utilization: Technologies that harness tidal movements for energy generation are becoming increasingly popular. This can include tidal barrages or underwater turbines.

4. Improved Turbines and Generators: New turbine and generator designs can enhance the efficiency of converting water's potential energy into electricity.

5. Integration with Renewable Energy Sources: Hydroelectric systems can be integrated with other energy sources such as solar and wind energy to ensure stability and flexibility of energy systems.

These new schemes and technologies help make hydroelectric power more accessible, efficient, and sustainable, thereby contributing to its further development and deployment worldwide.

In Biomass Energy:

1. Biogas Plants: These plants use biological processes to decompose organic materials and produce biogas, primarily composed of methane. Biogas can be used for electricity and heat production.

2. Biomass Heating: In some regions, biomass is used to generate heat for heating homes, businesses, and other buildings. This can involve using wood, burning agricultural residues, or producing heat through biogas plants.

3. Cogeneration Biomass Boilers: These boilers use biomass to simultaneously produce heat and electricity. This increases the efficiency of biomass use and reduces energy costs.

4. Bioethanol and Biodiesel: These biofuels are produced from biomass such as sugarcane, corn, soybeans, and other plants. They can be used as alternatives to traditional petroleum products for powering vehicles and machinery.

5. Biomass Gasifiers: These devices convert solid biomass into syngas, which can be used for electricity generation, heat, or liquefied fuels.

These innovations in biomass energy research and development are contributing to more sustainable energy solutions, helping to reduce reliance on fossil fuels and mitigate environmental impacts.

These advancements across hydroelectric, wind, and biomass energy sectors illustrate ongoing efforts to enhance energy efficiency, reliability, and sustainability, aiming for broader adoption and integration into global energy systems.

These new schemes and technologies make biomass utilization more efficient, clean, and economically viable, facilitating the transition to more sustainable and environmentally friendly energy sources.

In the field of geothermal energy, there is continuous development of new types of installations and technologies for more efficient use of heat extracted from the Earth's crust:

- Hydrothermal Engines: These technologies use hot underground waters to drive turbines and generate electricity. They can be particularly effective in regions with high-temperature hydrothermal sources.

- Low-Temperature Geothermal Systems: These systems are designed to utilize low-temperature geothermal resources, such as heat from the Earth, for heating buildings or producing thermal energy.

- Geothermal Heat Pumps: These systems use heat from the Earth or hot underground waters as a heat source for heat pumps, which can be used for space heating or water heating.

- Binary Geothermal Plants: These plants use the heat from hot underground waters to heat a second circulating working fluid, which then drives a turbine and generates electricity. This allows the use of resources with lower temperatures.

- Experimental Research and Technologies: Current research is focused on developing new methods to extract heat from the Earth's crust, such as hydraulic fracturing (fracking), hydro-molybdenum, and other innovative approaches.

These new types of geothermal installations and technologies contribute to increasing the efficiency, availability, and sustainability of geothermal energy, promoting its spread as an alternative energy source.

Implementation of various measures will enhance energy efficiency in Uzbekistan's key economic sectors:

Electric Power Sector:

- Implementation of highly efficient technologies at power plants and automatic systems for controlling electricity consumption.

Heat Power Sector:

- Introduction of new technologies for thermal energy production, modernization of boiler equipment, installation of modern metering devices, and use of solar collectors.

Oil and Gas Industry:

- Modernization of compressor stations and gas distribution networks to reduce natural gas losses, implementation of efficient loss control technologies, and use of alternative energy sources.

Renewable Energy Sources:

- Approval of maximum tariffs for purchasing electricity from renewable sources, modernization of the power supply system, and localization of equipment production for generating energy from renewable sources.

Construction and Operation of Buildings:

- Improvement of building energy efficiency, reconstruction of apartment buildings, introduction of energy-saving standards, and creation of incentives for energy conservation.

Transportation:

- Development of production and use of energy-efficient and environmentally friendly transport vehicles, including electric vehicles and gas-powered cars, as well as development of new transport logistics systems and road infrastructure.

Water management: Application of energy-efficient irrigation technologies, prevention of soil salinity, and widespread use of information and communication technologies.

Agriculture: Restoration of pastures, diversification of crops, and prevention of water pollution with agricultural waste.

Solid waste management: Development of waste collection and recycling systems for using them as an alternative energy source.

The spread of renewable energy sources (RES) can be significantly accelerated thanks to innovative technologies such as automation, artificial intelligence (AI), and blockchain. Implementation of advanced materials management processes and production operations also plays a key role in optimizing energy production and RES asset operation efficiency.

These technologies provide opportunities for efficient use of RES and increasing market efficiency. For example, blockchain can ensure transparency and reliability in energy trading, improving RES integration into energy grids. The use of advanced materials in the production of solar panels and wind turbines also contributes to their efficiency and durability.

These methods not only help reduce costs of operating RES assets and electricity production but also facilitate more efficient integration of RES into energy grids. Automation, in particular, reduces financial and time costs, thereby enhancing the competitiveness of RES in the energy market.

The use of AI technologies plays a crucial role in optimizing the integration of renewable energy resources (RES) into the energy system. The accuracy of weather forecasts provided by AI technologies allows efficient use of wind and solar resources, which are key components of RES energy production.

AI-based systems can process diverse data, including satellite imagery, weather station data, statistics, and sensor information from wind turbines (WT) and solar power plants (SPP). Such AI systems handle vast amounts of information, creating detailed forecasts based on weather data and renewable energy resource potential.

Thanks to AI technologies, more accurate weather forecasting and, consequently, renewable energy production volumes are possible. This enables efficient planning and management of the energy system, optimizing the use of renewable resources and ensuring stable and reliable energy supply.

Advanced manufacturing materials and technologies, such as perovskite and 3D printing, can indeed revolutionize solar and wind energy. Perovskite technology for solar energy promises significant improvement in the efficiency of solar cells, a breakthrough compared to silicon, which researchers have been working on for over half a century.

Perovskite is a new type of material used in solar cells that offers high transparency and solar absorption efficiency. This material increases electricity production at lower costs, making solar energy more accessible and competitive.

3D printing technology also plays a crucial role in solar and wind energy, allowing innovative designs of solar panels and wind turbines. This improves the efficiency and performance of energy installations and reduces production and installation costs.

Thus, advanced materials like perovskite and modern production technologies, including 3D printing, have the potential to fundamentally change the landscape of solar and wind energy, making them more efficient, accessible, and sustainable.

Additive manufacturing technologies indeed open up new possibilities for wind energy, especially in the field of wind turbine blade production. Creating preforms for 3D printing turbine blades significantly reduces financial and time costs, reducing manufacturing time from a year to several months.

3D printing of blades allows the use of new combinations of materials and embedded sensors to optimize costs and performance. This technology enables blades to be manufactured directly at the wind turbine installation site, eliminating logistical costs and risks associated with transporting finished blades over long distances.

Therefore, the application of additive manufacturing technologies in wind energy significantly simplifies the blade production process, making it more efficient, economically viable, and environmentally sustainable.

Renewable energy sources (RES) are competitive solutions in the electricity sector, possessing numerous advantages and ready for deployment. Political models anticipate their replication and adaptation to local conditions. With appropriate market conditions and policy foundations, RES can provide reliable electricity services, enhance energy security, and reduce harmful emissions and air pollution.

The advantages of using RES include:

1. Environmental Cleanliness: RES do not produce greenhouse gas emissions and other pollutants, thereby improving air quality and reducing negative environmental impacts.

2. Energy Security: Using RES reduces dependence on imported traditional energy sources like oil and gas, ensuring energy supply stability and reducing risks of energy instability.

3. Economic Benefits: RES offer long-term economic benefits by reducing fuel and maintenance costs, as well as creating new jobs in the manufacturing, installation, and maintenance of renewable energy equipment.

Thus, promoting RES contributes to reducing energy dependence, improving the environmental situation, and stimulating economic growth.

To stimulate the growth of renewable solutions, governments can adopt a range of measures to attract stakeholders and support renewable energy development. Here are several key steps:

- Setting Ambitious Global Goals: Establishing ambitious regional, national, and sector-specific goals provides clear direction and incentives for RES development.
- Creating Market Conditions: Facilitating confident investments in the sector and enabling large energy consumers to integrate RES into their decarbonization strategies.
- Accelerating Investments in Renewable Electricity: Developing new or strengthening existing RES policies for heating, cooling, and transport.
- Encouraging Sector Integration: Identifying and supporting synergy between electricity, heating, cooling, and transport sectors.
- Aligning Regional, National, and Subnational Policies: Coordinating regional, national, and subnational policies and supporting cities in their actions to develop RES.
- Adopting Comprehensive Policies: Implementing policies that simultaneously promote energy efficiency and facilitate the adoption of RES technologies.
- Supporting Job Creation: Supporting the creation of jobs and ensuring fair labor transitions during the shift to RES.
- Ensuring Public Recognition: Ensuring public recognition and increasing public interest in renewable energy development.

In conclusion, it is essential to emphasize the importance of developing and implementing alternative energy sources for Uzbekistan, highlighting several key aspects:

- Energy Security: Developing alternative energy sources will help reduce dependence on imported energy resources and increase the country's energy independence.
- Environmental Sustainability: Using clean energy sources contributes to reducing greenhouse gas emissions and minimizing environmental impact, crucial for maintaining ecological balance.

- Economic Efficiency: Implementing alternative energy sources can stimulate economic growth, create new jobs in the energy sector, and reduce expenditures on imported energy resources.
- Technological Progress: Developing alternative energy sources promotes innovative technological development and enhances the country's competitiveness in the global market.

Social Well-being: Establishing sustainable and accessible energy infrastructure contributes to improving the quality of life for the population and ensures equal opportunities for all societal groups.

III. CONCLUSION

Overall, the implementation of alternative energy sources is a strategically important step for Uzbekistan towards sustainable development and overcoming challenges related to climate change and the limited availability of traditional energy resources.

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CHALLENGES AND DEVELOPMENT OF THE INSURANCE MARKET IN ALBANIA ON THE POST PANDEMIC PERIOD

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Abstract - The insurance market in Albania has experienced substantial changes in recent years. This analysis focuses on the structure and performance of the insurance market in Albania, including the main product categories such as compulsory and voluntary insurance. One of the main challenges for the insurance market in Albania is the low level of penetration compared to European standards. Public awareness and promotion of insurance culture are important factors in improving this aspect.

The study also addresses legal changes and innovations in the market, including changes in the legal framework and insurance technology. This analysis is based on various sources, including FSA reports, financial data of insurance companies, and insurance market trends. Understanding these aspects provides a complete overview of the developments and challenges of the insurance market in Albania and brings a basis for the discussion on the growth opportunities of this sector in the future. The methodology provides a structured approach to investigate the challenges and development of the insurance market in Albania in the post-pandemic period. By combining data from various sources, the study aims to produce a comprehensive analysis that can inform policy recommendations and strategic decisions for stakeholders in the Albanian insurance industry.

The study revealed that the market demonstrated resilience despite initial disruptions, with a gradual recovery in premium volumes and a rebound in demand for various insurance products. The pandemic accelerated the adoption of digital technologies, leading to improved customer service, streamlined operations, and enhanced data management.

Keywords: insurance market, market trends, premium, compulsory insurance, voluntary insurance

1. Introduction

The insurance market in our country is a developing market compared to other countries in the region. The banking market and the insurance market are the only ones that make up the financial system in our country. Based on this and the fact that we are all market actors in the large insurance industry, I was motivated to address such a topic. People's lives and properties are threatened every day by multidimensional factors. The insurance market in Albania is considered the only market where prices are determined by the market and are not influenced by other factors. There are many factors that make the development of this market necessary, such as the increase in people's living standards, the economic development of the country, the current low level of economic income, the increase in natural hazards, etc. The main objective of this paper is to provide a complete overview of the developments and challenges of the insurance market in Albania and to provide a basis for discussion about the development opportunities of this sector in the future. Another objective is also to address legal changes and innovations in the market, including changes in the legal framework and insurance technology. Regarding the two objectives of the study, we have raised two research questions

that will highlight some of the challenges and developments of the current insurance market in our country, as well as what legal changes and technological innovations have occurred in the insurance market since its inception to date. By answering these research questions, we will be able to achieve the defined objectives of this work.

1. Literature review

The insurance market in Albania has experienced various phases of development and has faced multiple challenges, particularly from 2019 to 2023. This literature review synthesizes existing research and reports on the major challenges and developments in the Albanian insurance market, providing insights into regulatory issues, market penetration, economic factors, and consumer behaviour. Multiple studies report that insurance penetration in Albania remains low, estimated at around 1% of GDP. Factors contributing to this include economic constraints, cultural attitudes towards insurance, and a general lack of awareness and understanding of insurance products (INSTAT, 2022). The literature points out that the Albanian insurance market is heavily biased towards compulsory insurance products, especially motor insurance. Adoption of optional insurance products, such as life, health, and property insurance, has been slow. Researchers attribute this to limited consumer interest, lower purchasing power, and a lack of targeted marketing strategies by insurers (Gjika & Ruka, 2019). Economic studies note that fluctuations in the Albanian economy, including periods of slow growth and financial instability, have impacted the insurance sector. The COVID-19 pandemic significantly exacerbated these issues, leading to a decline in the demand for non-core insurance products (World Bank, 2021). The underdevelopment of the broader financial sector in Albania, characterized by low banking penetration and limited financial literacy, has hindered the development of the insurance market. Studies highlight that the limited availability and accessibility of financial services create significant barriers to market expansion (OECD, 2020). Several authors discuss the historical distrust in insurance providers among Albanian consumers. Past experiences of poor service delivery and delayed claims settlements have contributed to a lack of confidence in the insurance sector. Building consumer trust remains a significant challenge for the industry (Hoxha, 2020). Research emphasizes the low levels of financial literacy of the Albanian population, which hinders the understanding and adoption of insurance products. Efforts to educate the public about the benefits and operation of insurance are seen as critical to market growth (Bank of Albania, 2021).

The literature highlights a trend towards digital transformation within the Albanian insurance market. Insurers are increasingly investing in technology to streamline operations, improve customer service, and facilitate access to insurance products. Online platforms and mobile applications are becoming more prevalent, although their adoption is still in the early stages compared to more developed markets (KPMG, 2022). There is an increasing focus on diversifying insurance products to better meet market needs. Innovations like micro insurance aim to provide affordable coverage to low-income people. Researchers suggest that these innovations could significantly boost market penetration and consumer engagement if properly implemented and marketed (UNDP, 2021). The insurance sector in Albania has been actively involved in broader economic recovery efforts post-COVID-19. Insurers have adapted their products and services to address new risks and consumer needs arising from the pandemic, which has helped in partially restoring consumer confidence and stabilizing the market (IMF, 2022). There are significant efforts to promote financial inclusion by integrating insurance products into the financial lives of more Albanians. Collaborations with banks and microfinance institutions are noted in the literature as key strategies to make insurance more accessible and affordable to a wider population (EBRD, 2020).

Thus, the literature review indicates a significant need for further investigation of tools, mechanisms, and strategies for insurance market development.

2. Methodology

In order to thoroughly analyse the challenges and developments of the current insurance market in Albania, the following methodology was used. The study covers the period from 2019 to 2023, a timeframe chosen to provide a rigorous analysis of recent trends, regulatory changes, and market developments over the past

five years, including the impact of the COVID-19 pandemic too. Data sources selected for this study include: regulatory reports, industry publications, economic data, academic research, and market surveys. Regulatory reports include annual reports and publications from the Financial Supervisory Authority (FSA), which provide insights into regulatory changes, market statistics, and industry performance. Economic data comes from the Albanian Institute of Statistics (INSTAT) and international organizations such as the World Bank and the International Monetary Fund (IMF). Academic research consists of peer-reviewed journals and academic papers focusing on the Albanian insurance market and comparative studies with similar economies. Data sources were selected based on their relevance, reliability, and comprehensiveness. The criteria included relevance, focusing on sources directly related to the insurance market in Albania and its regulatory environment; reliability, giving preference to official publications, peer-reviewed journals, and reputable research firms to ensure data accuracy and credibility; and comprehensiveness, prioritizing sources that provided detailed information on market trends, regulatory changes, consumer behaviour, and technological innovations.

The methodology to be used will be consistent with the objectives set in this paper. Given that the basic objective of this paper is to provide a complete overview of the developments and challenges of the insurance market in Albania, as well as to bring valuable basic information for the discussion on the growth opportunities of this sector in the future, we have raised two research questions:

1. What are some of the challenges and developments of the current insurance market in our country?
2. What are some of the legal changes that have occurred in the insurance market since its inception and what are some of the technological innovations that have affected this market?

The data analysis process involved several key steps: data collection, data cleaning, descriptive analysis, comparative analysis, thematic analysis, and synthesis and interpretation. Data collection involved gathering relevant data from selected sources, ensuring a broad and comprehensive dataset. Descriptive analysis summarized the data to identify key trends, market dynamics, and regulatory changes. Thematic analysis identified recurring themes and patterns in the data related to challenges and developments in the market. Finally, synthesis and interpretation integrated findings from different sources to provide a coherent narrative on the current state and future prospects of the Albanian insurance market.

Findings of the study

In order to answer the questions about the challenges and the development of the insurance market in Albania during the post-pandemic period, the following findings emerged from the study. Insurance penetration in Albania remains low compared to other European countries. This is attributed to limited public awareness, distrust in financial institutions, and economic constraints. Despite improvements, there are still regulatory challenges, such as enforcement of regulations, transparency issues, and ensuring fair competition within the market. The Albanian insurance market lacks diversity in its product offerings, with a heavy focus on basic insurance products like motor and property insurance. This limits the market's growth potential and ability to meet diverse consumer needs. The adoption of advanced data analytics and technology in underwriting, claims processing, and customer service is still in its infancy, which hampers efficiency and customer satisfaction. Low levels of financial literacy among the population hinders the uptake of insurance products, as many people do not fully understand the benefits and importance of insurance. Insurance companies are developing digital platforms and mobile applications to facilitate the purchase and management of insurance policies online, improving accessibility and convenience for customers. There is interest in the potential of blockchain technology to improve transparency, security, and efficiency in claims processing and fraud prevention, although this is still in the experimental phase. A growing number of Insurance Tech startups are entering the market, offering innovative solutions such as peer-to-peer insurance, microinsurance, and customized insurance products. Insurance companies are starting to utilize big data and advanced analytics to gain insights into customer behaviour, improve risk assessment, and personalize insurance products.

3. Limitations of the study

One significant limitation in studying the challenges and development of the insurance market in Albania during the post-pandemic period is the lack of comprehensive and up-to-date data. Many reports and statistical analyses may not capture the full scope of changes and emerging trends, particularly in a rapidly evolving economic landscape. Additionally, the unpredictable nature of the global economy post-pandemic can result in fluctuating market conditions that are difficult to anticipate and model accurately. Furthermore, the unique socio-economic factors specific to Albania, such as regulatory changes and consumer behaviours shifts, may not be fully comparable to global or regional trends, thereby complicating the application of broader market insights.

4. History of the Insurance Market

The insurance market in Albania has come a long way and has experienced great changes since the beginning of its activity. Here are some key events and periods in the history of the insurance market in Albania:

4.1 Before World War II

Insurance in Albania started quite late compared to other developed countries and developed with its own characteristics and history. The Albanian doctrine speaks of the existence of insurance starting from the period before the Second World War, when in the 1930-1940s foreign insurance companies, mainly Italian, such as: Assicurazioni Generali, Riunione Adriatica di Sicurtá, Fiume, etc., helped the creation of the insurance market in Albania. Initially, their insurance activity was concentrated in the main cities of the country and included products such as: building insurance, industrial insurance, accident insurance, life insurance and natural disaster insurance.

4.2 After World War II and the Period of Communism

After the Second World War and during the communist period in Albania, the insurance sector was nationalized and joined the structures of the state administration. After the Second World War, with the establishment of the communist regime, the government nationalized industry, banks and all commercial capital in the country. This automatically affected the entire insurance system, thus reflecting the policies of the communist government in its structuring and construction. Starting from 1948 to 1965, new forms of insurance began to be recognized in Albania, such as: compulsory state housing insurance provided for rent; compulsory passenger insurance; voluntary insurance of property, buildings and real estate; voluntary life insurance; voluntary insurance of agricultural crops and livestock; voluntary catastrophe insurance; voluntary insurance of household goods; voluntary insurance of the property of former agricultural cooperatives, civic organizations and living beings; compulsory insurance of imported goods, ships; voluntary fire insurance of buildings, etc.
At that time in Albania there was only the State Institute of Savings and Insurance Funds, an institute which dealt with the collection of citizens' savings, the few savings they had, and the insurance of cooperatives and export-import enterprises.

4.3 Transition and Return of Private Companies

After the fall of the communist system in 1990 and the beginning of the transitional period, the establishment of private insurance companies was allowed. On July 31, 1991, the first two laws were approved for the creation of two financial institutions: Savings Bank, and Insurance Institute (INSIG), consequently splitting the State Institute of Savings and Insurance Banks. At this moment, Albania moved from a centralized economy to a free market economy, where private property and the principle of free

economic initiative prevailed. Thus, the insurance market would turn into the first major segment of the financial market that developed the fastest after Albania entered the free-market economy model in the last decade of the last century. In 1999, the first private insurance company in Albania "SIGMA" SH.A. was created, followed a few months later by the creation of the insurance company "SIGAL" S.A., currently the largest company in the insurance market in the country. Establishment of the Insurance Company "Sigma" LLC also marked the beginning of the process of liberalization of the insurance market in Albania, a market which has evolved over the years both in the range of products it offers and in the way it operates, contributing as one of the most powerful companies.

The insurance market is the largest and most advanced market of the non-banking financial sector. Companies operating in the insurance market, together with investment funds and private pension funds are under the direct supervision of the Financial Supervisory Authority (FSA), and not the Central Bank.

5. How is insurance divided in Albania?

The insurance market is an extremely important part of the financial system. It includes private and state companies that carry out the process of insurance for individuals or businesses. To benefit from this service, individuals and businesses pay premiums to protect themselves against a specific incident, and in case of an incident, they benefit from the beginning a certain amount from the contract with the insurance company. From a legal point of view, insurance is divided into: Mandatory Insurance and Voluntary Insurance.

5.1 Compulsory insurance is defined by a special law. Businesses that, with their activity, present a high risk to third parties, are obliged by law to provide mandatory insurance for damages they cause to third parties. In Albania, compulsory insurance before 1991 was applied to some types of property insurance, but not to third party liability insurance. In 1993, the compulsory third-party insurance of motor vehicle owners began.

- The importance of compulsory insurance

– Safe compensation of third-party damages
– The security it offers to the injured
– The avoidance of social conflicts between the parties (the injured party and the party responsible for the damage)

- Compulsory insurance in the transport sector

This insurance includes:
- Compulsory Civil Liability insurance of the owner of the motor vehicle for damages caused to third parties by the use of this vehicle.
- Insurance of passengers in public transport in the event of an accident.
- Ensuring the liability of aircraft owners for damage caused to third parties.
- Ensuring the liability of owners of small boats for damage caused to third parties.
– Compulsory Motor Vehicle Owners Third Party Liability (MTPL) Policy.
This policy is issued for vehicles with Albanian license plates, for a period of 1 year, valid for the territory of Albania.
– Border Insurance Policy.
This policy is issued for vehicles with foreign license plates, which entered the territory of Albania and do not have a Green Card or it does not cover Albania. The term of these policies is related to the duration of their stay in our country, but not less than 15 days.
– Green Card. This policy is issued for vehicles that travel outside the territory of Albania and the minimum term of their coverage is 15 days to 1 year.
- Mandatory Public Transport Passenger Insurance.
This policy is issued for public transport vehicles such as buses, minibuses, taxis, etc. with a term of 1 year.

5.2 Other Compulsory Insurance Policies
– Builder's Liability Insurance Policy

This policy has a term of 10 years and the beneficiaries are the buyers of the apartments, according to the sales contract, and third parties.
– Employee accident insurance policy
This policy is issued for 1 year.
– Liability Insurance Policy for Traders of Oil, Gas and Their Byproducts
This policy covers liability to third parties of oil and gas dealers, such as gas stations, oil and gas depots, stores selling them as well as lubricating oils, etc.
– Professional Liability Insurance Policy
This policy is issued for certain special professions such as notaries, bailiffs, construction experts and designers, insurance loss assessors, insurance brokers, etc., according to the special VKM.
Compulsory insurance consists of the payment of a compulsory contribution percentage by employed persons and self-employed persons, for whom compulsory social insurance protects the following categories with income:
• Persons employed in relation to:
* Temporary inability to work due to illness;
* Pregnancy;
* Old age, disability and loss of family's breadwinner;
* Accident at work and occupational diseases;
* Unemployment.
• Other economically active persons (employer and self-employed), in relation to:
* Pregnancy;
* Old age, disability and loss of the family's breadwinner.

Voluntary insurance is provided for in law no. 7703 dated 11.05.1993 "On Social Security in the Republic of Albania" and is offered to all Albanian citizens aged 18 and over. The following cannot be insured voluntarily: self-employed persons in agriculture, non-Albanian citizens, as well as those who have acquired the right to benefits. By paying dues, all concerned can cover the previous periods starting from 01.10.1993 onwards.

6. Legal Framework

The insurance as an industry plays a very important role in the economy and in the development of the non-financial market of developing countries, such as in the case of Albania. There has been a positive development trend of the insurance market in our country over the last few years, based on significant legal and regulatory advances, largely aligned with EU directives, as well as based on the strengthening of the role and independence of the Insurance Authority. Financial Supervisory Authority (FSA). The legal framework on insurance in Albania includes several laws and normative acts that regulate the insurance sector. These laws and normative acts define the rights and obligations of insurance companies, insurance agencies, and insured parties. The Insurance Council has a key role in overseeing and enforcing these laws to ensure that the insurance market operates fairly and transparently. FSA, as the regulatory body of the insurance market in Albania, has undertaken comprehensive reforms in recent years, strengthening the legal framework, as well as revising the laws and regulations in the insurance market, such as: Law No. 32/2021 "On Compulsory Insurance in the Transport Sector", which is partially aligned with directive 2009/103/EC of the European Parliament and the Council, dated September 16, 2009, "On civil liability insurance, in relation to the use of vehicles motor vehicle and the implementation of the obligation to ensure such responsibility". Law no. 52, dated 22.05.2014 "On insurance and reinsurance activity". This law regulates the creation, activity and supervision of insurance, reinsurance and mediation companies, in order for the insurance market to operate in a safe, stable and transparent environment, in defense of the rights and interests of the consumer. Progress has been driven by the goal of alignment with EU requirements, as well as by the recommendations left in the assessment made by the World Bank and the International Monetary Fund in 2013. There is a developed legal framework for licensing, other regulatory actions, as well as eligibility requirements.

There is a framework of requirements for good governance and risk management, including risks related to reinsurance. The effectiveness and quality of the Authority's supervision were proven during the recent earthquakes and during the Covid-19 pandemic, where the insurance industry performed well by not raising premium prices and meeting obligations without problems. In order to bring the legislation of the European Union closer to the insurance market, the Financial Supervisory Authority (FSA) is drafting some important changes in the insurance law and the objective is to approve them within this year. The current law "On insurance and reinsurance activity" will be amended to comply with Directive 2009/138 on the initiation and pursuit of insurance business or as it is known the Solvency 2 Directive. Among the main innovations that the new law is expected to bring is the application of a different standard in capital requirements for insurance companies. Capital requirements will not be fixed, but variable, increasing according to the risk taken by each insurance company. However, the full implementation of the new legal requirements that will be based on the Solvency 2 directive is expected to be a gradual and time-consuming process. The objective is to achieve full implementation within a 7-year timeframe. According to the AMF, the new law is also expected to bring new qualitative requirements regarding the standards of corporate governance. Another innovation will be consolidated reporting at the level of business groups. For insurance companies operating with their subsidiaries in markets that are supervised by the Bank of Albania (banking, microfinance, or payment market), consolidated supervision will be pursued, in cooperation with the central bank.

7. Low Penetration in the Insurance Market

Albania is one of the countries with the lowest level of insurance penetration. Compared to the Gross Domestic Product, this figure is calculated at 0.64%. According to the Financial Supervisory Authority, there are several arguments, according to which they have not encouraged market development, such as: the general economic environment, especially the level of income per capita of the population; tax treatment of insurance products; the unconsolidated market for insurance products, especially by individuals; the relatively low level of development of the financial sector, in particular the credit and bond markets; non-consistent implementation of legal regulations for liability insurance products, relatively unconsolidated consumer trust in operators, etc. There is a strong correlation between increasing welfare levels and increasing insurance market penetration. The unfavorable tax treatment of insurance products, even at a disadvantage with banking products, constitutes another inhibiting factor. On the other hand, there is a significant relationship between the progress of lending in the country and the increase in the volume of activity of insurers. Consequently, any curb on lending has an immediate impact on the insurance market penetration rate. Moreover, the bond market remains underdeveloped and limits the possibilities for increasing the range of insurance products. Last, but not least, the Albanian legislation has provided for a series of products for liability insurance, but which have not been implemented in practice, thus limiting the opportunities for increasing the types of products in the market.

8. Developments of the Compulsory Insurance Market in Albania, 2019-2023

Comparing the data published by the Financial Supervisory Authority from time to time, not only every year, but also every 3 to 6 months, the insurance market in Albania, as a very important financial market, is showing consolidation. The year 2023, compared to the year 2022, actually has an upward trajectory.
Compulsory auto insurance premiums during 2023 reached about ALL 13,980 million, or 6.94% more than in 2022. The domestic MTPL product, in 2023, had an increase of 8.20% in the volume of gross written premiums. This was also accompanied by an increase in the number of contracts of 9.21% compared to the same period of the previous year. The Green Card product in 2023 had an increase of 1.16% in the volume of gross written premiums. This was accompanied by an increase in the number of contracts of 38.10% compared to 2022. The Border Insurance product, in 2023, had a 1.11% increase in the volume of gross written premiums compared to 2022. The number of contracts also increased by 11.58%.

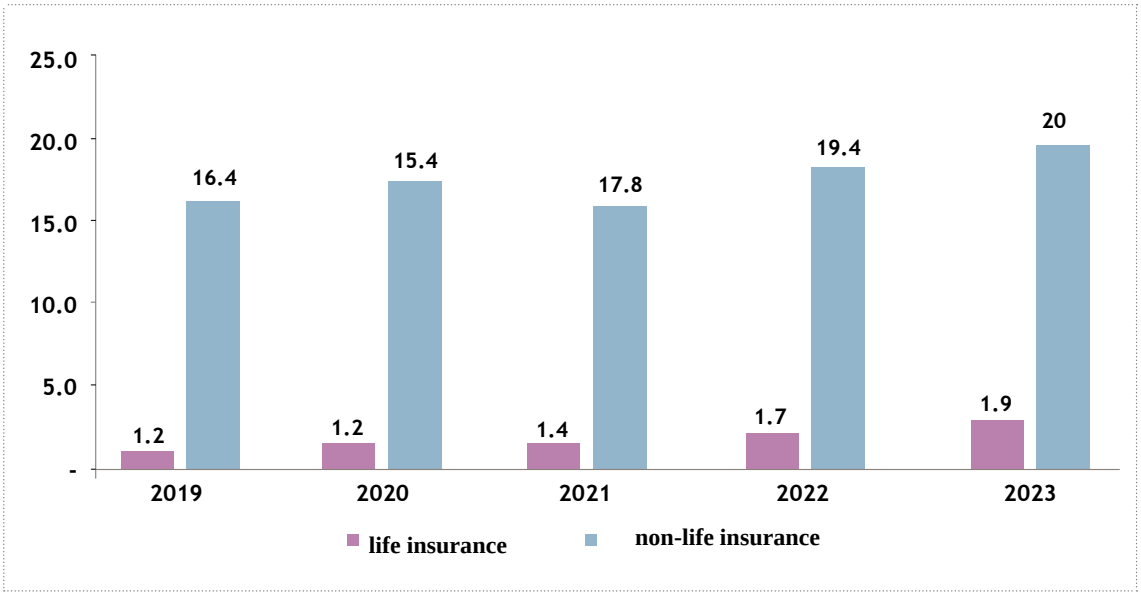
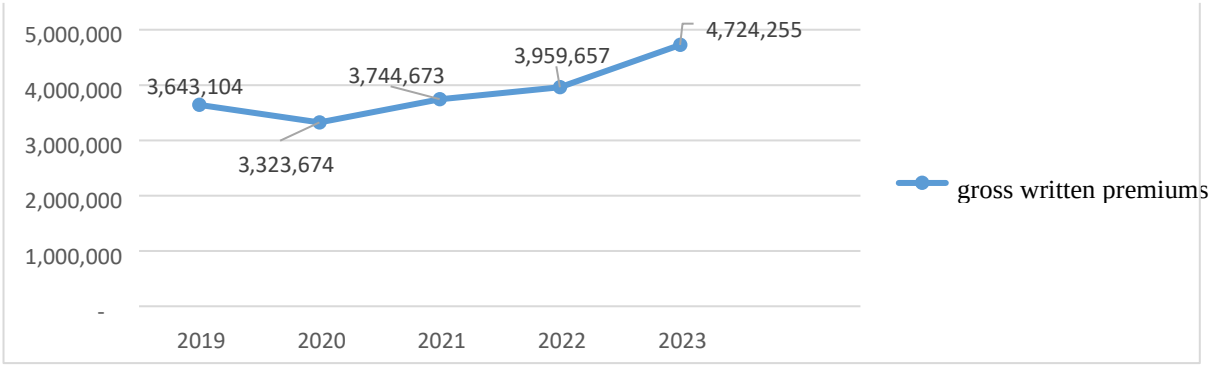


Chart 1: Progress of the gross written premium in years *(In billion ALL)*

Referring to the period of 2019-2023 according to chart 2, the trend of premiums results in a decrease in 2020 where it marks the lowest value and starts to rise gradually, marking the highest value in January-March 2023.



Source: AMF

Chart 2: The performance of gross written premiums in the insurance market (thousand ALL)

The market continues to be dominated by the compulsory motor insurance class owning 62.15% of the total gross written premiums, followed by about 17.11% by property insurance while the rest is divided between the other classes. Refer to chart 3, where the ratio of voluntary to mandatory insurances for the period January-March is presented, the proportion of voluntary insurances to total insurances is greater in the period January-March of 2023 with 41.86% and lower in 2019 with 36.73%. For the reporting period, the ratio is 41.86% to 58.14%.

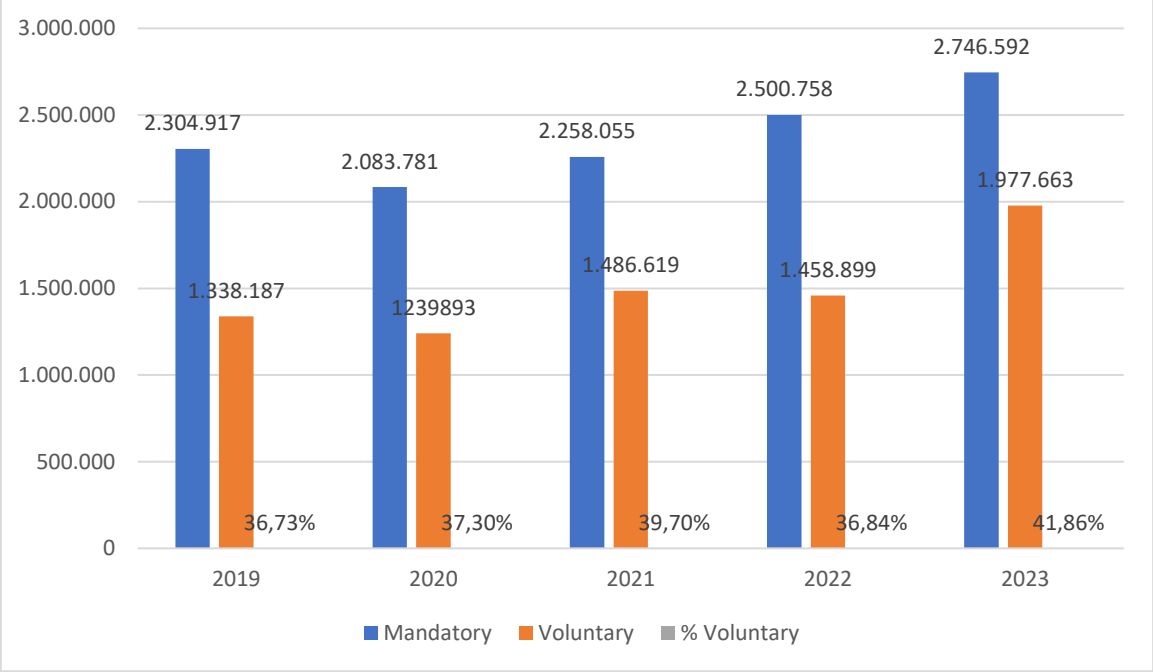
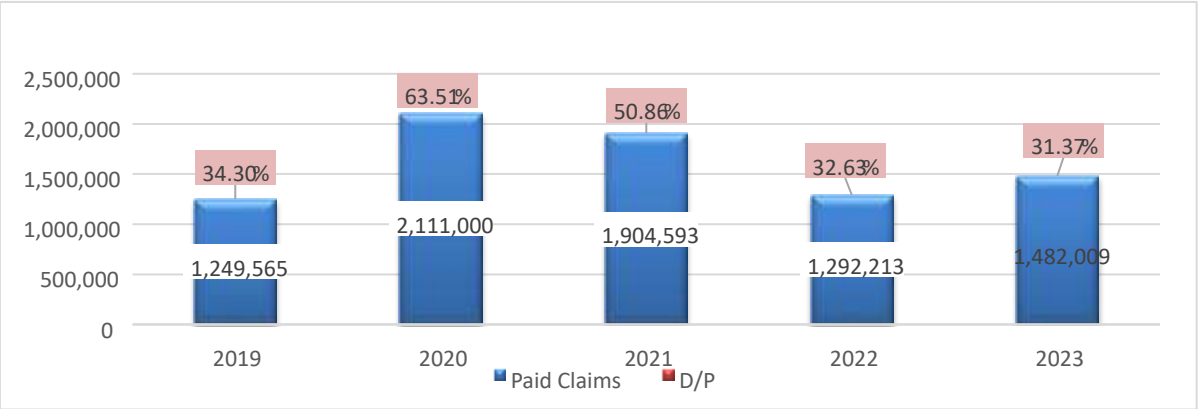


Chart 3: Voluntary/total ratio for the period 2019-2023 (thousand ALL)

Referring to mandatory motor insurance, compared to the same period a year ago, they all resulted in an increase, such as TPL insurance (+9.38%), border insurance (+5.66%), and green card (+12.91%). The number of contracts concluded for non-life insurance during the months of January-March 2023 is 254,948 contracts, marking an increase of 17.21% more than a year ago. The class of voluntary motor insurance and marine, aviation and transport are the only classes with a decrease in the number of contracts signed, respectively -5.32% and -7.14%, while the rest shows an increase, where the largest increase is maintained by the class of insurance credit.

Damages paid by the activity of No Life

During the period January-March 2023, from the non-life insurance activity, 1,482,009 thousand ALL claims were paid, marking an increase of 14.69% or 189,796 thousand ALL payments more compared to the period January-March 2022, and this is accompanied by a decrease in the number of cases of 1.50% or 203 cases less.



Source: AMF

Chart 4: Progress of claims paid by the market, 2019-2023 (thousand ALL)

According to chart 4, the highest value of damages paid is in the months of January-March of 2020 for the entire period of 2019-2023. During the months of January-March 2023, while the value of paid damages increases, the number of paid damages decreases, suffering a modest decrease of 1.50% or 203 fewer paid damages.
Most of the claims paid come from the type of motor insurance about 77.96% of the total, followed by property with 9.93%, accidents with 8.78% and Other with 3.33%

There are currently eight non-life insurance companies and four life insurance companies operating in the Albanian market. According to data from the AMF, at the end of the 9th month of 2023, the total assets of the market had the value of 46.7 billion ALL. Since the beginning of the year, the size of the insurance market has increased by 7.2%. The share capital of the market reached a total value of 15.4 billion lek or about 145 million euros. The performance of the market, measured by the value of gross written premiums, was also positive during 2023. For the 11th month of 2023, gross written premiums reached the value of ALL 20.5 billion, an increase of 8.4% compared to the corresponding period last year. The growth of the tourism sector had an indirect positive effect on the insurance market, but on the other hand, the strengthening of the Lek in the exchange rate has negatively affected the growth of the market, for the segment of products that are quoted in foreign currency. The net profit of the market reached the value of 2.6 billion lek, an increase of 54% compared to the same period of the previous year. If we compare it with neighboring countries, we see that Albania is the country that spends less on insurance. If our neighboring country Greece spends 2.24% of GDP on insurance, or Italy 6.27%, Germany 6.24%, Great Britain 11.44% and USA 12.15%, our country spends only 1% of its GDP. In recent years, insurance companies are trying to improve claims handling procedures and avoid, where possible, litigation. Although the numbers are increasing year after year, Albania continues to remain the last in the region and Europe in terms of insurance density. This is due to an inherited mentality and a lack of financial education.

9. Insurance Market Challenges

The insurance market has consolidated and matured during the challenging period that included earthquakes, pandemics and high inflation in recent years. Human resources are well trained and able to provide high quality services, as well as to deal with the new challenges that this market faces. However, this market is not showing significant qualitative developments, remaining small in size and mainly focused on mandatory products. In recent years, companies are trying to follow digitization trends and have built online product sales channels. However, compulsory motor insurance policies are still required in the form of a physical document and cannot be issued electronically. One of the main challenges of the poor development of voluntary products is the lack of insurance culture in Albania. In order to further develop the insurance market, more cooperation with institutions is required. Insurance companies must work to change the structure of premiums, which until now is dominated by compulsory insurance. However, the market needs an even greater focus on digitalization of services as well as technological development, to be close to customers in real time. Climate change and its negative effects, especially in the agricultural sector, necessitate a national insurance system for better risk diversification. It is necessary to have serious discussions with all stakeholders on this issue, as these insurances protect operators from unforeseen events and guarantee business continuity.

10. Conclusions

The insurance market in Albania plays a critical role in promoting economic growth and stability by providing risk management solutions, facilitating trade and investment, and encouraging savings. A well-developed insurance market contributes to the overall growth of the financial sector, promoting financial inclusion and the development of other financial services. Efforts to align Albanian insurance regulations with EU standards have led to a stronger regulatory framework, increasing investor confidence and market stability. However, the market faces significant challenges.

Future research should focus on understanding consumer behaviour, leveraging digital transformation, evaluating regulatory impacts, and exploring innovative insurance products and practices. Albanian insurance market has significant potential for growth and development, contributing to economic stability and social welfare. However, addressing the challenges of market penetration, regulatory frameworks, product diversification, and technological adoption is crucial. Through targeted research and strategic development, the Albanian insurance market can achieve greater efficiency, inclusivity, and resilience.

The establishment of the Financial Supervisory Authority (FSA) has been a significant step in regulating and overseeing the insurance market in Albania. Albania has been working to align its insurance regulations with EU directives, such as Solvency II, which focuses on the solvency and risk management of insurance companies. Legal changes have focused on aligning with EU standards, introducing compulsory insurance, and enhancing consumer protection. Technological innovations, though still emerging, are beginning to transform the market through digital platforms, automated underwriting, telematics, blockchain, Insurance Tech startups, and big data analytics. Addressing these challenges and continuing to embrace technological advancements will be crucial for the future growth and stability of the Albanian insurance market.

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SOLAR ENERGY POTENTIAL OF KARAMAN, ŞANLIURFA AND MERSİN PROVINCES LOCATED IN DIFFERENT REGIONS IN TURKEY

MUSTAFA ORUÇ ATALAY, Fikret AKINERDEM

Mühendislik Bilimleri Anabilim Dalı, Karamanoğlu Mehmetbey Üniversitesi

Abstract: We can understand that increasing the level of development of a country in the world by its energy consumption. In countries, the regions with the highest energy consumption are the regions with industrial activities. Fossil fuels are gradually increasing in price for energy needs, on the other hands at risk of extinction in industrial areas. Due to its geographical location, Türkiye has high solar energy potential for high-consumption facilities looking for more economical ways.

The use of renewable energy has become essential in Turkey due to the environmental pollution caused by the use of fossil resources. In Solar Power Plant applications, which are just developing in our country, Turkey's electrical energy consumption will increase by 7.7% compared to the previous year, reaching 329.6 billion kWh in 2021, and electricity production will increase by 8.1% compared to the previous year, reaching 331.5 billion kWh. has been realised. Türkiye is late for renewable energy sources. However, with rapid and high-capital investments, the deficiencies have been eliminated in recent years, and although the annual average sun duration in many countries is less than the annual average solar duration in our country, investments in solar energy, which is a renewable energy, are gradually increasing. In this context, it is very important to determine the solar energy potential of our provinces in different regions of our country and to meet our country's energy needs from solar energy, which is a renewable energy source, as it will gradually reduce foreign dependency and further increase the economic welfare level of our country.

Keywords: Solar Energy, Renewable Energy

GİRİŞ

Enerji canlılar için mutlak bir ihtiyaçtır. Bu bakımdan canlılığın başlangıcı enerjiyle olduğu gibi devamı da büyük oranda enerjiye bağlıdır. Zira gıda da bir enerjidir. Enerji genel anlamda yenilenemez (fosil) ve yenilenebilir (fosil olmayan) kaynaklardan olarak iki gruptan elde edilir.

Dünya'da enerji ihtiyacı büyük oranda, halen tükenme riski yüksek olan yenilenemez enerji kaynaklarından karşılanmaktadır. Bu yakıtların kullanımı çevresel kirliliklerin yanı sıra aynı zamanda insan sağlığı üzerinde de olumsuz etkilere neden olmaktadır.

Bu yüzden ülkeler yenilenebilir enerji kaynaklarına yönelmektedir. Yenilenebilir enerji kaynaklarının zaman içerisinde daha fazla önemsenmeye başlamasıyla devlet yöneticileri de bu sektörde iş yapan veya kullanmak isteyen kurumlara lisans vermeye başlamış ve belirli kurallar ve anlaşmalar çerçevesinde izin vermiştir.

Yenilenebilir kaynaklar bünyesinde bulunan güneş enerjisi oldukça minimal karbondioksit, kükürt, gaz ve radyasyona sahip olup çevreci bir enerji kaynadır. Günümüz teknolojisiyle günden güne enerji verimliliği artan güneş enerjisinin doğru politika ile hem enerji arz güvenliğine, fosil yakıtlardan kaynaklanan enerjide dışa bağımlılığın azalmasına hem de kurulacak olan Güneş enerji santrallerin de çalışacak personeller için istihdam sağlaması yönünde pozitif etkide bulunacaktır.

Ülkemizdeki Güneş enerji potansiyelini göz önünde bulundurduğumuzda yadsınamayacak kadar önemli ve göz önünde bulundurulması gereken bir enerji kaynağı olduğunu görüyoruz. Öyle ki Türkiye Cumhuriyeti'nin coğrafi büyüklüğünü, yıllık güneş alma süresini, radyasyon miktarını düşündüğümüzde halen yapılan güneş enerji çalışmalarının emekleme aşamasında olduğunu anlayabiliriz.

Yenilenebilir alanda güneş enerjisinin daha da yaygınlaşabilmesi için izlenen ve bu konuda atılan politik adımlar oldukça önemlidir. Özellikle güneş enerji santrallerinin ekonomik olarak faaliyete geçirilmesi zordur. Kullanılan malzemelerin üretimi malzemelerin üretimi ve yapılan ikili anlaşmalar genellikle ekonomik faktörlerden askıya alınmakta yahut ertelenmektedir. Bu konuda yatırımcıya ya da yatırımcı ile anlaşma yapan yüklenici firmalara kolaylıklar sağlanmalıdır. Yatırımcı firmaya teşvikler, KDV indirimleri yüklenici firmaya ise proje başvuru ve çağrı mektubu kolaylıkları sağlanıp daha hızlı bir aksiyon alınabilmesi için kolaylıklar sağlanmalıdır. Gelinen bu noktada dikkat edilmesi gereken bir diğer önemli konu ise bu yapılan projelerin önemli ölçüde devlet ve bağımsız denetmen firmalar ile birlikte denetimler yapılarak projelerin incelenmesidir.

Birçok kurulan güneş enerji santralleri 5-10 yıl içerisinde denetim eksikliğinden kaynaklı enerji üretimi konusunda oldukça verimsizleşmekte ve kurulan arazi ya da fabrika çatılarına yangın gibi tehlikelere yol açmaktadır.

Yine dikkat edilmesi gereken bir diğer önemli konu güneş enerji santrallerinin kurulması planlanan arazilerdir. Özellikle Türkiye coğrafyasında ülkemizin çok kıymetli olan toprak alanlarının korunması açısından çok önemlidir.

Bu alanlar şöyle sıralanabilir:

• Kıymetli tarım arazileri, bitki ve orman alanları veya bu arazilere yakın alanlar,

• Göller, nehirler, baraj gölleri ile sulak alanlar,

• Koru ormanları, ağaçlandırma alanları, özel ormanlar, fidanlıklar, sazlık ve bataklıklar, muhafaza ormanları gibi alanlara özenle dikkat edilmeli ve bunların korunması için gerekli her türlü tedbir alınmalıdır.

Türkiye'de enerji üretimi ve kullanımında ilk olarak, ulusal ve uluslararası hukuki düzenlemelerin yeniden yapılanması, enerji üretimi, enerji alanındaki teknolojik çalışmalar ve kaynak seçiminde çevresel etkileri dikkate alarak (tarım alanlarının, arkeolojik ve tarihi yapı alanlarının korunmasında da daha dikkatli olunarak) enerji üretim sahalarının ekonomiye kazandırılması ve enerji kullanımında verimliliğe daha fazla dikkatte alınması gerekmektedir. Bu nedenle, küresel ölçekte çevre kirliliğine ve iklim değişikliğine sebep olan klasik fosil yakıt kaynaklı enerji üretim sistemleri ve geleneksel üretim teknolojileri yerine, çevreci, sürdürülebilir yenilenebilir enerji kaynakların değerlendirilmesi ve bunlara ait teknolojilerin geliştirilmesi gerekmektedir.

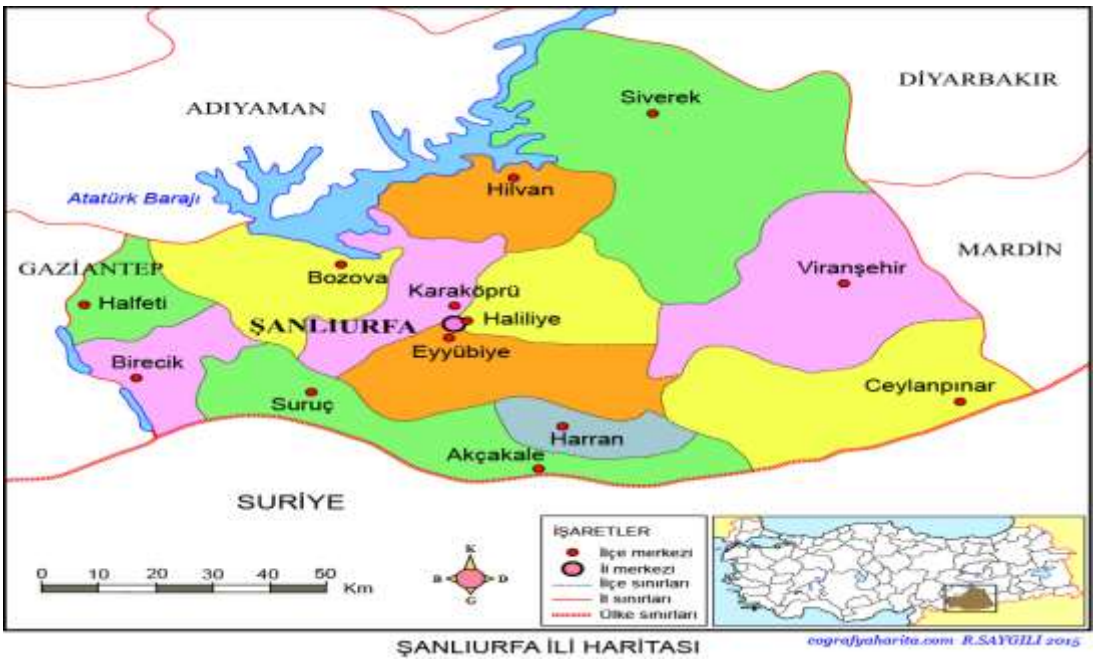
Ülkemiz yenilenebilir enerji kaynakları bakımından Avrupa'da öncü olabilecek kadar iyi bir duruma sahiptir. Yapılacak yeni kanuni düzenlemeler, çalışmalar ve yatırımlarla, bu yüksek potansiyellerdeki kendi yerel kaynaklarımızı, teknolojimizi ve teknik kadrolarımızı hayata geçirerek ve bilinçlenmeyi artırarak enerjide önemli adımlar atılmalıdır.

Ülkemizde enerji ve döviz tasarrufu yapılmalıdır. Türkiye enerji verimliliğini artırma yönünden en az %25 gibi oldukça yüksek bir potansiyele sahiptir ve bu potansiyelin en iyi şekilde ve hızla değerlendirilmesi gerekmektedir.

1. KARAMAN, ŞANLIURFA VE MERSİN İLLERİNİN GÜNEŞ ENERJİSİ POTANSİYELLERİ

1.1 Şanlıurfa İlinin Güneş Enerjisi Potansiyeli

Şanlıurfa ilimiz, 19.451 KM^2'lik yüz ölçümü ile ülkemizin en büyük 7. ilidir. Yükselti bakımından ortalama olarak 518 Metre olan Şanlıurfa; Suriye, Adıyaman, Mardin, Gaziantep ve Diyarbakır illeri ile komşudur. İlimiz 13 adet içleye sahiptir.



Şekil 4.1 Şanlıurfa İl Haritasısı

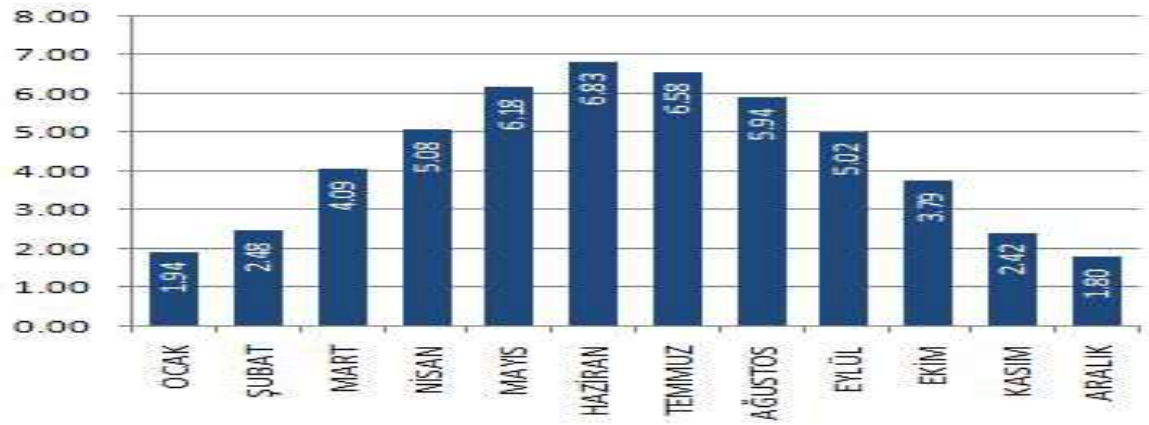
Şanlıurfa'da hem yenilenebilir hem de yenilenemez enerji kaynakları bulunmaktadır. Yalankoz, Bozova, Doğu Beşikli ve Çaylarbaşı mevkilerinde ham petrol alanları bulunmaktadır. Şehrin sınırları içerisinde bir petrol rafinerisi bulunmamakla birlikte kömür rezervi ve doğalgaz arama faaliyeti mevcut değildir (Değerleri nereden aldın bunları kaydet)

Senelik ortalama olarak 226.500 varil petrol üretilmektedir. (BOYACI, M. Z. 2023)

Şanlıurfa ilinin Güneş Enerjisi potansiyeli açısından değerleri ülkemiz ortalamasının üzerindedir. Şanlıurfa ilinin sıcaklık değerleri bölgede karasal iklim hâkim olmasına rağmen diğer illere (Mersin ve Karaman) kıyasla ortalama 2 derece daha sıcaktır.

Şekil 4.2 Şanlıurfa İlinin Güneş Radrasyon Haritası

Şekil 4.2 de de görüldüğü gibi Şanlıurfa iline ait ilçelerde güneş enerjisinin en yoğun olduğu alan 1650-1700 KWh'm^2/yıl ile Siverek ve Viranşehir ilçelerinin Kuzey-Doğu bölgeleridir. En düşük 1550-1600 KWh'm^2/yıl ile merkezi güneyi ile Ceylanpınar'ın kuzey tarafında bulunmaktadır.



Şekil 4.3 Şanlıurfa Aylara Göre Radyasyon Haritası

Şekil 4.3'te de görüldüğü üzere Şanlıurfa ilinde ocak ve şubat ayından itibaren haziran ayına kadar artan bir radyasyon grafiği vardır. 2 KWh'm^2/ay ile yaklaşık 7 KWh'm^2/ay arasındadır. Temmuz ayı ile birlikte aralık ayına kadar radyasyon miktarı giderek azalarak yaklaşık 6 KWh'm^2/ay ile yaklaşık 2 KWh'm^2/ay değerlerine düşmektedir.

Şekil 4.4 Şanlıurfa Güneşlenme Süreleri

Şekil 4.4'te de belirtildiği üzere ocak ayından temmuz ayına kadar güneşlenme süresi Şanlıurfa ilinde artarken değerler yaklaşık olarak 4,68 saat/ay ile 12.42 saat/ay arasındadır. Ağustos ayı ile birlikte aralık ayına kadar güneşlenme süresi azalmakta ve 11,26 saat/ay ile 4.40 saat/ay aralığındadır.

Tablo 4.1 İşletmedeki Güneş Santralleri

İşletmedeki Güneş Santralleri			
Santral Adı	**İlçe**	**Firma**	**Güç**
Astor Enerji Bozova GES	Bozova	Astor Enerji	8,97 MW
TİGEM Ceylanpınar GES	Ceylanpınar	TİGEM	6,00 MW
Odaş Şanlıurfa Güneş Enerji Santrali		Odaş Enerji	0,25 MW
ŞUTSO Güneş Enerji Santrali		ŞUTSO	0,10 MW
Şanlıurfa'daki diğer lisanssız GES'ler		Çeşitli Firmalar	436 MW
ÖZET: Şanlıurfa İli İşletmedeki Güneş Santralleri: 5 santral, 451 MWe			

Tablo 4.2 Yapım Aşamasındaki Güneş Santralleri

Yapım Aşamasındaki Güneş Santralleri			
Santral Adı	**İlçe**	**Firma**	**Güç**
Hitit Enerji Güneş Enerji Santrali	Viranşehir	Hitit Enerji	20 MW
Hilvan Güneş Enerji Santrali	Hilvan	Hilvan Enerji	20 MW
Catic Group Bozova Güneş Enerji Santrali	Bozova	Catic Group	6,00 MW

ÖZET: Şanlıurfa İli Yapım Aşamasındaki Güneş Santralleri: 3 santral, 46 MWe

Tablo 4.3 Üretim Lisansı Alınan Güneş Santralleri

Santral Adı	İlçe	Firma	Güç
G4 Viranşehir-5 GES	Viranşehir	Kalyon Holding	50 MW
G4 Viranşehir-7 GES	Viranşehir	Kalyon Holding	50 MW
G4 Viranşehir-8 GES	Viranşehir	Kalyon Holding	50 MW

ÖZET: Şanlıurfa İli Üretim Lisansı Alınan Güneş Santralleri : 3 santral, 150 MWe

Tablo 4.4 Ön Lisans Alan Güneş Santralleri

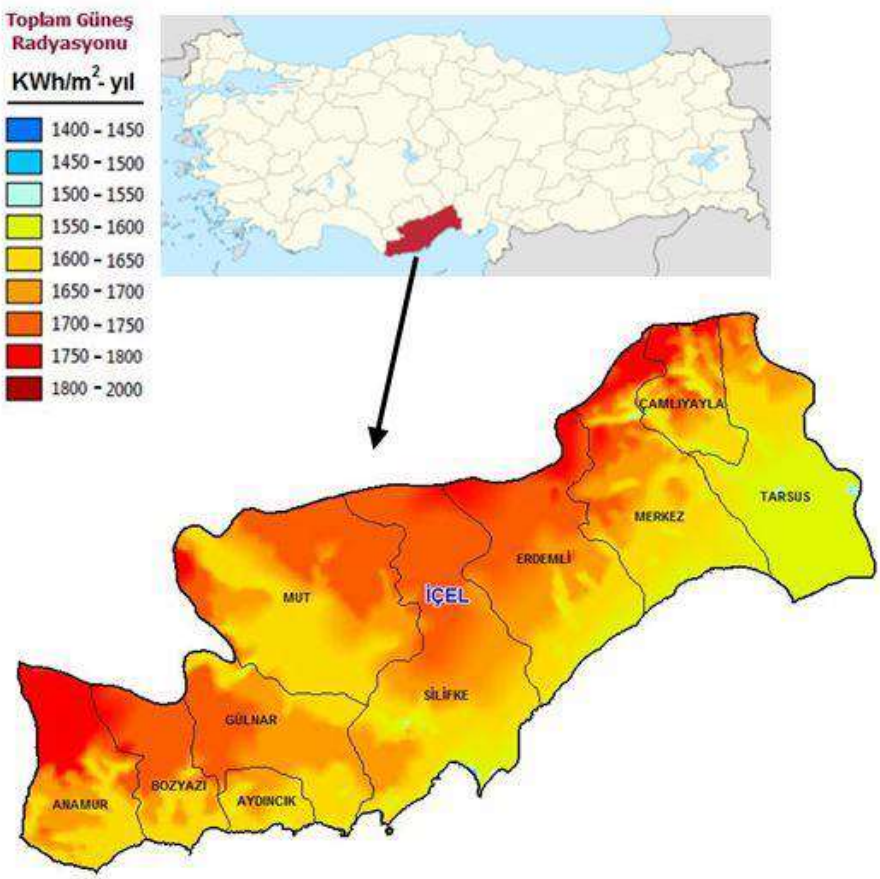
Ön Lisans Alan Güneş Santralleri			
Santral Adı	**İlçe**	**Firma**	**Güç**
Keberli GES	Eyyübiye	Sarı Perakende Enerji	200 MW
Atlantis 2 GES	Halfeti	Sarı Perakende Enerji	200 MW
Süel GES	Viranşehir	Kalyon Holding	200 MW
Karınca GES	Viranşehir	Kalen Elektrik	100 MW
Toprak GES	Viranşehir	Kalen Elektrik	100 MW
Bildim GES	Eyyübiye	Adis Elektrik	100 MW
Gölcük GES	Viranşehir	Kalen Elektrik	65 MW
G4 Viranşehir-2 GES	Viranşehir	Eksim Enerji	50 MW
G4 Viranşehir-6 GES	Viranşehir	Eksim Enerji	50 MW
G4 Viranşehir-10 GES	Viranşehir	Eksim Enerji	50 MW
G4 Viranşehir-1 GES	Viranşehir	AMR Enerji	50 MW
G4 Viranşehir-3 GES	Viranşehir	Reşitoğlu Enerji	50 MW

Ön Lisans Alan Güneş Santralleri			
Santral Adı	**İlçe**	**Firma**	**Güç**
G4 Viranşehir-9 GES	Viranşehir	Ral Enerji	50 MW
G4 Viranşehir-4 GES	Viranşehir	Ral Enerji	50 MW
Karakaş GES	Bozova	Viva 6 Enerji	33 MW
Çağa GES 1	Siverek	Smart Güneş	20 MW
Kırbaşı GES	Hilvan	Apricus Enerji	13 MW
ÖZET: Şanlıurfa İli Ön Lisans Alan Güneş Santralleri : 17 santral, 1.381 MWe			

Genel olarak bakıldığında Şanlıurfa ili, GES açısından büyük bir potansiyele sahiptir. Radyasyon ortalamasının Türkiye ortalaması üzerinde olması sebebi ile gelişmiş ve daha da gelişecek bir potansiyel mevcuttur.

2.2 Mersin İlinin Güneş Enerjisi Potansiyeli

Mersin ilimiz; ülkemizin güneyinde bulunan bir liman kentidir. 13 ilçeye sahip olan Mersin, sıcak ve ılıman astropikal iklime sahiptir. Yaz aylarında oldukça sıcak ve nemli, kışları ise ılık ve yağışlıdır. Mersin ilinin uzun yıllar içinde alınan sıcaklık ortalamasına bakıldığında Avrupa ve ülkemizin en sıcak kesimi olduğu görülmektedir.



Şekil 4.5 Mersin İli Radyasyon Haritası

Şekil 4.5'te de görüldüğü üzere Mersin iline ait ilçelerde güneş enerjisinin en yoğun olduğu alan 1800-2000 KWh'm^2/yıl ile Anamur, Bozyazı, Çamlıyayla ilçelerinin kuzey ve kuzey batı kesimleridir. En düşük 1550-1600 KWh'm^2/yıl ile Tarsus, Mersin merkez ilçelerinin güney ve güney doğu kesimleridir.

Tablo 4.5 İşletmedeki Güneş Santralleri

İşletmedeki Güneş Santralleri			
Santral Adı	**İlçe**	**Firma**	**Güç**
Kıvanç 2 GES	Gülnar	Kıvanç Enerji	35 MW
Sertavul RES Hibrit GES	Mut	Sertavul RES	28 MW
Şişecam Mersin Güneş Enerji Santrali		Şişecam Topluluğu	6,00 MW
Borusan EnBW Dayıcık Güneş Enerji Santrali	Gülnar	Borusan EnBW Enerji	6,00 MW
Gülnar Güneş Enerji Santrali	Gülnar		5,75 MW
Mersin Gülnar Güneş Enerji Santrali	Gülnar	T Dinamik Enerji	5,53 MW
Nar Solar Enerji GES	Gülnar	Nar Solar Enerji	5,00 MW
Tiryaki Agro Mersin Çatı Üzeri GES	Akdeniz	Tiryaki Agro Gıda	4,00 MW

İşletmedeki Güneş Santralleri			
Santral Adı	**İlçe**	**Firma**	**Güç**
Göl, Hörç ve Akova Tuluk GES	Silifke		3,00 MW
Yayla Agro Gıda GES		Yayla Agro Gıda	1,00 MW
Özipek GES			1,00 MW
Cemile Bingül Güneş Enerji Santrali	Erdemli	Cemile Bingül	1,00 MW
Ah-Fer GES	Gülnar		0,97 MW
Eren Tarım Güneş Enerjisi Santrali		Eren Tarım	0,48 MW
Opat Otomotiv Mersin Güneş Enerji Santrali	Mezitli	Opat Otomotiv	0,15 MW
Büyükeceli Camii	Akkuyu	Büyükeceli Camii	0,003 MW
Mersin'deki diğer lisanssız GES'ler		Çeşitli Firmalar	232 MW
ÖZET: Mersin İli İşletmedeki Güneş Santralleri: 17 santral, 335 MWe			

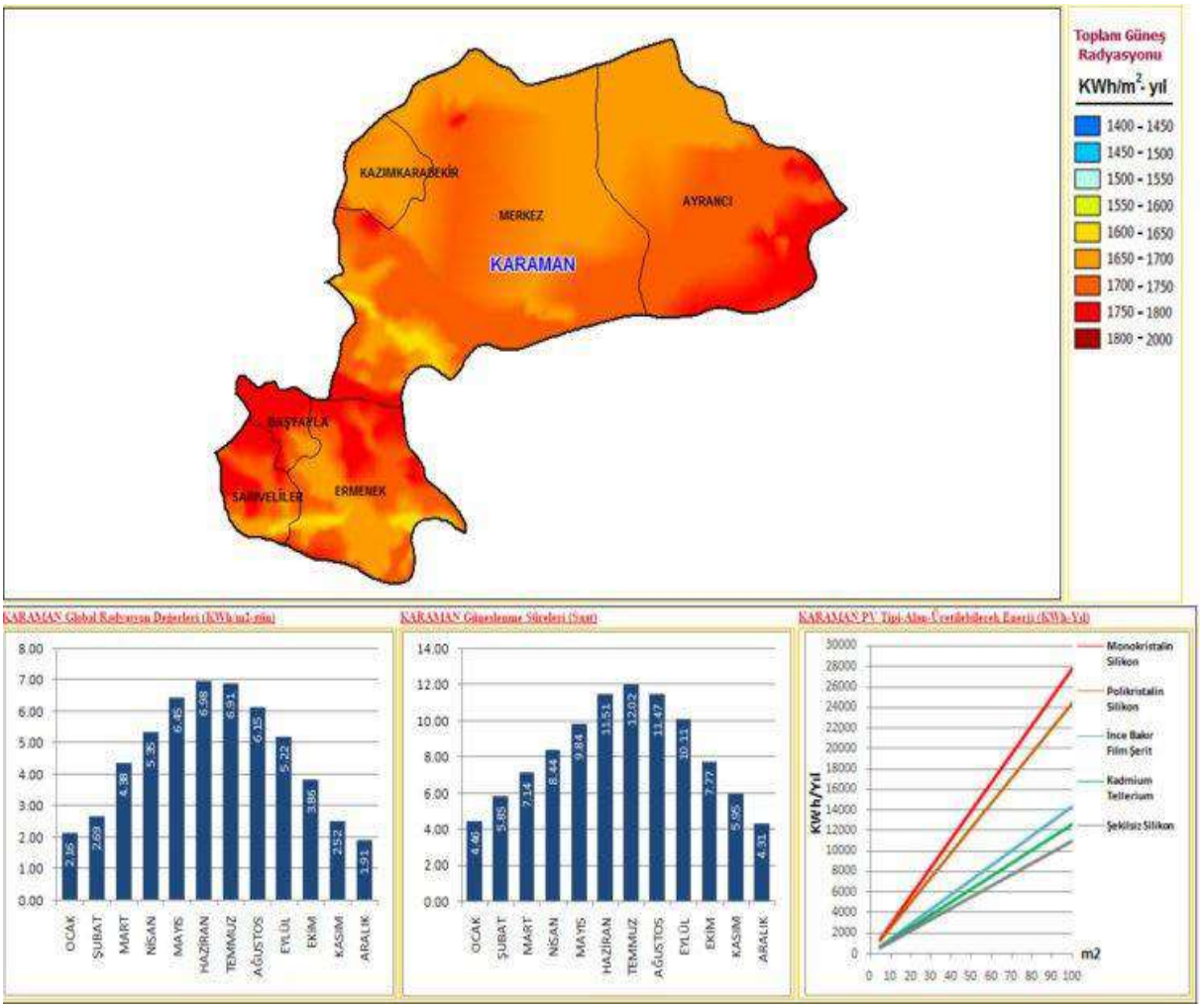
Tablo 4.6 Yapım Aşamasındaki Güneş Santralleri

Yapım Aşamasındaki Güneş Santralleri			
Santral Adı	**İlçe**	**Firma**	**Güç**
Tarsus Kapalı Pazaryerleri Güneş Enerji Santrali	Tarsus	Tarsus Belediyesi	3,50 MW
ÖZET: Mersin İli Yapım Aşamasındaki Güneş Santralleri: 1 santral, 3,50 MWe			

Mersin ilimizin güneş ışını alma ortalamasına ve radrasyon ortalamasına bakıldığında dağlık bir bölge olması sebebi ile hedeflenen GES potansiyeline henüz sahip değildir.

3.3 Karaman İlinin Güneş Enerji Potansiyeli

İç Anadolu Bölgesinde bulunan Karaman ilimiz; 1989 yılında Konya'dan ayrılarak il olmuştur. Farklı bölgelerinde farklı iklimler görülmektedir. Merkezi bölgelerde ılıman bir karasal iklim görülürken, güneye bakan bölgelerinde Akdeniz iklimi görülmektedir.



Şekil 4.6 Karaman İlinin Toplam Güneş Radyasyonu

Şekil 4.6'da da görüldüğü üzere Karaman Mersin iline ait ilçelerde güneş enerjisinin en yoğun olduğu alan 1800-2000 KWh'm^2/yıl ile Ayrancı ilçesinin güneydoğusu, Sarıveliler ve Başyayla ilçelerinin kuzey kesimleridir. En düşük 1600-1650 KWh'm^2/yıl ile Ayrancı, Merkez ilçelerinin kuzey doğu kesimleridir.

Karaman ilinin güneş radyasyonu haritasından da anlaşılacağı üzere Karaman ilin Güneş enerji potansiyeli göz ardı edilemeyecek kadar fazladır.

Karaman ili, ülkemizde gıda üretimi ve potansiyeli dışında hedeflenen projeler ile 10 yıl içerisinde enerji üretimi konusunda yüksek üretime sahip hale gelecektir. Karaman'da GES tesisleri hem elektrik içi hemde bina çatılarına kurularak sıcak su üretiminde de kullanılmaktadır.

Tablo 4.7 İşletmedeki Güneş Santralleri

İşletmedeki Güneş Santralleri			
Santral Adı	**İlçe**	**Firma**	**Güç**
Akyel 1 ve 2 RES Hibrit GES	Merkez	Sanko Enerji	50 MW
Teksin Enerji GES	Merkez	Teksin Enerji	33 MW
Ermenek Güneş Enerji Santrali	Ermenek		9,00 MW
Konar Enerji Ayrancı GES	Ayrancı	Konar Enerji	3,00 MW
Cereyan Karaman Güneş Enerji Santrali	Merkez	Solar Cereyan	2,97 MW
Emrullah Er GES	Kazımkarabekir		1,00 MW
Cerrahi Eğitim İnşaat GES	Kazımkarabekir	Cerrahi Eğitim İnşaat	1,00 MW
Eksun Enerji Güneş Santrali	Ayrancı	Eksun Enerji Üretim	0,99 MW
Halis Cem Enerji Güneş Enerji Santrali	Ayrancı	Halis Cem Enerji	0,99 MW
Karaman Belediyesi GES	Merkez	Karaman Belediyesi	0,99 MW
Onurlu Karaman Güneş Enerjisi Santrali	Merkez		0,50 MW
Karaman İl Özel İdaresi Güneş Enerji Santrali	Merkez	Karaman İl Özel İdaresi	0,50 MW
Karamanoğlu Mehmet Bey Üni. Güneş Enerjisi Santrali	Merkez	KMÜ	0,46 MW
Çavsa Güneş Enerjisi Santrali	Merkez		0,30 MW
Hacı Hasan Armutlu GES	Merkez		0,12 MW
Ermenek Hükümet Konağı GES Tesisi	Ermenek	Ermenek Hükümet Konağı	0,040 MW
Karaman'daki diğer lisanssız GES'ler		Çeşitli Firmalar	87 MW
ÖZET: Karaman İli İşletmedeki Güneş Santralleri : 17 santral, 192 MWe			

Tablo 4.8 Ön Lisans Alan Güneş Santralleri

Ön Lisans Alan Güneş Santralleri			
Santral Adı	**İlçe**	**Firma**	**Güç**
Sudurağı GES	Merkez	RNC Avrasya Enerji	100 MW
ÖZET: Karaman İli Ön Lisans Alan Güneş Santralleri : 1 santral, 100 MWe			

4.SONUÇ

Dünyamızda gerçekleşen küresel ısınma yüzünden bütün ülkeler yenilenebilir enerji kaynaklarına yönelmiştir. Özellikle günümüz teknolojisinde Güneş Enerjisinde kullanılan güneş hücrelerinin enerji verim oranının günden güne artması ile daha fazla GES inşa edilmeye başlanmıştır. Gelinen bu noktada kullanılan fosil yakıtların belirli zaman içerisinde tükenecek rezervleri sebebiyle yenilenebilir enerji kaynaklarına yönlenmiştir. Ulaşım, ısınma gibi sektörlerde kullanılan fosil yakıtlar aynı zamanda rezerv azlığından ziyade küresel ısınmayı hızlandırdıkları için tercih olmaktan çıkmaktadırlar.

Yenilenebilir enerji kaynakları hususunda gerçekleştirilen araştırmalar sonucunda, insanlığın enerji kullanımının sürekliliğinin devam etmesi ve enerji kullanımı ve üretimi sırasında çevreye verilen zararın en aza indirilmesi için kaynakların düzenli kullanılmasına dikkat çekilmektedir.

Türkiye için, yenilenebilir enerji kaynaklarının kullanımı ise Dünya geneli ortalamasının üstündedir. Ülkemiz coğrafi konumu sebebi ile birçok yenilenebilir enerji kaynağından yararlanabilmektedir. Bu sebeple birçok şirket farklı enerji üretim alanlarında projeler yürütmektedir. Özellikle son senelerde GES, RES, HES gibi tesislerin kurulumunda verilen teşviklerin artması ülkemizin enerji üretme ve kullanma potansiyelini de arttırmıştır.

Karaman, Mersin ve Şanlıurfa illerimiz içerisinde en çok Güneş enerji potansiyelini kullanan ilimiz Şanlıurfa'dır. Bunun sebebi daha engebesiz jeopolitik konuma sahip olması ve gün ışığı süresinin etkili olmasıdır. Karaman ise beklenen potansiyelin altında kalmaktadır. Bu durumda görünen en etkili sebep ekonomik yatırımların başka illere doğru kaymasıdır fakat ilerleyen yıllarda beklenen hedeflerine ulaşabilme potansiyeli çok yüksektir. Mersin ilinde dağlık bölgeler, yüksek nem, coğrafi şartların zorluğu ve turizm gibi birçok farklı sebepten ötürü gereken potansiyele ulaşamamıştır.

Ülkemiz için bütün illerimizde kamu yararına enerji santralleri kurulmalı ve temiz enerji üretilmelidir. Türkiye Cumhuriyeti'nin enerji tüketimi ve kullanımının kendi içinde üretim ile olabildiğince sağlanması ve enerji tüketiminin dışarıya bağlı kalma durumu günden güne azaltılmalıdır. Türkiye Cumhuriyeti kara konumu olarak Dünya'nın ortasında bulunmaktadır.

Dört mevsim yaşaması, düzenli gece ve gündüz döngüleri, güneş ışınım süresi gibi birçok faktör Türkiye Cumhuriyeti'nin enerji Potansiyeli açısından birçok ilini Dünya'ya kıyasla ön plana çıkarmaktadır.

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Digital Image Analysis in Determination of the Structural Parameters of Fancy and Conventional Yarns

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Abstract **-** Digital image processing is a popular and well-utilized in various fields of measurement and scientific investigation. In this paper, digital image analysis was used to determine the parameters of different types of yarns, including conventional and fancy yarns. The method proves to be optimal for measuring yarn diameter and can be considered reliable. As far as the number of protruding fibers is concerned, this method is precise but more time-consuming than instrumental methods. Digital image analysis is particularly valuable for fancy yarns that are not well-suited to conventional instrumental measurement methods. Therefore, its use is highly recommended for this group of yarns, as the measurements provide detailed insights into the structural characteristics of different fancy yarns and highlight their unique textures and appearances.

Keywords: digital, image analysis, yarn, conventional, fancy, testing

1 INTRODUCTION

Digital image processing is a very popular and well-used method in different fields of measurement and scientific investigation. The methods used in digital image processing can be classified into several groups, such as groups
image display methods, methods to improve the image, methods for image restoration, image compression methods, methods for image analysis and methods for image reconstruction from projections [1].

The basic problem of image display is the characterization of the size represented by one image element, which is called a pixel or pel for short. The image, depending on its origin, can represent the illumination of the objects on the scene (if it was obtained with a camera sensitive to the visible part of the spectrum), the absorption characteristics of the tissue (for X-ray imaging), the temperature of the objects on the scene (for infrared cameras), the reflection characteristics of the tissue (for ultrasound imaging), etc. An important problem of image display is the fidelity with which the image describes the observed physical phenomenon. The fidelity of the display depends on the quality of the sensor used in the camera, but also on the process of spatial and amplitude discretization (ie selection and A/D conversion). Image display deals with various image transformation procedures, which are used for better description of image content, correction of its quality, content compression, etc. Image modeling procedures are closely related to the problems of image representation. The image is most often modeled statistically using first- and second-order statistical characteristics. The assumption of image stationarity is often used, although this assumption is not always fulfilled.

With image enhancement methods, the basic goal is to change some characteristics of the image in order to make it more suitable for display on a monitor or for further analysis. In principle, enhancement does not improve the information content of the image, but facilitates the use of existing information. The most

common methods for image enhancement are: contrast enhancement, noise elimination, image sharpening, image coloring, etc. In some methods, each image pixel is treated independently of the others, and in some others, pixels are treated depending on their environment. It is characteristic of image enhancement methods that they are usually very simple, so they can be executed in real time.

Image restoration is also used to improve image quality, but in cases where image degradation is known or when a degradation model can be formed. Typical examples of restoration refer to correction of geometric distortions of the optical part of the camera, removal of noise whose statistical model is known, correction of reduced image sharpness due to movement or defocusing of the camera, etc. Unlike previous image enhancement methods, restoration methods are much more complex and usually not performed in real time. The transmission of such large amounts of data through telecommunication channels is a serious problem. There are similar problems if the image or video signal needs to be stored on a memory medium. In order for the transfer and storage of images to be technically possible and economically profitable, it is necessary to apply some compression techniques, which reduce the number of bits required for image representation. A large number of compression methods have been developed like compression methods that reduce the number of bits for image representation without any loss of information and compression methods that perform compression with the loss of an insignificant amount of information.

Image analysis is performed to determine the quantitative characteristics of the objects in the image and their mutual relationships. Simple examples of image analysis are: monitoring automatic production lines in industry, automatic image analysis in biomedicine, etc. More complex examples of analysis include shape recognition and are used in robotics and in a broad field known as machine or computer vision. Image analysis consists of several procedures that to a certain extent imitate the process of perception in humans. This group of procedures includes procedures for extracting edges, segmentation procedures, procedures for identifying objects in the scene, etc. The digital image analysis has over the years expanded its application in a number of scientific and practical fields. In the field of science, its use is valuable for precise analysis and is still emerging [2-5].

Image reconstruction from projections is a special group of restoration procedures that reconstruct a 2D (or multidimensional) object from multiple one-dimensional (or two-dimensional) projections. This group of techniques has found its greatest application in medical devices (various types of scanners), but also in non-destructive testing of materials, astronomy, etc.

Our previous research using digital image analysis was focused on knitted materials which was important to determine the overall porosity and cover factor of observed materials, to get insight into the shape and dimensions of voids within the main structure unit, as well to observe surface changes on of the material after a certain period of use [6-9].

The aim of this paper is to expand the use of digital image analysis for the determination of yarn properties and to define which options are best for determination of single yarn parameters.

2 MATERIALS AND METHOD

For the investigation of the application of image analysis, the Dino Capture 2.0 program was used [10]. The program is illustrated in Figure 1, while Table 1 presents major tools available within the program that should be observed for the determination of yarn parameters.

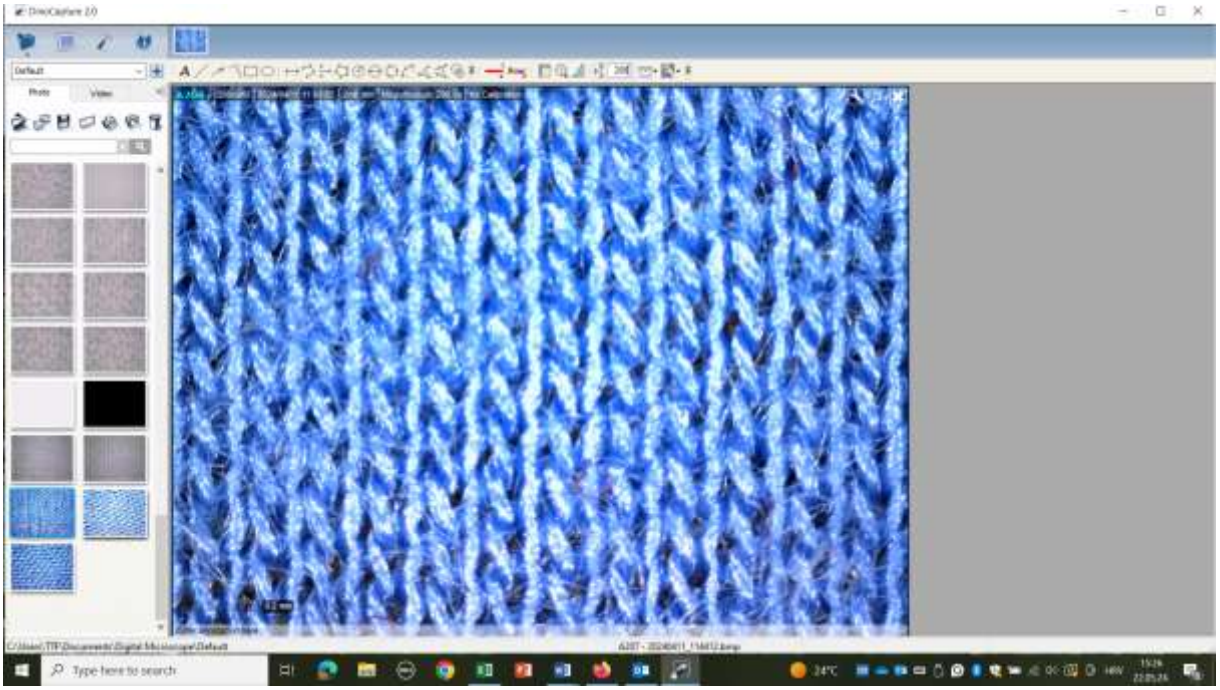


Figure 1. Dino Capture 2.0 program

Table 1. The overview of useful tools within Dino Capture 2.0 program

Tool	Symbol
Line	
Continuous line	
Poligon	
Radijus circle	
Diameter Circle	
Three points circle	

A Dino-Lite digital microscope, model AM7013MT, was used to record the image that is analyzed in the mentioned program. Dino-Lite Premier AM7013MT is a digital, handheld microscope with a 5 Megapixel sensor that can magnify up to 200 times depending on the working distance with a resolution of up to 2592x1944. It allows viewing and recording the smallest details of the object being analyzed. The robust design is realized with an aluminium housing in which, in addition to the sensor, bright white LED lighting is installed, which constantly optimally illuminates the object of observation/recording. The device itself comes with the corresponding DinoCapture 2.0 software, which enables taking pictures of samples, recording videos, and labelling images. Measurement and calibration options are also available. Data on the measurement distance and the observation area are given in Table 2.

Table 2 Measuring distance and observation areas [10]

M	WD	FOV (x)	FOV (y)
20	48.7	19.8	14.9
30	21.7	13.2	9.9
40	9.0	9.9	7.4
50	1.9	7.9	5.9
60	-2.3	6.6	5.0
220	-0.1	1.8	1.4
230	1.0	1.7	1.3
240	2.1	1.7	1.2

Legend: M - magnification rate, WD - working distance, FOV - field of view, DOF - depth of field unit

Within the experimental part using the tools available (Fig. 2) the measurement of the following yarn parameters is conducted:

- diameter
- length of protruding fibers
- cross section and
- different elements of fancy yarns.

For the measurements are used conventional ring-spun yarns and fancy yarns differing in the structure, i.e. boucle, chenille, marl and chain yarns.

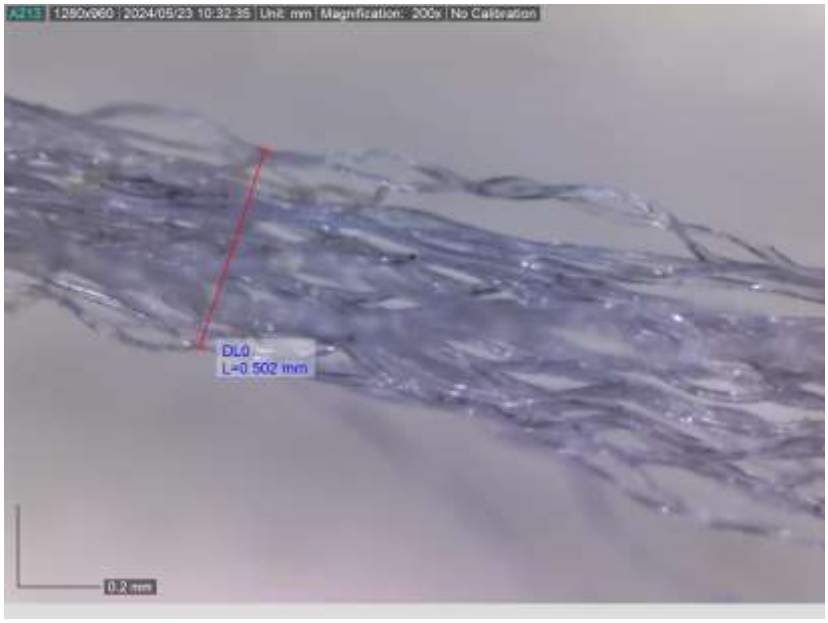


Figure 2 Use of tools within Dino Capture 2.0 program

3 RESULTS

The results are presented in Figures 3-5 and Table 3.

For the measurement of yarn diameter, the line tool was used. The results of the measurements are given in Figure 3. As can be seen from Figure 3, there is a slight deviation within the results of measurement (the standard deviation of the results is 0.046), what is in accordance to the nature of the used yarn (cotton ring-spun yarn). Regarding the results, this method can be considered as reliable for the measurement of yarn diameter.

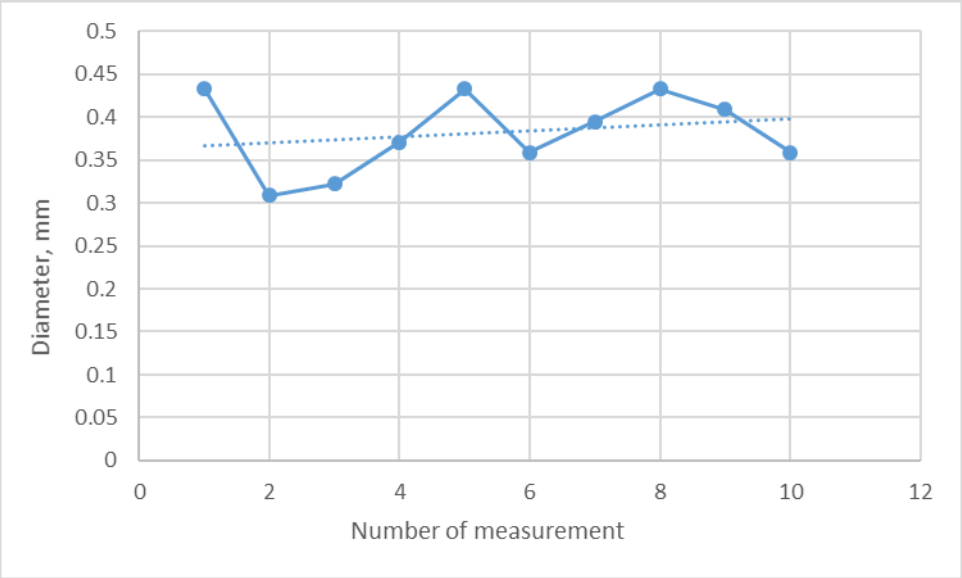


Figure 3. Diameter

The number of protruding fibers from the body of a yarn is determined using the tool Continuos line (Figure 4). For different types of yarns, especially those produced of natural fibers, it is common to have a wider range of protruding fibers in different lengths. Therefore the standard deviation is not a typical indicator of the property observed. This method is very precise, but in comparison to some instrumental methods (like hairiness apparatus), it is time-consuming.

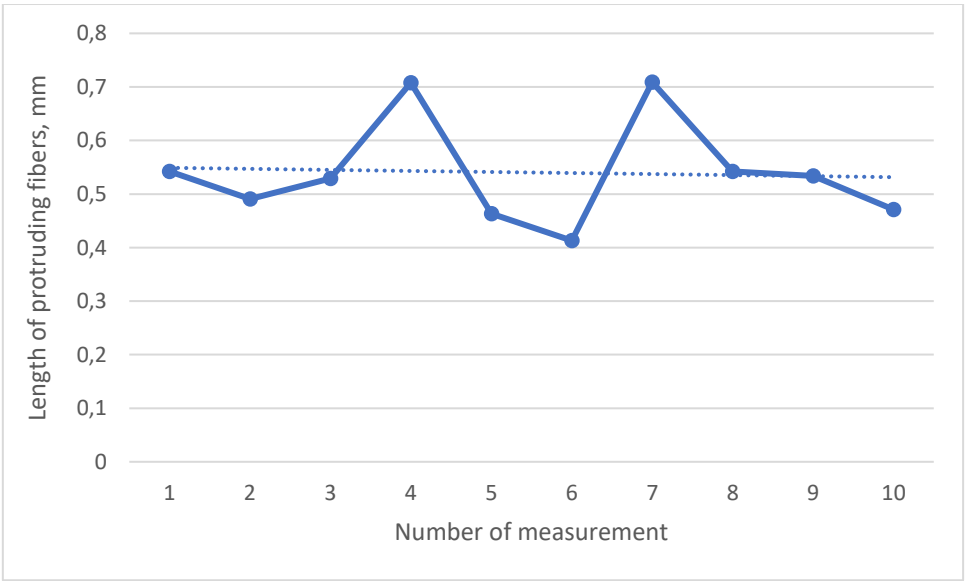


Figure 4. Length of protruding fibers

For the determination of parameters that describe the yarn cross-section, the use of three tools within the software is possible. Those are the three points circle, diameter circle and radius circle. All three tools may

be used to determine the circumference of the cross-section (C), the surface of the cross-section (A) and the radius of the cross-section (R).

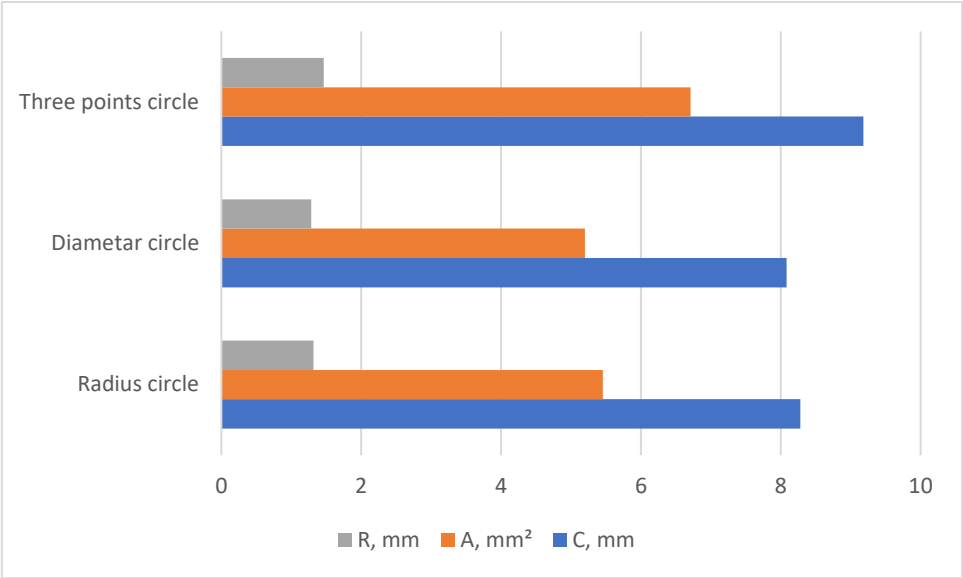
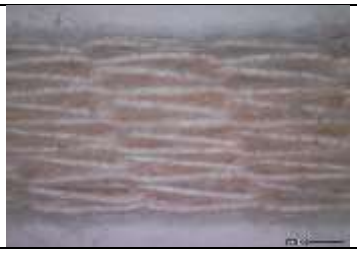


Figure 5. Cross-section parameters (R, A, C)

The circumference values (Figure 5) show some variation among the three methods. The "Three points circle" method yields the highest circumference, while the "Diameter circle" method gives the lowest value. The "Radius circle" method is intermediate. These differences might result from how each method approximates the shape of the cross-section, with the "Three points circle" possibly capturing a larger or more irregular perimeter. For the surface area, the "Three points circle" again produces the largest value, indicating that this method might encompass more of the cross-sectional area or consider slight deviations in shape more accurately. The "Diameter circle" method gives the smallest surface area, and the "Radius circle" method falls in between.The radius measurements also vary, with the "Three points circle" showing the largest radius, suggesting it measures the distance to the farthest point more generously. The "Diameter circle" method yields the smallest radius, which aligns with its lower circumference and surface area values. The "Radius circle" is, once more, in the middle range. The choice of method for measuring cross-sectional parameters from image analysis can significantly influence the results. The "Three points circle" tends to provide larger measurements, which may be more accurate for irregular shapes, while the "Diameter circle" provides the smallest measurements, potentially underestimating certain parameters. The "Radius circle" method offers intermediate values. Understanding these differences is crucial for selecting the appropriate tool based on the specific requirements of the analysis and the nature of the cross-section being measured.

The results of the use of digital image analysis for determination of fancy yarn parameters are presented in Table 3. Overall, the properties measured provide detailed insights into the structural characteristics of each type of fancy yarn, highlighting their unique textures and appearances. Depending on the type of fancy yarn, different tools may be used. For this specific group of yarns, digital image analysis os of special importance, as those yarns are not supposed to be measured using instrumental techniques that are used for the measurement of conventional yarns. Therefore, the use of digital image analysis is highly recommended for this group of yarns. Taking into account a wide range of different fancy yarn types, the future investigation is to be forwarded towards different types of fancy yarns that were not covered within this experiment.

Table 3. Use of digital image analysis for determination of fancy yarn parameters

Type of fancy yarn	Image of fancy yarn under magnification	Tool to be used	Property to be measured	Measured average value
Chenille yarn		Line	Length of protruding fibers in the efect component	0.053 mm
		Line	Distance between the effect components	4.109 mm
		Line	Length of effect component	4.121 mm
		Continuous line	Circumfence of effect component	12.592 mm
		Polygon	Surface of effect component	9.324 mm^2
Marl yarn		Line	Distance between segments of the same	3.044 mm
		Continuous line	Length of protruding fibers	2.185 mm
Boucle yarn		Polygon	Surface of the effect component	9.075 mm^2
		Polygon	Circumfence of the effect component	10.985 mm
		Line	Distance between the effect components	3.715 mm
		Line	Diameter of effect component	3.667 mm
Chain yarn		Line	Yarn diameter	3.973 mm
		Line	Length of a repeating unit	2.710 mm
		Line	Length of protruding fibers	0.871 mm
		Polygon	Surface of a repeating unit	0.583 mm^2
		Polygon	Circumfence of a repeating unit	4.934 mm

4 CONCLUSION

The application of digital image analysis for the measurement of yarn properties brought to the following concluding remarks:

- the method is optimal for measuring yarn diameter and can be considered reliable. The slight deviation in results matches the expected variability of ring-spun yarn.
- regarding the number of protruding fibers, while precise, this method is more time-consuming than instrumental methods.
- in determination of yarn cross-section parameters using different measuring tools, circumference values varied, with the three-point circle method yielding the highest values and the diameter circle method the lowest. The radius circle method provided intermediate values, reflecting each method's approach to approximating the cross-sectional shape. Surface area measurements showed similar trends.
- digital image analysis is especially valuable for fancy yarns, which are not well-suited to conventional instrumental measurement techniques. Therefore, its use is highly recommended for this group of yarns, as the measurements offer detailed insights into the structural characteristics of various fancy yarns, emphasizing their unique textures and appearances.

Acknowledgments

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MODELING AND EXTRACTION OF ESSENTIAL OIL FROM BIOMASS USING GREEN SOLVENT

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Abstract **–**In Algeria, the plant kingdom is very rich in natural substances. These substances contain molecules which have antioxidant activities. The purpose of this study is the valorization of natural substance using green solvent. Factorial design of two parameters (mass and flow) is used to verify the single factors on extraction efficiency. The study concerns the extraction of essential oil from Algerian Rosmarinus Officinalis *L*. by steam entrainment. The oil yield was calculated to control the extraction process efficiency on different experimental condition. The interactions between factors were determined. The characteristic model released is a second order model which was evaluated by the statically significant model properly tested by ANOVA using Statgraphics plus software version 5.1.The R-squared statistic indicate that the model as fitted explain 88.22% of the variability in oil yield. The adjusted R-squared statistic, which is more suitable for comparing model with different numbers of independent variables, is 76.45%. The standard error of the estimate shows the standard deviation of the residual to be 0.1 and mean absolute error is 0.06. Since the DW value is greater than 1.4, there is probably any serious autocorrelation in the residuals. The model correctly describes the system studied. Algerian Rosmarinus Officinalis *L*. is valorized as biomass and van be considered as potential source of bioactive compounds.

Keywords –Rosmarinus Officinalis L., biomass, Essential oil, extraction, modeling

I. INTRODUCTION

In Algeria, the plant kingdom is very rich in natural substances. These substances contain molecules which have antioxidant activities. In the last year the use of natural antioxidants in food industry has increased. These compounds are synthesized exclusively by plants (fruits, flowers, leaves, roots, bark) [1, 2]. Essential oils have interesting properties: antioxidant, antibacterial, ect... The purpose of this study is the valorization of natural substance using green solvent. We choose Rosmarinus officinalis *L*. It belongs to the botanical family Lamiaceae (the genus Rosmarinus). It is a green shrub from 0.5 to 2 m. The woody stem is covered with a greyish bark and divides into many opposite branches [3]. In this work, modelling and extraction of Essential oil was investigated.

II. MATERIALS AND METHOD

The plant material used in our study was Rosmarinus officinalis *L*. leaves. The extraction of essential oil was carried out by steam entrainment. Factorial design of two parameters (mass and flow) is used to verify the single factors and their interactions on extraction efficiency. Experimental design used is constructed and statically analysis was processed using Statgraphics plus software version 5.1.

III. RESULTS

The experiments were performed according to the design of experiments shown in Tables 1. The same table displays observed and predicted responses.

Table 1. Example of a table

Essai	Factor A	Factor B	Observed value	Fitted value
1	0	0	3.62	3.56
2	-1	1	3.12	3.07
3	-1	0	3.32	3.46
4	0	0	3.62	3.57
5	0	-1	3.10	3.22
6	-1	-1	3.29	3.20
7	0	0	3.61	3.57
8	0	1	3.23	3.27
9	1	0	3.43	3.44
10	1	1	3.04	2.77
11	1	1	3.22	2.99

The effect of extraction factors is presented in Figure 1. Pareto chart traduces ANOVA for operating parameters and their combinations. It shows their own effects from the most to the least significant level at 5%. The vertical line indicates the statistical level.

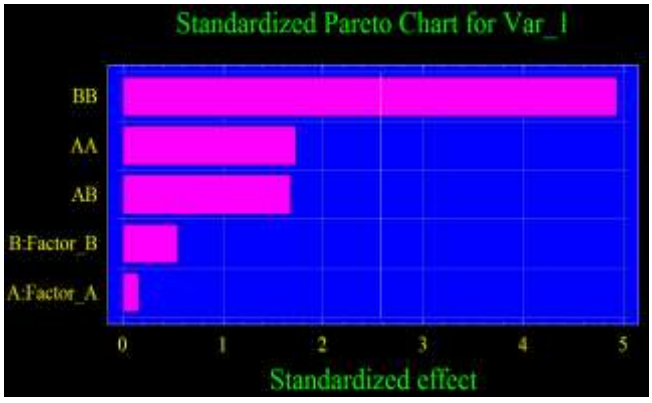

Fig. 1**.** Pareto Chart for essential oil yield

The results for essential oil yield effects studied by analysis of variance were summarized in Table 2.

Table 2. Analysis of variance (ANOVA)

Source	Sum of square	Df	Mean square	F-Ratio	p-value
A	0.000266667	1	0.000266667	0.02	0.8817
B	0.00326667	1	0.00326667	0.3	0.6071
AA	0.0324386	1	0.0324386	2.98	0.1446
AB	0.030625	1	0.030625	2.82	0.1540
BB	0.264559	1	0.264559	24.34	0.0043
Total error	0.0543364	5	0.0108673	/	/
Total (corr)	0.461418	10	/	/	/

The fitted mathematical model for essential oil yield with 95% for coefficient level was given. The value of R^2 was 88.22 and R^2 adj was 76.45

$$Y = 3.56526 - 0.0066666\,A + 0.0233333B - 0.1131158A^2 + 0{,}0875AB - 0.323158B^2$$

IV. DISCUSSION

The effect of the extraction factors on essential oil extraction is presented in figure below. This figure shows that one parameter B^2 has a significant effect on essential oil extraction. The Durbin-Watson (DW) value was 2.92. Since the DW value is greater than 1.4, there is no serious auto correction in the residuals. The values of R^2 was 88.22%, it indicates that there is a good correlation between the experimental and predicted data.

V. CONCLUSION

The effect of the main process variables (mass, flow) on extraction essential oil yield has been studied. The characteristic of the model released is a second-order linear models with interactions. The effect study of each factor on the response shows that flow of water vapor has a significant effect. The best experimental result was obtained at the central point. These preliminary results are interesting and we think further investigations. Algerian Rosmarinus Officinalis *L*. can be valorized as biomass and considered as potential source of bioactive compounds.

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Detecting the Undetectable: A new approach to the Blind Spot Detection for Trucks and Buses

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***Abstract*—** Driving in today's traffic can be incredibly risky. In fact accidents are more likely to occur if the driver is unaware of vehicles or objects, in their blind spots. The main goal of this research is to create a system that enhances road safety for trucks and buses. It's a wireless, portable system equipped with sensors that continuously monitoring the truck's blind spots. When it detects another vehicle or even a pedestrian sneaking into those blind spots, it doesn't just stay silent – it sounds a buzzer along with a warning by flashing an LED display right in front of the driver. What makes this system even more appealing is portability, low cost and easy installation. It is designed to fit on different trailers/Buses or other vehicles.

Keywords— Blind spot, safety system, Automotive system, Ultrasonic sensor, Wireless communication, NRF24l01 transceiver, Vehicle detection

I. INTRODUCTION

A blind spot refers to areas around the vehicle that the driver cannot directly observe while looking forward or through either the rear-view or side mirrors. This can pose a risk for accidents, especially when changing lanes if another vehicle is in the blind spot. Many modern vehicles are equipped with blind spot detection systems to alert drivers to objects in these areas. Blind spots play a significant role in causing accidents, especially in driving and operating machinery, due to the limitations they impose on a person's ability to perceive their surroundings fully. Here's how blind spots contribute to accidents:
When a driver attempts to change lanes or merge onto a roadway, vehicles in adjacent lanes may be in the driver's blind spot, making them invisible through mirrors. If the driver doesn't physically check these spots by turning their head or if they rely solely on mirrors, they might collide with these unseen vehicles. Similar to lane changes, when a driver tries to overtake or pass another vehicle, especially on two-lane roads, they might not see vehicles in their blind spots. This can lead to side-swipe accidents if they move over too soon.

II. LITERATURE REVIEW

This paper describe the recent deep learning methods for hyper spectral anomaly detection (HAD) face challenges due to a lack of supervision and the issue of reconstructing both backgrounds and anomalies. To address this, we introduce BS3LNet, a self-supervised network that creates training patches with blind spots from a single hyperspectral image. This network reconstructs each pixel using its neighbors, resulting in high reconstruction errors for anomalies and low errors for background pixels [1].

Recent advancements in deep learning for hyper spectral anomaly detection (HAD) have struggled with distinguishing anomalies from backgrounds due to their tendency to reconstruct both. To address this, a new method called PDBS Net is introduced, which uses a pixel-shuffle down sampling blind-spot

reconstruction network. This network operates in a self-supervised manner and features a blind-spot architecture, where the center pixel is unseen by the network and is reconstructed using neighboring pixels. Since anomalies have different spectral signatures compared to their surroundings, this setup results in high reconstruction errors for anomalies and low errors for background pixels. Additionally, the pixel-shuffle down sampling technique breaks spatial correlations, further distinguishing anomalies from backgrounds. By combining these strategies, PDBS Net enhances background features and weakens anomaly features, leading to higher reconstruction errors for anomalies. The differences between the original and reconstructed images are used as anomaly scores. Extensive testing on four datasets shows that PDBS Net performs exceptionally well compared to other top methods [2].

This paper describe the rapid advancement of electric vehicles and AI technology has accelerated the development of the autonomous driving industry. However, both autonomous and traditional vehicles still face the risk of traffic accidents due to blind spots. This article introduces a method that combines data from cameras and LiDAR sensors to improve vehicle perception. By merging camera semantic data with LiDAR range data, it identifies the type and location of objects. This processed information is then sent to nearby vehicles in real-time using 5G and V2X technology for early blind spot warnings. Experiments and simulations have shown that this approach can significantly reduce traffic accidents caused by blind spots, enhancing traffic safety [3].

It effectively highlights the significance of the proposed system in addressing blind spot challenges and enhancing driver safety. The inclusion of specific details about the vision-based approach, daytime and nighttime operation, object detection and tracking, warning system, integration with vehicle systems, and the evaluation and validation process provides a comprehensive overview of the paper's content. Overall, your summary effectively communicates the main points of the paper [9].

This paper introduces a specialized Blind Spot Detection System tailored for semi-trucks, with the primary goal of enhancing safety and minimizing accidents attributed to blind spots. The system integrates radar and strategically positioned sensors on the truck to identify objects within blind spot areas, covering various zones around the vehicle. Employing advanced object detection and tracking algorithms enables real-time monitoring, ensuring continuous updates for the truck driver. In the event of detecting a potential hazard, the system issues timely warnings through visual alerts, audible signals, or haptic feedback. Seamless integration with the truck's existing systems is a key aspect, potentially involving communication with the onboard computer for automatic responses or interventions. The paper likely includes results from real-world testing in diverse scenarios, such as highway driving, urban environments, and challenging weather conditions. could offer valuable perspectives on usability and acceptance. It's crucial to note that specific details will depend on the actual research and findings in the paper. Accessing the paper directly would provide a more accurate and detailed understanding of the proposed Semi-Truck Blind Spot Detection System [10].

With an emphasis on collision warning, this paper offers a Real-Time Obstacle Detection and Status Classification system created for a Vehicle Active Safety System. By identifying impediments and recognizing them in real-time for proactive collision alerts, the technology seeks to improve vehicle safety. Real-time obstacle detection is used by the system, which probably makes use of a variety of sensors, including cameras, lidar, and radar. These warnings can inform the driver of possible accident risks in a timely and efficient manner. Knowing how drivers react to the collision alerts can tell you a lot about how well-liked and useful the system is. It's crucial to remember that the paper's specifications will vary depending on the information and conclusions it contains. A more precise and thorough knowledge of the Real-Time Obstacle Detection and Status Classification system for Collision Warning in a Vehicle Active Safety System can be obtained by accessing the complete publication [11].

Complex traffic movements, pedestrian presence, and challenges in gauging speed and distance contribute to accidents at intersections. Accidents are more likely in urban areas due to traffic congestion and challenges in maneuvering large vehicles through narrow streets. Improper lane changes, especially on highways, and large blind spots can contribute to accidents during merging problems with brakes, tires, or other critical components, can lead to accidents. Heavy traffic increases the likelihood of accidents, particularly in urban areas where maneuvering space is limited. Driver Fatigue: Long hours of

driving and tight schedules can lead to driver fatigue, impacting reaction times and decision-making. Excessive speed is a significant contributor to accidents, reducing the time available for drivers to react. Distractions: In-vehicle distractions, Large blind spots on HGVs and buses can lead to collisions, especially during lane changes. Aggressive driving, road rage, or impaired driving can contribute to accidents involving heavy goods vehicles and buses. These factors highlight the complexity of road safety, requiring a multifaceted approach including driver training, infrastructure improvements, and vehicle maintenance to mitigate risks and enhance safety [12].

This suggests that the Blind Spot Warning System is integrated or built directly into a particular device or system. This could imply that the Blind Spot Warning System operates continuously, without interruptions, providing alerts or warnings at any given time. This is a common automotive safety feature that alerts the driver if there is a vehicle in their blind spot, typically using sensors and indicators to enhance situational awareness. Combining these elements, an "Embedded All-Time Blind Spot Warning System" could be a continuous, integrated safety feature within a device or system that alerts users to potential blind spot hazards, possibly in the context of automotive or other scenarios where blind spot awareness is crucial [13].

This paper focuses on enhancing the safety of heavy car interfaces, particularly through the redesign of the rearview mirror. The main methodology employed is the COPRAS (Complex Proportional Assessment) Multiple Criteria Decision Making (MCDM) approach. The goal is to reduce the reliance on certain parameters and propose design changes that contribute to improved safety. The study incorporates both human judgment, using FARE (Fuzzy Analytic Hierarchy Process) and AHP (Analytic Hierarchy Process), and mathematical procedures, employing entropy size, to calculate the weights of various properties. The model underwent modification, and the effectiveness of the proposed changes was validated through observation in a specific case. The paper emphasizes the significance of this research in the realm of car safety, particularly addressing blind spots around heavy vehicles. The potential improvement in safety, especially in reducing blind spots, makes this study a valuable contribution to automotive security [14].

The paper presents a Visual Blind spot Monitoring System designed to enhance safety during lane changes by addressing the challenge of blind spots. The system utilizes advanced imaging technology, including cameras and sensors, to monitor the vehicle's surroundings in real-time. When potential hazards are detected in the blind spots, the system provides visual feedback to the driver, such as alerts on side mirrors or an in-vehicle display. The goal is to seamlessly integrate with the driver's behavior, offering timely and intuitive information to assist in safe decision-making during lane changes. The paper may detail specific technologies like computer vision algorithms, image processing techniques, or machine learning components employed to enhance blind spot detection accuracy. The system's effectiveness is likely validated through simulations or real-world testing, demonstrating its ability to reduce collision risks during lane changes. The conclusion summarizes the key contributions of the Visual Blindspot Monitoring System to automotive safety and may suggest areas for future improvements or research. In essence, the paper introduces a technological solution to mitigate blind spots, contributing to the broader objective of improving road safety [15].

III. PROPOSED BLIND SPOT DETECTION SYSTEM

We've proposed a system to help trucks deal with blind spots, those areas where truck drivers can't see and where there might be High Vehicle (HV) drivers at risk. In our setup, we've used six Ultrasonic sensors on each side of the truck, as you can see in Figure 1. To make our system work better, we've added two sensors at a known distance apart, called "d," and set at the same angle, which we'll call "α." This helps improve the system's effectiveness in detecting blind spots.

The sensor that can find the blind spot works within 6.45 meters and reads data at a rate of 20 Hz, which means every check happens in 50 milliseconds. So, we need to collect data quickly enough to notice a vehicle in the blind spot and get precise measurements. How clear and detailed the readings are depends on how many times the sensor checks for things in between each detection.

$$Sensor_{resolution} = \frac{d}{n*(n+1)\Delta} \quad (1)$$

Figure 1-Blind spot Scenario

$$d_2 \geq (v_1 - v_2) \times t \qquad (2)$$

$$d_3 \geq (v_3 - v_1) \times t + \frac{(v3-v1)}{2a3} \qquad (3)$$

In order to obtain precise measurements with a low rate of false detections, we employed six sensors positioned at a fixed distance "d," from each other and at a known angle θ as shown in equation 4, where R represents the distance between the sensor and the HV. By substituting equations 4 and 5 into equation 6, we can determine the angle at which the HV is approaching.

$$R = d\ sin\theta \qquad (4)$$

$$\frac{\Delta\emptyset}{R} = \frac{2\pi}{\lambda} \qquad (5)$$

$$\theta = \arcsin.\left(\lambda \cdot \Delta\emptyset / 2\pi \cdot d\right) \qquad (6)$$

By incorporating two sensors and measuring the relative velocity and distance of the vehicle, the accuracy of detection data is significantly improved.

IV. SYSTEM DESIGN

The entire system is designed around the positioning of sensors, with the goal of enhancing safety. As a proof of concept, six strategically placed sensors will be utilized in key areas of both the truck and its trailer. In total, the system consists of four components. The sensors are responsible for gathering data from blind spots, enabling the determination of whether a vehicle is present in those areas. Inside the truck's cabin, there will be a central hub system and a display system along with sound alert system for alerting the driver in a situation when an object enters the blind spot region.

The LEDs will blink in response to wireless data transmission, indicating to the driver when a vehicle enters a blind spot. Once a vehicle exits the blind spot, the corresponding LED will automatically switch off. The overall design and implementation of the system can be seen in the figure below.

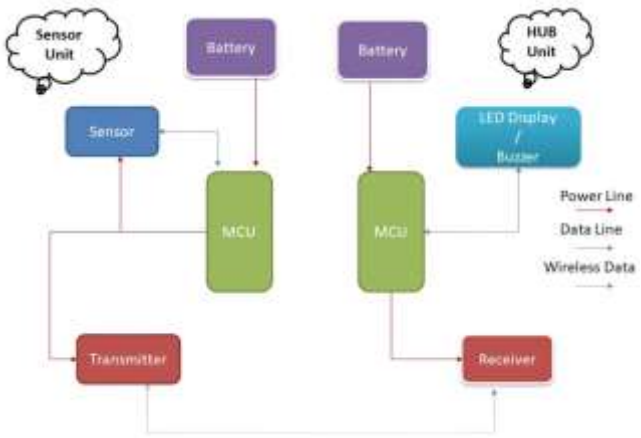

Figure 2-Overall Block Diagram

On one side of the illustration, we can observe the sensor units, which are made up of identical components. These components include a battery that supplies power to the sensors, microcontroller, and NRF24l01 transceivers. Whenever a vehicle enters the blind spot, the sensor will be able to identify its presence. The information detected by the sensor will then be analyzed by the microcontroller. If the vehicle's location within the blind spot exceeds a certain trigger distance, the sensor's unique identifier will be transmitted over the network to the hub unit. In summary, the sensors, powered by a battery, detect vehicles in the blind spot and send relevant information to the hub unit when certain conditions are met.

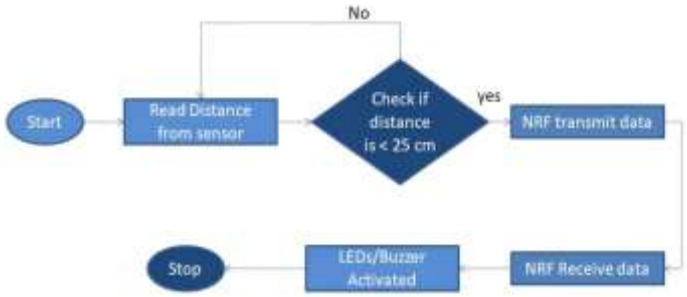

Figure 3-Flow Chart

The entire communication system is wireless. The primary objective in developing the Truck Smart system is to create a flexible and user-friendly solution that can be seamlessly integrated into various truck trailers, regardless of their sizes. To ensure practicality and easy installation, wireless communication was selected as the method for transmitting data between the sensors and the central hub. After thorough evaluation, we discovered that Wi-Fi was a bit too sturdy for what we needed, and Bluetooth ended up draining too much power. In the end, we found that NRF24l01 technology was the perfect fit for meeting the specific requirements of the Truck Smart system.

Algorithm 1 Alert

```
1:    function NRF_READING(A,s,l)
2:      Signal=”
3:      arrayLength=A.length()
4:      if arrayLength <l then
5:        l=arrayLength
6:    end if
7:    for count =1 to l do
8:      if A[count] < s then
9:         signal=”RED signal with blink”
10:     elseif A[count] < 15 then
11:        signal=”only RED signal”
12:     Else
13:        signal=”GREEN signal”
14:     end if
15:   end for
16:   end function
```

- Where A=array, s=safe distance, l= car limit

The transmitter is equipped with a total of 125 channels, where each channel occupies a bandwidth that is smaller than 1 MHz. Consequently, in order to choose our desired radio frequency (RF) channel, we employ the equation (7) for the selection of our frequency selector.

$$Freq_{selectror} = 2{,}400 + CH_x \quad (7)$$

Within our system we employ a Multi tranceiver architecture consisting of a single receiver and multiple transmitters denoted as X. The Receiver, situated within the primary system, acquires data from the transmitters concurrently, leveraging a distinctive identifier. This identifier serves the purpose of preventing data duplication and subsequent disregard of redundant information.

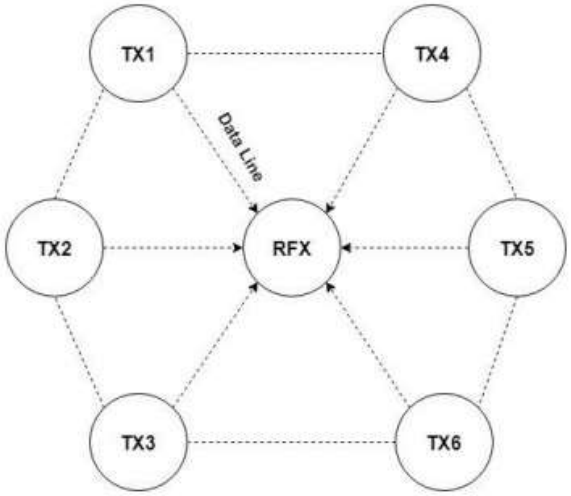

Figure 4- NRF Module Transmission line

The communication between the transmitter and receiver is facilitated through the transmission of data packets. Upon successful transmission, the transmitter awaits the automatic Packet Handling (APK) to be received. Once the APK is received, the Transmitter Receiver (TR) utilizes the Interrupt Request (IRQ) interrupt mechanism to monitor the presence of new data, as illustrated in Figure 5.

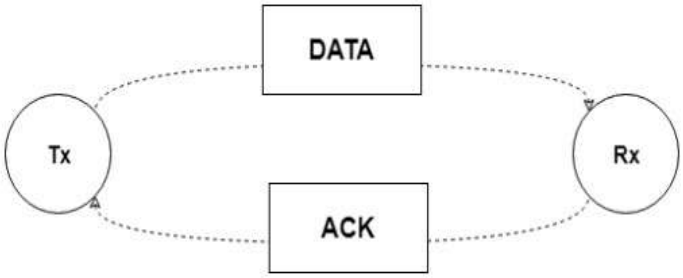

Figure 5- APK handling System

V. ELECTRICAL DESIGN

The electrical design of the Truck Smart system is designed to be small, flexible, and efficient. It incorporates voltage regulators and bypass capacitors to prevent voltage spikes. The system delivers 5V to the ATMega328P microcontroller and 3.3V to the NRF24L01 transceiver. The ATMega328P then generates the necessary voltages for various functions such as LED notifications, buzzer packet transmission/reception, and internal data handling for logic operations. Power LEDs are also included for practicality. The resistance values for the notification LEDs are adjusted to ensure optimal voltage levels based on the LED color, ranging from 1.5V to 3.8V.

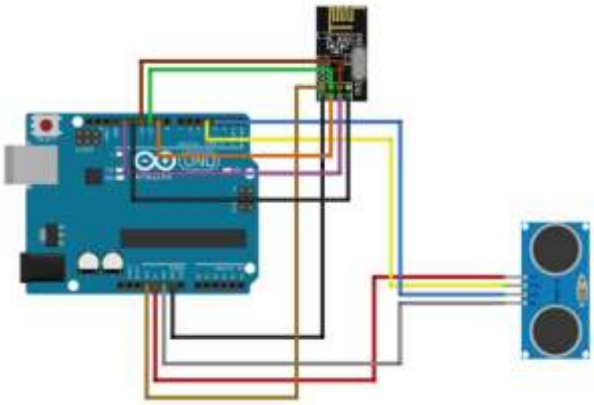

Figure 6(a)-Transmitter Side

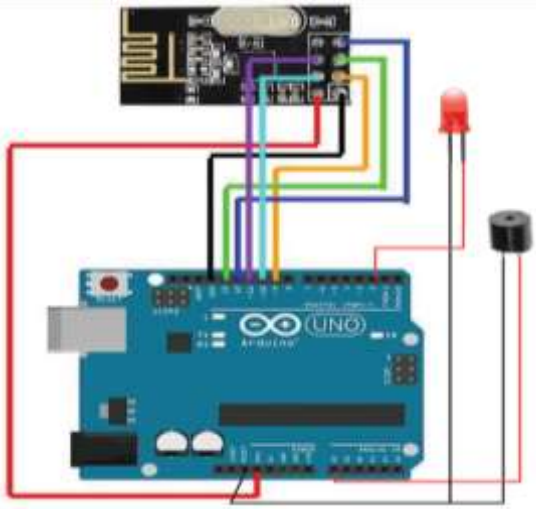

Figure 6(b)-Receiver Side

VI. Software Design

The NRF24L01 units were setup using Arduino & the microcontrollers were programmed using the Arduino language, based on C and C++, using the Arduino IDE. The software was specialized for each type of unit, the sensor and the hub.

A. Hub Unit

The hub unit is positioned conveniently within the vehicle's cabin, allowing easy access for the driver. It serves as the intermediary between the sensors and the user, performing several important tasks. Firstly, it is programmed to configure the nrf24l01 module and establish a network. Secondly, it manages this network by identifying sensor units with the same network ID, adding them to the network, and consistently monitoring their status. Thirdly, it receives and processes data transmitted by each sensor unit. Next, it interprets and presents the relevant information to the user through various LEDs.

B. Sensor Unit

The sensor unit, similar to the hub unit, has five main responsibilities. Upon initial power-up, it will search for and try to connect to an NRF22l01 device that matches its network. Once successfully joined to a network, it will send a test transmission to ensure that both the wireless communication and the sensor are functioning correctly. After confirming the proper functioning, the sensor unit will enter its main stage, which operates in a continuous loop. In this loop, it will first read data from the sensor and compare it to the previous state, represented as either 0 or 1 depending on whether the sensor detected anything nearby. If there is a difference in the state, the sensor will update the data, send it to the hub unit, record the time, and repeat the loop. If the state remains the same as before, the sensor will check if it has transmitted any data to the hub within the last few seconds. If not, it will send the data regardless of the previous state. However, if it has already sent data within the past few seconds, it will complete this iteration of the loop without taking any further action.

VII. OVERTAKING SITUATION

In the context of a passing maneuver, when a vehicle approaches from the rear or there is a need to overtake, the NRF24L01 sensor is utilized to perform a series of evaluations. This sensor analyzes various parameters such as speed, position, and distance, enabling it to generate a signal that is transmitted to the driver. Based on this signal, the driver can make an informed decision regarding the feasibility of executing the overtaking maneuver.

- In the context of vehicular prioritization, precedence is given to vehicles with higher speeds over those with lower speeds.
- Specifically, when a higher speed vehicle overtakes a lower speed vehicle, the latter is signaled with a red indicator, which subsequently begins to blink once the overtaking maneuver is completed while maintaining a safe distance.

In the context of overtaking scenarios, I have identified four distinct conditions that warrant consideration.

The decision-making process and signal acquisition associated with these conditions are illustrated in a flowchart.

Scenario 1 entails Vehicle A's intention to overtake Vehicle B, which is positioned ahead of it. The future position, denoting the anticipated location of Vehicle A after overtaking, must be free from any obstructions that could impede the overtaking maneuver on Vehicle B. In this situation, it is determined that Vehicle A can proceed with the overtaking maneuver on Vehicle B.

In Scenario 2, Vehicle A seeks to overtake Vehicle B while both are occupying the same lane. However, the presence of Vehicle C approaching from the opposite lane renders the overtaking maneuver unsafe and poses a potential hazard.

Scene 3: In the given scenario, Vehicle A intends to perform an overtaking maneuver on Vehicle B. However, the anticipated position of Vehicle A after overtaking reveals the presence of Vehicle E. Consequently, there is insufficient available space for Vehicle A to execute the overtaking maneuver. Therefore, overtaking is not possible in this case.

Scene 4: Let us consider a one-way road with two lanes. Vehicle A desires to overtake Vehicle B, and upon completion of the overtaking maneuver, there are no other vehicles expected in the future position. Nevertheless, a high-speed vehicle, namely Vehicle H, is approaching from behind in the same direction as Vehicle A. In this situation, the priority is given to the vehicle with the higher speed. If Vehicle A has a higher speed, it will proceed with the overtaking maneuver. Conversely, if Vehicle H, approaching from the rear, has a higher speed than Vehicle A, the overtaking maneuver by Vehicle A will be withheld, allowing sufficient space for Vehicle H to advance.

Based on the analysis of these four overtaking scenarios, a flowchart representing the decision-making process is presented in Figure 7.

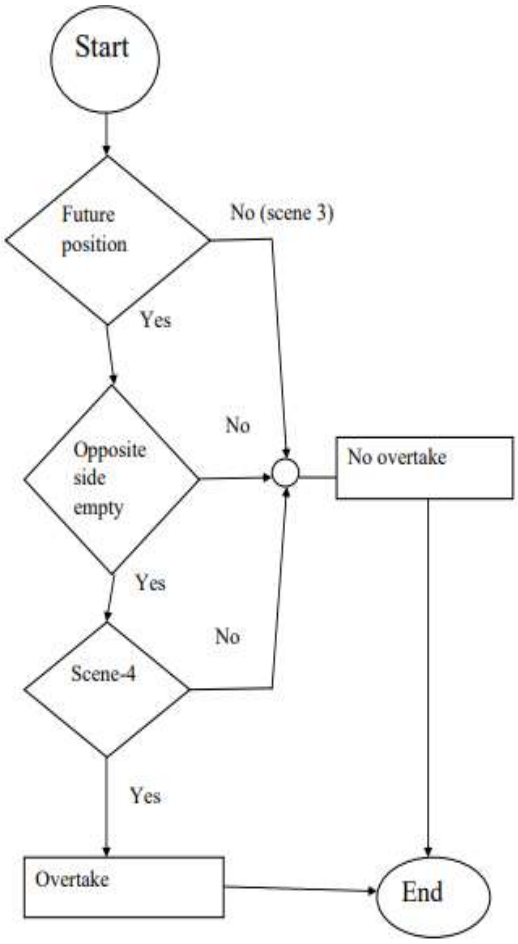

Figure 7: Flow chart of overtaking decision making based on the four scenes

Algorithm 1 OVERTAKING

1: **function** OVERTAKING(A,f)
2: **if** f-future position is free then
3: **if** other vehicle coming from opposite lane then
4: "Do not overtake"
5: **else if** other vehicle is coming from behind then
6: **if** other vehicle speed is greater then
7: "Do not overtake"
8: **Else**
9: "OVERTAKE"
10: **end if**
11: **end if**
12: **Else**
13: "Do not overtake"
14: **end if**
15: **end function**

- Where A=array, f= future position

VIII. DERIVATION OF SAFE DISTANCE BETWEEN VEHICLES

In order to ascertain the appropriate safety gap, we establish the presence of two vehicles, denoted as A and B, traveling in the same direction consecutively, with velocities V and U, respectively. Assuming that vehicle A is positioned ahead, our primary focus lies on the trailing vehicle, B. Thus, the relative velocity between vehicle B and the reference point can be expressed by means of equation (8).

$$V^*(A,B)=V-U \quad (8)$$

A collision can occur only when the velocity of vehicle U exceeds that of vehicle V. This circumstance can arise from either the acceleration of vehicle B or the deceleration of vehicle A. In the scenario where vehicle A initiates deceleration at time t = t1 and comes to a complete stop at time t = t4, it is assumed that vehicle B detects the deceleration of the leading vehicle and begins decelerating at time t = t2, ultimately ceasing its deceleration at time t = t3. The deceleration rates of vehicle A and B can be mathematically expressed using equation (9) and equation (10), respectively. It is also assumed that the deceleration rates remain constant over time.

$$\frac{V-0}{t4-t1}=a \quad (9)$$

$$\frac{U-0}{t3-t2}=b \quad (10)$$

The safe distance (d) in technical terms can be mathematically described as the difference between the travel distance of vehicle B from the initial time (t = 0) to a specific time (t = t4), and the travel distance of vehicle A from the initial time (t = 0) to a different specific time (t = t3).

$$d=\left[Vt2+\frac{1}{2}\frac{U}{(t3-t2)}*(t3-t2)^2\right]+\left[Vt1+\frac{1}{2}\frac{V}{(t2-t1)}*(t2-t1)^2\right]$$

$$d=\frac{(t3+t2)U}{2}+\frac{(t2-t1)}{2} \quad (11)$$

Substituting (9) and (10) in (11) gives,

$$d = 0.5*\left(\frac{U^2}{b}-\frac{V^2}{b}\right)+Ut_2-Vt_1 \quad (12)$$

Considering the limitations of vehicle B, which solely permits the measurement of relative velocity and its own velocity, the equation denoted as (12) can be reformulated in U and V(A,B). By employing the information presented in equations (8) and (12), a comprehensive analysis can be conducted.

$$d = 0.5*\left(\frac{U^2}{b}-\frac{U+V(A,B)^2)}{a}\right)+(t_2-t_1)+(A,B)*t_1$$

The computation of relative velocity can be formulated using temporal and spatial measurements. The rear vehicle's distance sensors gauge the spatial gap between itself and the forward vehicle at two successive moments in time. By calculating the ratio of the distance covered during this temporal interval to the duration elapsed, the relative velocity can be determined. This iterative procedure is performed continuously to detect alterations in relative velocity, serving as an indicator of potential collision hazards.

IX. Results and Discussion

The graph below shows the response time of the transmitter No 4 to receiver, measured in milliseconds (ms), on the left and the corresponding distance between the sensor and the vehicle, measured in meters (m), on the right.

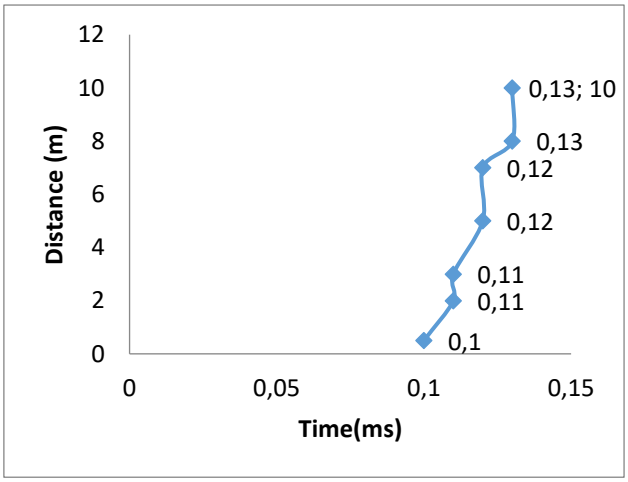

Figure 8: Distance-Response Time between Transmitter No 4 and Receiver

- The response time increases as the distance between the sensor and the vehicle increases.
- There is a 0.02 milliseconds difference in response time between the closest measurement (0.5 meters) and the farthest measurement (10 meters).

We can infer that the speed of the signal is roughly 250,000 meters per second (m/s) since it takes 0.02 ms for the signal to travel 9.5 meters (difference between the farthest and closest measurements). This is close to the speed of light (299,792,458 m/s), which is the speed at which electromagnetic waves travel.

The graph below shows the response time of the transmitter No 3 to receiver, measured in milliseconds (ms), on the left and the corresponding distance between the sensor and the vehicle, measured in meters (m), on the right.

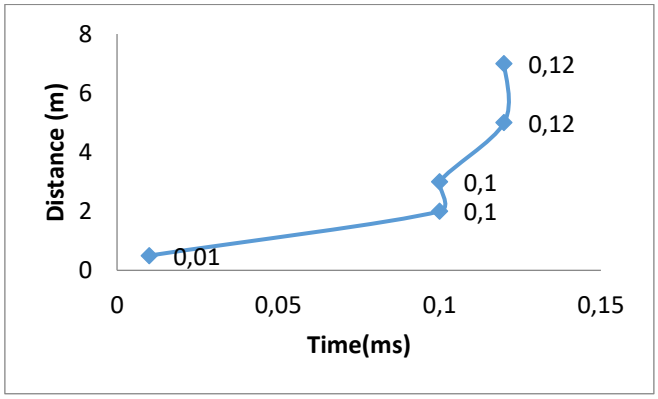

Figure 9: Distance-Response Time between Transmitter No 3 and Receiver

- The response time increases a little bit as the distance between the sensor and the vehicle increases.

The graph below shows the response time of the transmitter No 2 to receiver, measured in milliseconds (ms), on the left and the corresponding distance between the sensor and the vehicle, measured in meters (m), on the right.

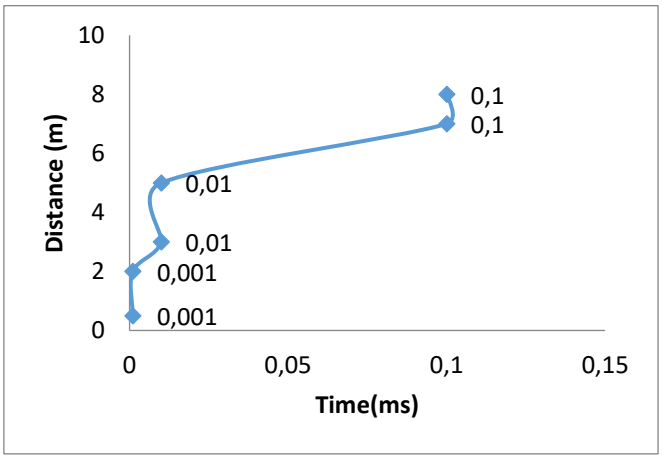

Figure 10: Distance-Response Time between Transmitter No 2 and Receiver

The above three graph shows the response time between transmitters and receiver. We can see in the above graphs that the response time increases a little bit as distance increases.

X. CONCLUSION

Truck Smart has a fundamental structure comprising several straightforward elements. These components, when effectively combined, provide a valuable safety technology solution for an industry that requires an upgrade. During the design phase, significant attention has been given to prioritize the safety of the end user above all else in the Truck Smart system. Various secondary aspects, including system testing, fault reporting, and the potential cognitive impact on the user, have been thoroughly considered to ensure that the final product surpasses any comparable technology in its field. The Truck Smart system has been comprehensively developed to address all aspects and requirements.

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Optimizing Solar Energy Harvesting through Advanced Solar Tracking Systems

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***Abstract* —** The global population is depleting all available income to fulfill their daily energy requirements, and it is highly foreseeable that we will exhaust many naturally occurring resources, including ores, minerals, and petroleum, in the near future. Consequently, there is a growing demand for renewable energy solutions to preserve natural resources and address the energy crisis. Solar energy has emerged as a prominent and sought-after renewable energy source. However, the efficacy of solar panels remains a crucial factor. While the sun traverses a curved path throughout the day, the solar panels typically employed in our region are stationary, fixed either to a pole or the roof of a building. Consequently, their efficiency significantly declines over the course of the day. In our project, we have developed a solar tracking system with a single axis that can continuously track the sun's movement, enabling maximum energy production.

Keywords: LDR sensors, microcontroller, PV Panel, servo motor

INTRODUCTION

Solar energy has garnered increasing attention as a renewable and environmentally-friendly power source. Photovoltaic cells are utilized to directly convert solar energy into electrical energy. This generated energy can be applied in various ways, such as illuminating spaces, providing heat, and operating various devices. The solar cell consists of a semiconductor material that utilizes the photovoltaic effect. When sunlight falls on the exterior or outermost layer of the solar pannel, it results in a higher efficiency system, enabling the maximum production of electrical energy. Numerous experiments have been conducted to optimize the performance of photovoltaic cells. In the past few decades, solar cell modules have been developed and arranged in a series to optimize the output voltage. A solar tracking system is a control system that includes sensors to determine the alignment of sunlight with the PV panel. A controller then sends signals to one or more actuators to adjust the panel to its optimal position. Currently, the dual-axis solar tracker mechanism is gaining interest in the research and development field due to its potential for increasing PV panel efficiency. Researchers are now exploring the use of dc-dc boost converters to match the output voltage and enhance the low voltage from the photovoltaic system. The purpose of the dc-dc boost converter is to raise the low output voltage to a higher level while preventing reverse current flow using a blocking diode. Additionally, researchers are utilizing the Pulse-width Modulation (PWM) approach to regulate the dc-dc boost converter. The Maximum Power Point Tracking (MPPT) method aims to extract the maximum power from solar panels. An intelligent controller is crucial for supporting the efficiency of the PV control system and the mechanical tracking structure. One reliable MPPT method is the fuzzy logic controller, which enables rapid and effective tracking for different optimal operating points. This technique ensures optimal power output under varying weather conditions. Furthermore, Data Acquisition (DAQ) is employed to record

the output voltage from the solar panel for comparison with different weather conditions. Photovoltaic modules utilize sunlight to produce electrical energy via the photovoltaic phenomenon. These modules can be made of crystalline silicon cells or thin-film cells. They require protection against mechanical damage and moisture. While most modules are rigid, there are also semi-flexible options available based on thin-film cells. The cells are electrically connected in series to reach the desired voltage and then in parallel to increase current. The power output of the module is determined by the voltage and current. It is important to note that the manufacturer's specifications for solar panels are found under typical circumstances, which may differ from the actual operating conditions at the installation site.A photovoltaic junction box is connected to the rear of the solar module to serve as the output interface. MC4 connectors are commonly used for external connections, providing impermeable links to the rest of the system.

LITERATURE SURVEY

In their research paper, Ashok Kumar Saxena et. al. [3] provided an explanation regarding the main focus of their study.The key emphasis lies in the controller's capacity to receive data related to photovoltaic technology and weather conditions. For effective control of the tracking system and data monitoring, an electronic controller in the form of a microcontroller is utilized. The section dedicated to the Design aspect centers on the creation of a fully automated and user-friendly system. To accomplish this, four pulse width modulation (PWM) signals are employed to drive a stepper motor, and the essential operating program is stored in an EPROM. The tracking mechanism encompasses both open and closed-loop strategies, while the system also keeps a check on parameters such as Isc, Voc, and Pm to ensure proper load and battery management. The closed-loop strategy enables the solar panel to trace its movement from the initial home position to the maximum position, and subsequently return to the home position. On the other hand, the open-loop strategy is employed specifically for the purpose of data monitoring.

Yaseer M. Safan et. al. [4] elucidated in his scientific publication concerning the Diverse categories of solar tracking mechanisms that exist, each with the objective of maximizing the electrical yield of photovoltaic modules while simultaneously reducing energy usage. One approach involves utilizing a PID controller to track the movement of the sun. This particular intention emphasizes maintaining an optimal angle for the solar panel to receive maximum solar radiation, thereby increasing power generation. Tracking systems can be classified based on the number of axes or degree of independence and drive ability. Examples include one-side and dual-side solar trackers. Additionally, there are active, passive, and hybrid solar trackers. This paper focuses on the design of a hybrid solar tracker, employing both open loop and closed loop strategies. The open loop strategy encounters tracking errors due to sun sensor inaccuracies, while the closed loop plan employs reaction from sun position sensors and placement data to ensure accurate tracking. The construction of the hybrid solar tracker involves three main subsystems: a mechanical system consisting of an aluminum solar tracker structure, an electrical system comprising a solar panel and two stepper motors, LDR and a microcontroller.

Mohamed I. Abu El-Sebah [5] the main purpose of their paper is that discussion has revolved around photovoltaic (PV) systems and how their efficiency can be improved. These systems rely on solar radiation as their main input, which cannot be controlled and varies in intensity throughout the day and seasons. To address these variations, a solar tracking system can be employed. By continuously adjusting the position of the PV panels, the solar tracking system optimizes the absorption of solar radiation, maximizing the output power of the photovoltaic system. However, a drawback of the sun tracking process is its potential to reduce efficiency due to high power intake involved in operating the tracing system. Solar trackers can be broadly categorized into two types: single-axis and dual-axis, based on their degree of freedom and movement capabilities. Furthermore, PV trackers can be categorized as either dynamic or static, contingent upon the tracking mechanism and propulsion system employed.

S.Gupta et.al.[6] their paper include that Due to the scarcity of energy resources, scientists have turned their attention to harnessing solar energy for electricity generation. In their pursuit, they have discovered that photovoltaic cells are capable of converting solar energy into electrical power. To maximize the efficiency of these cells and develop better systems, researchers have found that their performance depends on the factor such as materials used, size of the cells, intensity of sunlight, and atmospheric conditions.

To study the behavior of solar photovoltaic cells, scientists have analyzed the voltage-current curve under different levels of incident radiation throughout the day. They specifically focused on the mid-day readings, as this is when solar radiation is most abundant worldwide. Based on their comprehensive analysis, the researchers arrived at the conclusion that the electric current produced by a photovoltaic cell is contingent upon several key factors, namely its efficacy, surface area, and the incident solar radiation intensity.

Extensive works reviews have documented various methods and techniques for maximizing power output from solar systems. Until 2007, the prevalent approach was maximum power point tracking (MPPT), which aimed to optimize power generation. However, fixed solar systems have since replaced MPPT in many cases. Researchers have compared these different approaches, considering factors such as system cost, speed, efficiency, and the use of direct current (DC) converters.

Ayushi Nitin Ingole and colleagues (7) conducted a study emphasizing the importance of utilizing solar power. The significance of employing solar energy cannot be overstated. With globalization leading to an ongoing increase in the demand for electricity every year, conventional resources for generating power are being depleted. Consequently, individuals have actively been searching for alternative methods and technologies that make use of renewable energy sources. Renewable energy refers to the energy derived from natural resources that are readily available in the environment. Among these alternatives, solar energy emerges as the most feasible option due to its abundant and cost-free availability in nature. Hence, it is logically justified to harness solar energy for the purpose of electricity generation. Additionally, solar energy exhibits a high degree of environmental sustainability by virtue of its negligible emissions of pollutants compared to conventional fossil fuels. Solar energy embodies harnessed by absorbing solar radiations through solar panels, which convert it into direct current (DC) electric energy. In Malaysia, a country with exceptionally high levels of solar radiation, solar energy holds immense potential for its conversion into electrical energy.

This scholarly paper by Deepthi S. and colleagues [8] explores various categories of solitary-direction monitoring mechanisms, which entail continuous adaptation of solar panels' orientation to align with the sun's movement from dawn to dusk. There exist three primary kinds of solitary-direction tracking systems: horizontal, vertical, and inclined. In the horizontal configuration, the panels revolve around a level axis that runs parallel to the ground. Conversely, in the vertical setup, the panels rotate around a vertical axis at an inclination relative to the ground. The inclined system involves rotation around an axis positioned between horizontal and vertical, where the panel surface remains parallel to the rotation axis, much like the horizontal configuration. Typically, these monitoring systems employ two light-sensitive resistors (LDRs) positioned on the eastern and western sides of the solar panel. By gauging the sunlight intensity on both LDRs, the system can ascertain the sun's position and accordingly regulate the panel's rotation. Throughout the course of the day, the strength of the light-dependent resistor (LDR) on the western side grows, leading the controller to pivot the solar panel in the direction of the west. You may be curious about the functioning of a solar tracker. To address this, let's delve into its operation. As previously mentioned, for optimal power generation, the solar panel needs to be oriented towards the sun. Therefore, our system consists of two main stages: firstly, identifying the sun's position, and secondly, adjusting the solar panel to align with its movement.

SYSTEM CONFIGURATION

The primary aim of the intelligent system is to achieve optimal alignment between the incoming sun rays and the surface of the photovoltaic (PV) panel in order to maximize power generation. The illustrative

diagram depicting the components of the intelligent Dynamic Active Sun Tracking (DAST) system is presented in the figure below. The tracking system operates based on the program integrated into the ATMega328 microcontroller of the Arduino UNO board. Serving as the central processing unit of the entire system, the ATMega328 microcontroller converts the analog readings from light-dependent resistor (LDR) sensors into digital signals and utilizes a single output channel to regulate the movement of the PV panel via servo motors. Consequently, the panel rotation occurs along a single axis.

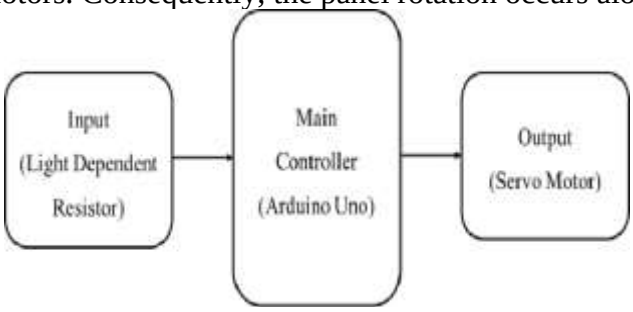

figure 1

HARDWARE SYSTEM

As depicted in the preceding illustration, the sun tracking setup comprises the photovoltaic (PV) module, light-dependent resistors (LDRs) functioning as irradiance sensors, servo motors, and the Arduino UNO board housing the integrated ATMega328 microcontroller.

SOLAR PANEL (PV MODULE):

A PV module, also known as a photovoltaic module or solar panel, is a device that converts sunlight directly into electrical energy through the photovoltaic effect. It is a key component of solar power systems used to harness renewable energy from the sun.

A PV module consists of multiple interconnected solar cells, typically made of silicon-based materials, that generate electricity when exposed to sunlight. These solar cells are encapsulated in a protective material, such as tempered glass, to ensure durability and resistance to environmental factors.

When sunlight strikes the surface of the PV module, the photons in the light excite electrons in the solar cells, creating a flow of electricity. The generated electricity is in the form of direct current (DC). To make it compatible with standard electrical systems, an inverter is often used to convert the DC power into alternating current (AC) electricity.

PV modules vary in size, power output, and efficiency. They can range from small panels used for charging batteries or powering small devices to larger installations used in residential, commercial, or utility-scale solar power systems. The output power of PV is measured in Watts(W) and is influenced by factors such as the surface area of the module, the efficiency of the solar cells, and the intensity of sunlight.

PV modules have become increasingly cost-effective and efficient over the years, contributing to the widespread adoption of solar energy as a clean and renewable source of electricity. They are a key component in harnessing solar power for a wide range of applications, including residential and commercial electricity generation, remote power systems, and off-grid installations.

Arduino UNO:

Arduino Uno is a popular open-source microcontroller board widely used in the field of electronics and prototyping. It is based on the ATmega328P microcontroller, which is integrated onto the board. Arduino Uno provides a user-friendly platform for developing and programming various electronic projects.

The Arduino Uno board features digital input/output pins, analog input pins, a power jack, USB connection, a reset button, and other essential components. The device can be energized via either the Universal Serial Bus (USB) interface or an external power supply, such as a rechargeable battery or an Alternating Current-to-Direct Current (AC-to-DC) adapter.The board is compatible with the Arduino programming language, allowing users to write and upload code easily using the Arduino Integrated Development Environment (IDE).

With its simplicity and versatility, Arduino Uno is widely utilized by beginners and professionals alike to create interactive projects, control sensors and actuators, and build electronic prototypes. Its open-source nature enables a vast community of developers to share libraries, code examples, and resources, making it an accessible and flexible platform for realizing a wide range of innovative applications.

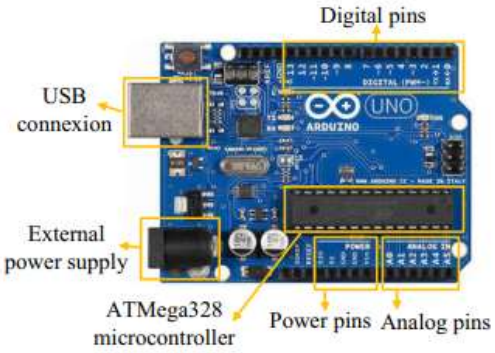

figure 2

Servo Motor:

A servo motor is an electric motor utilized in diverse applications necessitating meticulous regulation of angular or linear positioning, velocity, and acceleration. It operates as a closed-loop system, integrating a motor, a position sensing component (such as a potentiometer or an encoder), and a control circuit.

The main characteristic of a servo motor is its ability to accurately position the output shaft to a specified angle or position. This is achieved by receiving control signals, typically in the form of pulses, from an external controller. The control circuit compares the desired position with the actual position feedback received from the sensor, and adjusts the motor's speed and direction to reach and maintain the desired position.

Servo motors are known for their high precision, responsiveness, and repeatability. They can quickly and accurately move to a desired position, making them suitable for a wide range of applications, including robotics, automation systems, CNC machines, remote-controlled vehicles, and more.

The speed and torque of a servo motor can also be controlled, allowing for smooth and controlled motion. Servo motors are available in various sizes and power ratings, depending on the specific application requirements. They are typically designed to operate on low-voltage DC power sources, making them compatible with battery-powered systems.

Overall, servo motors play a critical role in achieving precise and controlled motion in a wide range of applications, making them a popular choice in industries that require accurate positioning and motion control.

figure 3

Light Dependent Resistor(LDR):

LDR stands for Light Dependent Resistor, also known as a photoresistor or photocell. It is an electronic component that exhibits changes in resistance based on the intensity of light falling on it. LDRs are passive components that do not require an external power supply to function.

LDRs are typically made of a semiconductor material whose conductivity varies with light exposure. When exposed to light, the photons interact with the semiconductor material, causing a change in the number of charge carriers, which in turn affects the resistance of the LDR.

In bright light conditions, LDRs exhibit low resistance, allowing current to flow easily. Conversely, in low light conditions or darkness, the resistance of the LDR increases, restricting the flow of current. This light-dependent behavior makes LDRs useful in various applications where light sensing or control is required.

LDRs are commonly used in automatic lighting systems, where they can detect ambient light levels and trigger the activation or deactivation of lighting sources accordingly. They are also utilized in photography equipment, burglar alarm systems, solar-powered devices, and other light-sensitive applications.

The resistance of an LDR can be measured using analog or digital circuits, and its response can be calibrated to specific light levels. LDRs are available in different sizes, shapes, and response characteristics, allowing for customization based on the intended application.

Overall, LDRs provide a simple and cost-effective way to sense and respond to changes in ambient light levels, enabling a wide range of light-based control and sensing applications.

figure 4

METHODOLOGY

The single-axis solar tracking system is specifically designed to guarantee that the solar panel constantly faces the sun during the entire day by rotating from the east to the west. This system employs two Light Dependent Resistors (LDRs), a servo motor, and an Arduino microcontroller. The servo motor establishes a mechanical linkage with the solar panel via a shaft. A Light Dependent Resistor (LDR) is strategically positioned on the eastern side of the panel, with another LDR being located on the western side.

LDRs serve as active sensors that detect the brightness level of light. As the sunlight intensity increases, the resistance of the LDR also increases. Within this system, the LDRs function as inputs, continually monitoring the brightness level of the sunlight. When the intensity measured by the western LDR surpasses that of the eastern LDR (as the sun progressively moves towards the west throughout the day), the servo motor rotates the panel in the westward direction.

To accomplish this rotation, a program written in assembly language is created and stored in the Arduino microcontroller. The software architecture of the system can be bifurcated into two principal modules. The first module encompasses the positioning procedure, wherein the system necessitates manual alignment of the panel towards the eastern direction subsequent to sunset and prior to the following sunrise, before system activation.

The subsequent section centers around the empirical displacement of the panel, which constitutes the fundamental element of the program. Once the panel is initially positioned, it continuously tracks the brightness level of the sunlight and makes precise adjustments accordingly. The compiled program governs the entire operation of the hardware, ensuring that the solar panel optimally aligns itself with the sun's position throughout the day.

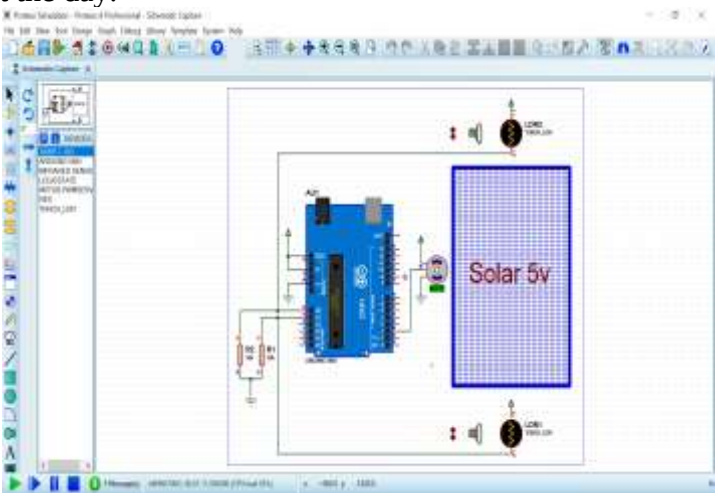

figure 5

SOFTWARE IMPLEMENTATION

The process of implementing the software involves writing the tracking system algorithm using the Arduino IDE platform and then transferring it to the microcontroller. The flowchart illustrating the operation of the microcontroller is depicted in Figure 6.

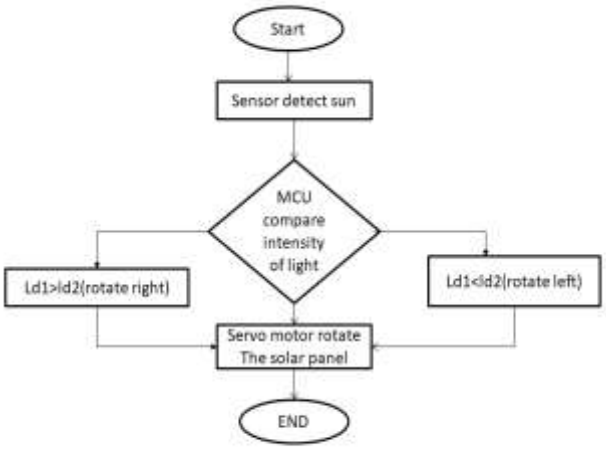

figure 6

ARDUINO ALGORITHIM

1st of all we have to sets both LDRs on East and West side
#define ldr1 A0 // set ldr 1 Analog input pin of East LDR as an integer
#define ldr2 A1 // set ldr 2 Analog input pin of West LDR as an integer
Then we have to set its initial position and some tolerance
int pos = 90;
int tolerance = 20;
In Void loop Portion Int val 1 will read LDR 1 and Int val 2 will read LDR 2
int val1 = analogRead(ldr1);
int val2 = analogRead(ldr2);
If average of both is less than tolerance there will be no movement.If value of LDR1 greater than LDR2 it will increment+1 & If value of LDR2 greater than LDR1 it will decrement+1.
if((abs(val1 - val2) <= tolerance) || (abs (val2 - val1) tolerance)) {
} else {
if(val1>val2) // if ldr1 senses more light than Idr2
{
pos=pos+1;
if(vall < val2) // if ldr2 senses more light than Idr1
{
pos=pos-1;

RESULTS AND DISCUSSION

Sr No	Time	Fixed Panel			With-Tracker		
		V	I	P	V	I	P
1	9.00	5.5	0.05	0.275	6.3	0.07	0.44
2	11.00	6.34	0.07	0.114	7.1	0.2	1.42
3	12.00	7.8	0.22	1.716	8.0	0.24	1.93
4	14.00	7.03	0.09	0.633	7.5	0.12	0.9
5	16.00	6.56	0.08	0.558	7.5	0.1	0.75
6	18.00	5.2	0.05	0.25	6.8	0.09	0.61
Total Power				**3.875**			**5.144**

The table shows the response time of the transmitter to receiver, measured in milliseconds (ms), on the left and the corresponding distance between the sensor and the car, measured in meters (m), on the right.

Here are some observations from the table:

The response time increases as the distance between the sensor and the car increases.

There is a 0.02 milliseconds difference in response time between the closest measurement (0.5 meters) and the farthest measurement (10 meters).

We can infer that the speed of the signal is roughly 250,000 meters per second (m/s) since it takes 0.02 ms for the signal to travel 9.5 meters (difference between the farthest and closest measurements). This is close to the speed of light (299,792,458 m/s), which is the speed at which electromagnetic waves travel.

$$\frac{Total\ power\ with\ tracker \times Total\ power\ of\ fixed\ pannel}{Total\ power\ with\ tracker} \times 100$$

$$\frac{5.144 - 3.875}{5.144} \times 100 \qquad = 24.67\%$$

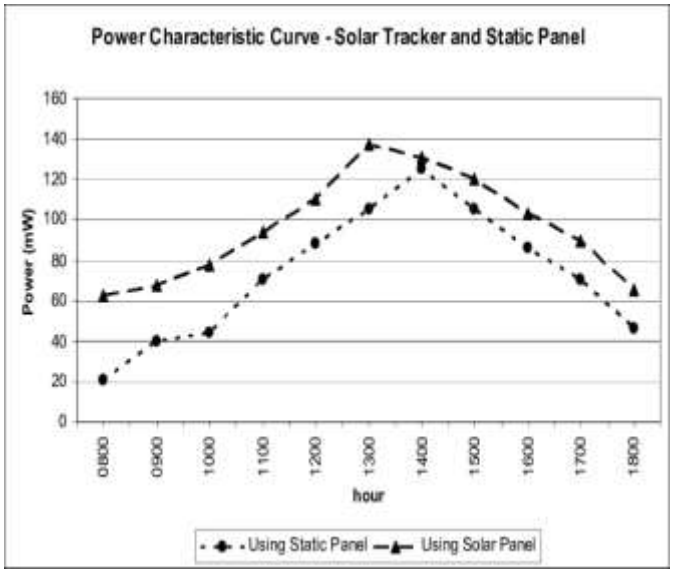

figure 7

Hence, percentage increase in output of solar tracker with respect to fixed panel is 24.67 % per day.
As solar trackers extend the operational period by adjusting the angle during mornings, evenings, and even in partially cloudy conditions, they effectively lengthen the time of productive power generation to achieve better performance. Fixed solar panels are set to maximize power output at 12:00 o'clock; consequently, their output is low in the morning as well as in the evening. In the morning, the temperature is also low, and due to the fixed angle of the solar panels, they receive less irradiance, resulting in a power output of 0.275W at 9 o'clock. On the other hand, solar panels equipped with trackers rotate based on irradiance measurements, adjusting their angles accordingly and generating 0.44W of power. A similar phenomenon occurs throughout the day.

CONCLUSION

A Single Axis Solar Tracker is a device that follows the movement of the sun throughout the day to maximize the amount of solar energy captured. Unlike fixed solar panels, which are stationary, the tracker adjusts its position to directly face the sun, resulting in the absorption of more solar rays. Studies have shown that this type of tracker can generate up to 20% additional power per year compared to fixed installations.

The tracker operates by employing a variable elevation mechanism that allows it to track The diurnal trajectory of the sun, progressing from an eastern to a western direction, is governed by constant

positional adjustments. the tracker ensures that the solar panels receive optimal sunlight throughout the day, resulting in increased power generation. This is especially beneficial in areas where sunlight conditions change throughout the year.

To achieve the best performance, the system utilizes a low-speed DC geared motor. This motor is specifically chosen to eliminate the need to consider motor speed as a variable, allowing the system to solely focus on tracking the intensity of the sun. By simplifying the motor's operation, the system can efficiently and accurately track the sun movement, maximizing the power output of the solar panels.

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İhracatta İstikrarsızlığın Ekonomik Büyümeye Etkisi: Türkiye İçin Ampirik Bir Analiz

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Özet – İhracat artışı ekonomik büyümeye önemli bir katkı sağlamakta ve bu da kalkınma ve refah artışında önemli bir rol oynamaktadır. Ancak bu katkı ihracat gelirlerinin istikrarına bağlıdır, dolayısıyla ekonomik büyüme ve ihracattan elde edilen getiriler arasındaki bağlantı ihracat istikrarsızlığı nedeniyle bozulabilir. Gelişmekte olan ekonomilerin en büyük sorunlarından biri ihracat ve ticaret dengesinde yaşanan istikrarsızlıktır. İhracat gelirlerindeki kısa vadeli veya yıllık dalgalanmalar, ihracatın büyüme eğilimi etrafında ihracat istikrarsızlığı olarak nitelendirilmektedir.

1980'lerden itibaren hızla liberalleşen Türkiye ekonomisi ihracata dayalı büyüme yaklaşımını benimserken istikrarlı ve yüksek hacimli ihracat hedeflerine pek ulaşılamamıştır. Bununla birlikte 2000'li yıllarda ihracat hacminde yaşanan gelişmeler ve ihracatçı sektörlerin yapısındaki değişim ihracatın sürdürülebilir büyüme açısından önemini artırmıştır. Bu çalışmada, Türkiye'de ihracat gelirlerindeki dalgalanmanın büyümeye etkisi zaman serileri analizi yöntemleriyle araştırılmıştır. Elde edilen bulgular kısa ve uzun dönemde ihracat gelirlerindeki dalgalanmanın Türkiye'nin ekonomik büyümesine istatistiksel olarak anlamlı ve pozitif etkide bulunduğuna işaret etmektedir. Buna göre genel olarak artış yönünde seyreden ihracat değişkenliğinin Türkiye'de ekonomik büyüme açısından bir risk oluşturmadığı, aksine ekonominin bu dalgalanmalardan olumlu yönde yararlandığı anlaşılmaktadır.

Anahtar Kelimeler – İhracat istikrarsızlığı, ekonomik büyüme, zaman serileri analizi, ARDL modeli, Türkiye

I. GİRİŞ

İhracat artışı, ekonomik büyümeye önemli bir katkı sağlamakta ve bu da kalkınma ve refah artışında önemli bir rol oynamaktadır. İhracatın ekonomik büyümeyi teşvik etmedeki bu önemli ve öngörülebilir rolü, ihracat kazançlarında net ve belirli büyüme oranları gerektirir. Buna ek olarak, güvenilir ve uygulanabilir kalkınma planları oluşturmak için ihracatçı veya ithalatçı ülkenin koşulları altında gelecekteki kazancı tahmin etme becerisi gerektirir. Dolayısıyla ihracat gelirlerindeki istikrarsızlık, ihracat ve ekonomik büyüme arasındaki ilişkinin yanı sıra ihracatçı ülkelerde kalkınma planlarının uygulanmasını da etkilemektedir. Ancak ihracat istikrarsızlığının özü, diğer ekonomik değişkenler gibi ihracat kazançlarının da zaman içinde düzgün veya belirli bir yol izlememesidir. Bu tür kazanç davranışları yerel ekonomi için maliyet yaratır (Abu Lila vd., 2021).

İhracattan sağlanacak katkı ihracat gelirlerinin istikrarına da bağlıdır, dolayısıyla ekonomik büyüme ve ihracattan elde edilen getiriler arasındaki bağlantı ihracat istikrarsızlığı nedeniyle bozulabilmektedir. Bu istikrarsızlık fiyat istikrarsızlığı, emtia yoğunlaşması ve ihracat piyasasında gözlenebilen coğrafi yoğunlaşma nedeniyle ortaya çıkabilir (Abdelhadi vd., 2019). İhracat istikrarsızlığının kötü sonuçları, yükselen piyasalar ve az gelişmekte olan ülkelerin çoğunda olduğu gibi, ihracat sektörü birincil ürünlere bağlı olan bir ülkenin ekonomik konumunu tehdit edebilir. Gelişmekte olan ekonomilerin en büyük sorunlarından biri ihracat ve ticaret dengesinde yaşanan istikrarsızlıktır. İhracat gelirlerindeki kısa vadeli veya yıllık değişimler, ihracatın büyüme eğilimi etrafında ihracat istikrarsızlığı olarak nitelendirilmektedir.

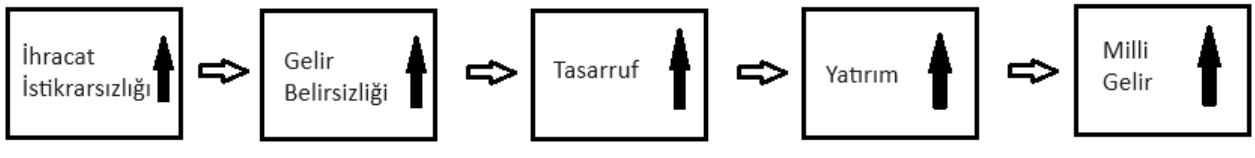
İhracat gelirlerindeki istikrarsızlık öncelikle ihracatçı firmaların üretim ve finans yapısını etkileyerek, daha sonra ise hem doğrudan bu firmaların hem de bu firmalarla irtibatlı olan diğer firmaların performanslarındaki düzensizliğin toplam yayılma etkisi yoluyla ekonominin genelinde olumsuz bir sonuç doğurabilmektedir. Dışsal ve/veya içsel siyasi veya ekonomik nedenlerin ihracat gelirlerinde yaratabileceği istikrarsızlık öncelikle ihracatçı firmaların borç ve yükümlülüklerini, üretim planlarını ve sipariş yapılarını bozacaktır. İstikrarsızlığa neden olan faktörlerin derinlik, yaygınlık ve kalıcılığına bağlı olarak bu bozucu etkinin ilişkili sektörlerden başlayarak ekonominin geneline yayılması neredeyse kaçınılmazdır.

1980'lerden itibaren hızla liberalleşen Türkiye ekonomisi ihracata dayalı büyüme yaklaşımını benimserken, bir yandan bürokratik işleyişteki aksaklıklar diğer yandan iç ve dış şoklar karşısındaki ekonominin genel kırılgan yapısı ihracat gelirlerinin dalgalı bir seyir izlemesine neden olmuştur. Bununla birlikte 2000'li yıllarda ihracat hacminde yaşanan gelişmeler ve ihracatçı sektörlerin yapısındaki değişim ihracatın sürdürülebilir büyüme açısından önemini daha da artırmıştır. İhracatın Türkiye ekonomisi için önemine binaen bu çalışmada Türkiye'de ihracat gelirlerindeki dalgalanmanın büyümeye etkisi zaman serileri analizi yöntemleriyle araştırılmıştır.

II. İHRACAT İSTİKRARSIZLIĞI VE BÜYÜME

Birçok çalışmada elde edilen ampirik kanıtlar, ihracat istikrarsızlığının ihracatın emtia yoğunlaşma derecesi ve ihracat gelirlerinin birincil mal satışlarından elde edilen oranları ile pozitif, kişi başına düşen gelir ve ihracatın coğrafi varış bölgesine göre yoğunlaşması ile negatif ilişkili olduğu sonucuna varmıştır (Okonkwo ve Douglas, 2016). İhracat gelirlerindeki dalgalanma ekonomik performansı kısıtlayabilir. Öyle ki, döviz gelirlerindeki aşırı dalgalanma, yatırım kararlarını ve girişimcilerin geleceğe yönelik beklentilerini olumsuz etkileyerek yeni yatırım fırsatlarının riskini artıran beklenmedik sinyaller ürettiği için gelişmekte olan ülkelerin kalkınması üzerinde bir kısıtlama haline gelebilmektedir. Bu durum da düşük büyüme beklentilerine yol açmaktadır. Ayrıca ihracattaki düzensizliğe bağlı olarak döviz gelirlerindeki dalgalanma, kalkınma için gerekli temel mal ve makinelerin ithalatına yönelik fonları da azaltmaktadır (Chaudhary ve Qaisrani, 2002). Bazı çalışmalarda ise ihracat istikrarsızlığının belirsizlik ve gelecek korkusu yoluyla ekonomik büyümeyi olumlu etkilediğini, böylece tasarrufları ve dolayısıyla yatırımları artırdığı öne sürülmektedir. İhracat istikrarı ve ekonomik büyüme arasındaki belirsiz ilişki, özellikle az gelişmekte olan ülkelerde, ekonomi literatüründe tartışma konusu olmaya devam etmektedir.

A. İhracattaki istikrarsızlığın ekonomik büyüme üzerindeki olumsuz etkileri



B. İhracattaki istikrarsızlığın ekonomik büyüme üzerindeki olumlu etkileri

Şekil 1. İhracattaki İstikrarsızlığın Ekonomik Büyüme Üzerindeki Etkileri

Fosu (1992) ve Rashid vd. (2012), ihracat istikrarsızlığının ekonomik büyüme üzerindeki olumlu veya olumsuz etkisini açıklayan mekanizmayı bir dizi çalışmaya dayanarak ortaya koymuşlardır. İhracat istikrarsızlığının olumsuz etkisini üretim sürecinde girdi eksikliği ile açıklamışlardır, çünkü artan ihracat istikrarsızlığı yabancı rezervlerde azalmaya yol açarak ülkenin üretim süreçlerinde ihtiyaç duyulan sermaye mallarını ithal etme kabiliyetini azaltmaktadır. Ayrıca, sermaye malları ve sermaye birikimindeki azalma, yatırımların ve dolayısıyla üretim hacminde, dolayısıyla gelirde bir azalmaya yol açmaktadır (Şekil 1-A).

İhracat istikrarsızlığı ile ekonomik büyüme arasındaki pozitif ilişki ise ihracat istikrarsızlığının tüketim ve tasarruflar üzerindeki etkisi ile açıklanmaktadır. İhracat daha istikrarsız hale geldiğinde, bireylerin gelirlerine ilişkin belirsizlik artar, bu da tüketimlerini azaltarak ihtiyatlı bir şekilde tasarruflarını artırmalarına neden olur, bu durumda marjinal tüketim eğilimi düşerken marjinal tasarruf eğilimi yükselir. Ekonomide artan tasarruf yatırımların ve dolayısıyla üretimin artmasına yol açar. Bu da gelir artışı demektir (Şekil 1-B).

II. İLGİLİ LİTERATÜR

İhracat gelirleri birçok ülke için kalkınma ve büyümenin en önemli belirleyicileri arasındadır. Bu nedenle ihracata dayalı büyüme hipotezi akademik olarak birçok çalışmaya konu olmuş ve geçerliliği farklı yöntem ve model yapılarıyla araştırılmıştır. Buna karşılık, sözkonusu ilişkinin geçerliğini etkileme potansiyeline sahip olan ihracat gelirlerinde istikrar konusu üzerinde gerektiği kadar durulmadığı söylenebilir. Konuyu ampirik olarak ele alan az sayıda çalışmada farklı veri türleri (yatay-kesit, zaman serileri, panel veri) ve spesifikasyonlar yoluyla ihracat istikrarsızlığı ile ekonomik büyüme arasındaki ilişkinin araştırıldığı görülmektedir.

İhracat dalgalanmaları ile ekonomik büyüme arasındaki bağlantıyı araştıran çalışmalardan çıkan sonuçlar bir fikir birliği sağlamaktan uzaktır. Bu konudaki ilk kavramsallaştırmalar neredeyse değişmez bir şekilde ihracat dalgalanmalarının açık ekonomilerin, özellikle de az gelişmiş ülkelerin performansı üzerindeki olumsuz etkisini vurgulayan argümanların geliştirilmesine yol açmıştır. Olumsuz etkiler, ihracat istikrarsızlığı ile ilişkili belirsizliğin verimliliği ve yatırım seviyesini düşürmesi ve dolayısıyla büyüme eğilimini etkilemesi gerektiği temelinde varsayılmıştır. Bazı ampirik çalışmalar daha sonra bu hipotezi doğrulamıştır [bkz. Glezakos (1973) ve Voivodas (1974)]. Ancak bu bulgu hem ampirik hem de teorik olarak birçok kez sorgulanmıştır. Caine (1958), McBean (1966), Knudsen ve Parnes (1975) ve Yotopoulos ve Nugent (1976), diğerlerinin yanı sıra, yaygın kanının aksine, ihracat kazançlarındaki belirsizliğin büyümeyi teşvik edebileceğini savunmuşlardır. Ayrıca bu hipotez için bazı ampirik destekler de sağlamışlardır. Son olarak diğer yazarlar, elde edilen ilişkilerin zaman içinde istikrarlı olmadığının kanıtlandığını ileri sürmüşlerdir [bkz. Kenen ve Voivodas (1972)]. Ancak bu sonuçlara ilişkin herhangi bir açıklama veya uzlaşma ortaya konmamıştır (Moran, 1983).

Konuyla ilgili öncü çalışmasında Glezakos (1973) ihracat istikrarsızlığını miktar ve gelir açısından ayrı ayrı ele almıştır. Regresyon analizi bulguları ihracat istikrarsızlığının az gelişmiş ülkelerde genellikle gelişmiş ülkelerden daha büyük olduğu ve bu istikrarsızlığın ilkinde ekonomik büyümeye zarar verirken ikincisinde zarar vermediği yönündeki a priori argümanları desteklediği sonucuna ulaşılmaktadır.

Kaushik ve Klein (2008), Hindistan örneğinde konuyu ele aldıkları çalışmada kısa dönemde ihracat istikrarsızlığının büyümeyi negatif ancak uzun dönemde pozitif yönde etkilediği yönünde bulguya ulaşmışlardır. Arshed vd. (2022) ise ihracat istikrarsızlığı ile ekonomik büyüme arasında ters-U biçimli bir ilişki olabileceği düşüncesinden hareketle karesel bir model aracılığıyla ilişkiyi incelemişlerdir. Elde ettikleri sonuçlar, Pakistan örneğinde doğrusal olmayan ilişkinin varlığına işaret etmektedir.

III. YÖNTEM, MODEL VE VERİLER

Bu çalışmada değişkenler arasındaki uzun dönemli ilişkinin varlığı (eşbütünleşme) ve katsayı tahminleri için otoregresif dağıtılmış gecikme (Autoregressive Distributed Lags-ARDL) modeli yaklaşımı takip edilmiştir. Pesaran vd. (2001) tarafından geliştirilen ARDL modeline dayalı "sınır testi" farklı dereceden bütünleşik seriler arasındaki eşbütünleşme ilişkisinin varlığını araştırmayı mümkün kılmaktadır. Bunun dışında yöntemin Johansen tarafından önerilen VAR modeline dayalı eşbütünleşme testine göre başka avantajları da vardır.

İki değişkenli (Y ve X) bir durum için doğrusal ARDL(p,q) modeli aşağıdaki gibi yazılabilir:

$$\Delta Y_t = \mu + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \sum_{j=0}^{q} \delta_j \Delta X_{t-j} + \beta_1 Y_{t-1} + \beta_2 X_{t-1} + \omega_t$$

Değişkenler arasında eşbütünleşme ilişkisi bulunmadığı şeklindeki sıfır hipotezi modifiye edilmiş *F*, *t* veya Wald testi yoluyla test edilebilir. Eşbütünleşme ilişkisinin varlığı kanıtlandıktan sonra ikinci aşamada, değişkenler arasındaki uzun dönemli ilişki aşağıdaki denklem yardımıyla tahmin edilmektedir:

$$Y_t = \eta + \sum_{i=1}^{p} \theta_i Y_{t-i} + \sum_{j=0}^{q} \omega_j X_{t-j} + u_t$$

Son olarak, değişkenler arasındaki kısa dönem ilişkisinin varlığı da aşağıdaki hata düzeltme modeli aracılığıyla incelenmektedir:

$$\Delta Y_t = \lambda + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \sum_{j=0}^{q} \delta_j \Delta X_{t-j} + \varphi ECM_{t-1} + \upsilon_t$$

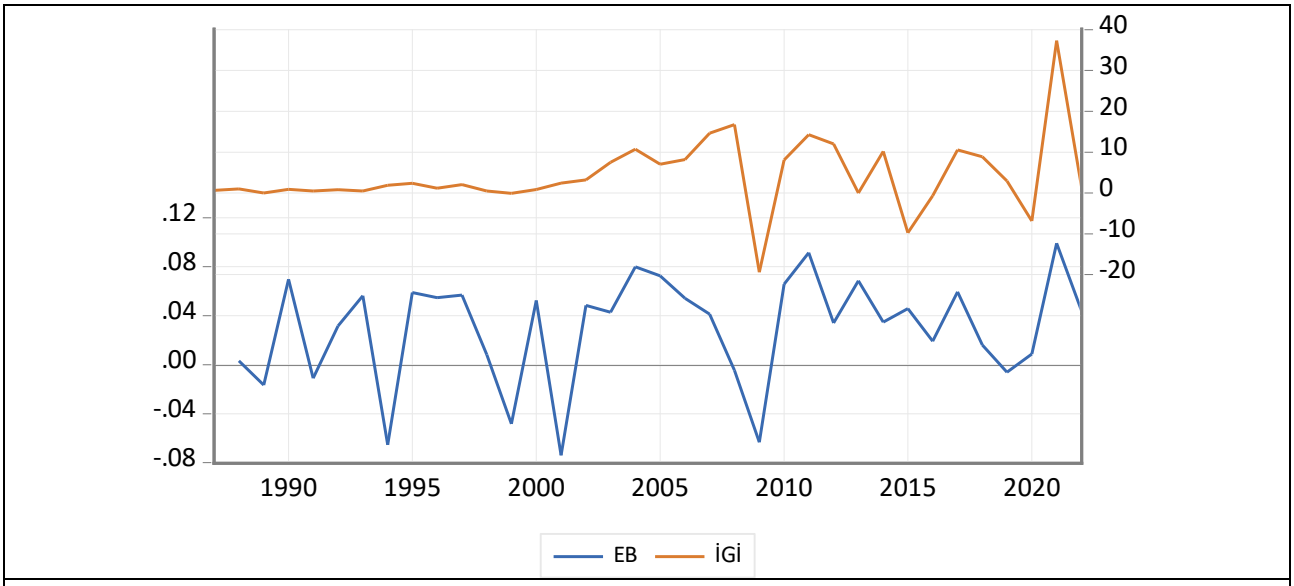
Çalışmanın odak noktasını oluşturan ihracat gelirlerinin istikrarsızlığının nasıl ölçüleceği konusu üzerinde durmak gerekmektedir. Bölüm II'de de ifade edildiği gibi literatürde "ihracatın oynaklığı" ve "ihracatın istikrarsızlığı" kavramları çoğu zaman birbiri yerine kullanılabilmektedir. Ancak genel bir kavram olarak "oynaklık" (volatility) genellikle standart sapma veya daha sofistike bir yöntem olarak GARCH modeli yoluyla ölçülmektedir. İhracat istikrarsızlığı için kimi çalışmalarda ihracat için tahmin edilen (doğrusal veya karesel) trend denkleminin (Massell, 1970; Gyimah-Brempong, 1991; Bilquees ve Mukhtar, 2011), kimi çalışmalarda ise ihracat değer endeksi (İDE)'nin AR(1) modelinden elde edilen kalıntıların tahminleri kullanılmaktadır (Arshed vd., 2022). Ancak, ilk yaklaşıma başvurulduğunda trend yapısının isabetli bir şekilde teşhis edilememesi (örneğin karesel trend yerine doğrusal trend varsayımı) veya seride deterministik değil de stokastik trend bulunması halinde tahminler sapmalı olacaktır (Araujo vd., 1999). Bu nedenle burada ikinci yaklaşım benimsenerek ihracat gelirleri istikrarsızlığı (*İGİ*) aşağıdaki AR(1) modelinden elde edilmektedir:

$$IDE_t = \mu + \varphi IDE_{t-1} + \varepsilon_t \quad , \qquad IGI_t = \hat{\varepsilon}_t$$

Ekonomik büyüme çok sayıda faktörden etkilenebilen ve çok farklı teorik yaklaşımlarla doğası açıklamaya çalışılan bir olgudur. Burada ekonomik büyüme, Gyimah-Brempong (1991) ve Fosu (1992)'nun yaklaşımlarını izleyerek, temelde emek ve sermayenin bir fonksiyonu olarak makro düzeyli çıktı miktarı şeklinde düşünülerek Cobb-Douglas tipi bir üretim fonksiyonu ile karakterize edilmiştir. Bu kurguyla uyumlu olarak çıktı miktarı yerine fark belirten büyüme değil ekonomik üretim hacminin bir göstergesi olan kişi başına GSYH kullanılmıştır. Buna göre, modelde bağımlı değişken kişi başına GSYH (*KGSYH*), kor bağımsız değişkenler ise sermaye girdisini temsilen gayrısafî sabit sermaye oluşumu (*GSSO*) ve emeği temsilen toplam işgücü (*TİG*)'nden oluşmaktadır. Bu üretim fonksiyonu ihracat gelirlerinin istikrarsızlığını temsil eden *İGİ* ile genişletilmiştir. Buna göre tahmin edilecek ekonometrik model ARDL formunda aşağıdaki gibi yazılabilir:

$$\Delta KGSYH_t = \mu + \sum_{i=1}^{p} \alpha_i \Delta KGSYH_{t-i} + \sum_{j=0}^{q} \beta_j \Delta GSSO_{t-j} + \sum_{j=0}^{q} \gamma_j \Delta TIG_{t-j} + \sum_{j=0}^{q} \theta_j \Delta IGI_{t-j} + \pi_1 KGSYH_{t-1} + \pi_2 GSSO_{t-1} + \pi_3 TIG_{t-1} + \pi_4 IGI_{t-1} + \omega_t$$

Örneklem dönemi 1987-2022 arasını kapsamaktadır. *İDE* verileri TCMB-EVDS'den, diğer tüm veriler Dünya Bankası'nın Dünya Kalkınma Göstergeleri (WDI) veritabanından derlenmiştir. Örneklem dönemi içinde ekonomik büyüme ve ihracat gelirlerinde istikrarsızlığın (*İGİ*, $\hat{\varepsilon}_t$)'nin değişimi Şekil 1'de görülmektedir. 2000'lerin başına kadar ihracat gelirlerinde istikrarsızlığın düşük olduğu ama bu tarihlerden itibaren ciddi bir istikrarsızlığın ortaya çıktığı görülmektedir. 2008 küresel finans krizinin bir yıl gecikmeli etkisi ve COVID-19 pandemisi sonrasındaki artış dikkat çekmektedir. İstikrarsızlığın hissedildiği 2000 sonrası dönemde büyümeye koşut davranış biçimi göze çarpmaktadır.



Şekil 1. Ekonomik büyüme ve ihracat gelirleri istikrarsızlığının zaman içindeki seyri

IV. BULGULAR

Zaman serileri analizinde ilk aşama serilerin durağanlık özelliklerinin araştırılmasıdır. Olası bir sahte regresyon ilişkisinden kaçınmak ve ilişkiyi daha doğru bir şekilde modellemek açısından serilerin durağan bir davranış sergilemesi önemlidir. Bu amaçla tüm serilerin orijinal/düzey değerleri için Dickey ve Fuller (1979) tarafından geliştirilen ve Said ve Dickey (1984) tarafından genişletilen ADF testi yürütülmüştür. Elde edilen bulgular serilerin karma bir bütünleşme davranışı sergilediklerini göstermektedir (Tablo 1). İhracat istikrarsızlığını ölçen *İGİ* ve *İDE* değişkenleri düzeyde durağan iken diğer değişkenler *KGSYH*, *GSSO* ve *TİG* düzeyde durağan değiller, fakat farkları alındığında durağan hâle gelmektedirler.

Tablo 1. ADF birim-kök testi sonuçları

	Düzey		**Fark**		
	Sabit	**Sabit + Trend**	**Sabit**	**Sabit + Trend**	**Karar**
KGSYH	0,7555 0,9917	*-2,3771* *0,3844*	*-6,0781* *< 0,001*	-6,2220 < 0,001	I(1)
İGİ	*-7,6526* *< 0,001*	-7,6040 0,0085	*-6,6523* *< 0,001*	-6,5642 < 0,001	I(0)
İDE	-3,4261 0,0117	*-7,2169* *< 0,001*	*-12,9030* *< 0,001*	-8,1829 < 0,001	I(0)
GSSO	-0,6975 0,8345	*-2,7646* *0,2190*	*-6,4152* *< 0,001*	-6,3222 < 0,001	I(1)
TİG	0,8393 0,9933	*-1,4582* *0,8249*	*-5,9889* *< 0,001*	-6,1729 < 0,001	I(1)

Notlar: *ENF serisinin ADF testine göre I(2) iken LS iki kırılmalı birim-kök testinde I(1) olduğu anlaşılmıştır (kırılma tarihleri: 2001, 2020). Her bir test için Schwarz kriterine göre uygun bulunan spesifikasyon italik olarak belirtilmiştir. Hücrelerdeki ikinci değer p-değeridir.

ADF birim-kök testi sonuçlarına göre bütün serilerin düzeyde durağan yani I(0) olmadıkları anlaşıldıktan sonra sahte regresyona meydan vermemek için değişkenler arasındaki eşbütünleşme ilişkisinin varlığı araştırılmaktadır. Tablo 2'de ARDL sınır testinin sonucu ve Schwarz bilgi kriterine göre uygun bulunan ARDL(1,1,0,1) modelinin uzun ve kısa dönem katsayılarının tahminleri verilmiştir. Uzun dönem tahminlerine göre sermaye oluşumu ve emek girdileri kişi başına GSYH ile temsil edilen ekonomik üretim hacmini pozitif yönde ve istatistiksel olarak anlamlı bir şekilde etkilemektedirler. İhracat gelirlerindeki istikrarsızlığın etkisi ise yine istatistiksel olarak anlamlı ancak genel beklentilerin aksine pozitif işaretlidir.

Değişkenlerin standartlaştırılmış katsayıları dikkate alındığında (sırasıyla 0,5113; 0,5756 ve 0,2104) büyüme üzerinde en büyük etkiye sahip değişkenin işgücü (*TİG*) olduğu, onu sermaye (*GSSO*) ve ihracat gelir istikrarsızlığının (*İGİ*) izlediği anlaşılmaktadır.

Kısa dönem tahminleri incelendiğinde sermaye ve ihracat gelirlerindeki istikrarsızlığın pozitif ve anlamlı etkide bulunduğu, emek faktöründeki kısa dönemli değişimlerin ise çıktı üzerinde etkili olmadığı dikkat çekmektedir. Hata düzeltme teriminin negatif ve istatistiksel olarak anlamlı katsayıya sahip olması uzun dönem dengesinin korunduğuna işaret etmektedir.

Tablo 2. ARDL(1,1,0,1) modeli katsayı tahminleri

Değişken	**Katsayı**	**Std. Hata**	**t-değeri**	**p-değeri**
Uzun Dönem:				
$GSSO_t$	0,2524	0,0622	4,0588	0,0004
$TİG_t$	1,0353	0,2592	3,9942	0,0004
$İGİ_t$	0,0076	0,0036	2,0762	0.0472
Kısa dönem:				
Sabit	– 3,1491	0,5319	– 5,9207	< 0,001
$\Delta GSSO_t$	0,2823	0,0182	15,4815	< 0,001
$\Delta İGİ_t$	0,0011	0,0002	5,0256	< 0,001
ECM_{t-1}	– 0,2088	0,0351	– 5,9473	< 0,001
Sınır testi F-değeri	7,9869	Anlamlılık düzeyi	I(0)	I(1)
		10%	2,958	4,100
		5%	3,615	4,913
		1%	5,198	6,845
Teşhis Testleri	Test istatistiği	p-değeri		
Normallik	1,1068	0,5750	CUSUM	Kararlı
Değişen varyans	29,0681	0,1429	$CUSUM^2$	Kararlı
Otokorelasyon	2,8881	0,0892		

Not: Hata terimlerinin normalliği için Jarque-Bera, değişen varyans için White, otokorelasyon için Breusch-Godfrey testleri yürütülmüştür.

Uzun dönem katsayıları Dinamik OLS (DOLS) yöntemiyle tahmin edilmiştir (Tablo 3). Büyüklük açısından kısmen farklılık olsa da DOLS tahminleri işaret ve anlamlılık açısından ARDL tahminleriyle paralellik göstermektedir. Böylece sermaye ve emek faktörlerinin ekonomik büyümeye pozitif yönde etki ettiği, ihracat gelirlerindeki istikrarsızlığın da büyümeye zayıf ama pozitif yönde katkı sağladığı bir kez daha desteklenmektedir.

Tablo 3. DOLS tahminleri

Değişken	**Katsayı**	**Std. Hata**	**t-değeri**	**p-değeri**
Sabit	– 10,3087	0,6818	– 15,1187	< 0,001
$GSSO_t$	0,3177	0,0229	13,8815	< 0,001
$TİG_t$	0,6565	0,0720	9,1174	< 0,001
$İGİ_t$	0,0023	0,0013	1,7411	0,0970

V. TARTIŞMA

Tablo 2 ve 3'teki sonuçlar, gayri safi sabit sermaye oluşumunun kişi başına gayri safi yurtiçi hasıla üzerinde pozitif ve istatistiksel olarak anlamlı bir etkisi olduğunu göstermiştir. Gayri safi sabit sermaye oluşumundaki %1'lik bir artış reel gayri safi yurtiçi hasılada yaklaşık olarak %0,3'lük bir artışa yol açmaktadır ki bu durum sermayenin ekonomik büyüme için önemini belirten ekonomik teorilerle tutarlıdır.

Ayrıca, sonuçlar ihracatın istikrarsızlığının gayri safi yurtiçi hasıla üzerinde pozitif ve istatistiksel olarak anlamlı bir etkisi olduğunu göstermiştir; ihracatın istikrarsızlık göstergesindeki %1'lik artış reel gayri safi yurtiçi hasılada %0,007'lik bir artışa yol açmaktadır. Her ne kadar zayıf olsa da bu sonuç, artan ihracat istikrarsızlığının bireylerin gelirlerine ilişkin belirsizliği artırarak, tüketimlerini azaltarak tasarruflarını ihtiyatlı bir şekilde artırmalarına yol açtığı anlamına gelmektedir. Bu da marjinal tüketim eğiliminin düşmesine ve marjinal tasarruf eğiliminin artmasına neden olmaktadır. Bu davranış ekonomide tasarrufların artmasına, bu da yatırımların ve dolayısıyla üretimin artmasına yol açmaktadır. Bu bulgu Kaushik ve Klein (2008)'ın Hindistan, Abu-Lila vd. (2021)'in Ürdün, Arshed vd. (2022)'nin Pakistan için elde ettikleri bulgularıyla bağdaşmaktadır.

VI. SONUÇLAR

Büyümenin lokomotifi olmasa da bir aracı olarak ihracat, faktör kullanımını artırması, faktör donanımını genişletmesi, çok sayıda ileri ve geri bağlantı oluşturması, değerli döviz kazandırması, teknolojik değişimlere ayak uydurmaya zorlaması ve uluslararası rekabet gücünü koruması açısından gelişmekte olan ülkeler için önemlidir. Bu faydaların ne ölçüde yayıldığı ülkenin büyüklüğü, kaynak donanımının çeşitliliği, uygulanan teknolojinin durumu ve dışa açıklık derecesi gibi faktörlere bağlıdır (Afxentiou ve Serletis, 2000). İhracat gelirlerinin istikrarsız bir seyir izlemesi de ihracattan beklenen faydanın elde edilmesini etkileme potansiyeline sahip bir diğer faktördür. Bu nedenle, ihracat performansı ve gelirlerindeki istikrarsızlığın ekonomik sonuçlarını araştırmak uygun politikaların geliştirilmesi açısından önem taşımaktadır.

1980'lerden itibaren hızla liberalleşen Türkiye ekonomisi ihracata dayalı büyüme yaklaşımını benimserken bir yandan bürokratik işleyişteki aksaklıklar, diğer yandan iç ve dış şoklar karşısındaki ekonomik genel kırılgan yapısı ihracat gelirlerinin dalgalı bir seyir izlemesine neden olmuştur. Bununla birlikte 2000'li yıllarda ihracat hacminde yaşanan gelişmeler ve ihracatçı sektörlerin yapısındaki değişim ihracatın sürdürülebilir büyüme açısından öneminin daha da artırmaktadır. Sözü edilen önemine binaen bu çalışmada, Türkiye'de ihracat gelirlerindeki dalgalanmanın büyümeye etkisi zaman serileri analizi yöntemleriyle araştırılmıştır. Elde edilen bulgular kısa ve uzun dönemde ihracat gelirlerindeki dalgalanmanın Türkiye'nin ekonomik büyümesine istatistiksel olarak anlamlı ve pozitif etkide bulunduğuna işaret etmektedir. Buna göre genel olarak artış yönünde seyreden ihracat değişkenliğinin Türkiye'de ekonomik büyüme açısından bir risk oluşturmadığı, aksine ekonominin bu dalgalanmalardan olumlu yönde yararlandığı anlaşılmaktadır.

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Sosyoekonomik Gelişmenin Enflasyona Etkisi: Türkiye'den Bulgular

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Özet – Enflasyon ve ekonomik büyüme ilişkisi de dahil olmak üzere enflasyonun belirleyicileri hakkında ekonomi literatüründe önemli miktarda çalışma mevcuttur, ancak sosyoekonomik kalkınmanın enflasyon üzerindeki etkisine ilişkin pek fazla çalışma bulunmamaktadır. Düşük ve istikrarlı bir enflasyon düzeyine sahip ekonomilerin genellikle sosyoekonomik açıdan gelişmiş olmaları iki değişken arasında bir ilişkinin mevcut olabileceğini akla getirmektedir. Son elli yıldır zaman zaman üç haneli rakamlara ulaşan yüksek ve kalıcı enflasyonla boğuşan Türkiye'de sosyoekonomik açıdan hızlı bir gelişme göze çarpmaktadır. Bu durumun enflasyonla mücadelede Türkiye'nin elini rahatlatan bir faktör olup olmayacağını belirlemek uygun politikaların geliştirilebilmesi açısından önem taşımaktadır. Bu noktadan hareketle çalışmada, Türkiye'de gözlenen sosyoekonomik gelişmenin enflasyona etkisi zaman serileri analizi yöntemleriyle araştırılmıştır. Elde edilen bulgular sosyoekonomik gelişimin enflasyon üzerinde istatistiksel olarak anlamlı ve negatif etkide bulunduğuna işaret etmektedir. Ayrıca, elde edilen bulgular modelde kontrol değişkenleri olarak yer verilen döviz kuru, ham petrol fiyatı ve asgari ücretin de Türkiye'de genel fiyat düzeyi üzerinde enflasyonist bir baskı oluşturduğuna işaret etmektedir.

Anahtar Kelimeler – Sosyoekonomik gelişme, enflasyon, zaman serileri analizi, Johansen eşbütünleşme testi, DOLS.

I. GİRİŞ

Enflasyon üretim maliyetlerinin yapısı ve refah seviyesi üzerinde kötü etkiler yaratabildiği için hükümetler de dahil olmak üzere ekonomik aktörler tarafından en çok üzerinde durulan makroekonomik göstergelerden biridir. Ayrıca istikrarsızlık, ekonomik büyüme, rekabet gücü, faiz oranı, gelir dağılımı ve işsizlik gibi çok geniş bir yelpazede etkileri ortaya çıkmaktadır. Yüksek enflasyon yaşayan bazı ülkelerde enflasyonun sosyal ve siyasi istikrarsızlığa yol açacağı ve Keynesyen görüşün aksine ekonomik büyüme yaratmadığı gözlenmiştir [1]. Bu çok yönlü etkileri, enflasyon konusunun hem teorik hem de ampirik açıdan yoğun bir şekilde tartışılmasına yol açmaktadır.

Ekonomik büyümenin, doğuracağı gelir ve talep artışı nedeniyle enflasyona yol açabileceğine dair çeşitli ampirik kanıtlar mevcuttur. Ancak büyümenin sadece GSYH veya GSMH'deki artışla ifade edilmesi, sosyal boyutlarının göz ardı edilmesi ilişkinin bütünüyle tanımlanabilmesini zorlaştırmaktadır. Çünkü artan gelirin nasıl harcandığını belirleyen en önemli unsur toplumun sosyal yapısıdır. Bu nedenle ekonomik ve sosyal dinamikleri bir arada dikkate alan bir kalkınma göstergesinin dikkate alınması fiyat hareketlerinin karmaşık yapısını daha isabetli biçimde çözümlemeye yardımcı olacaktır. BM-UNDP tarafından oluşturulan İnsani Gelişmişlik Endeksi bileşimi itibariyle bu tür bir amaca hizmet edebilir görünmektedir.

Düşük ve istikrarlı bir enflasyon düzeyine sahip ekonomilerin genellikle sosyoekonomik açıdan gelişmiş olmaları iki değişken arasında bir ilişkinin mevcut olabileceğini akla getirmektedir. Son elli yıldır zaman zaman üç haneli rakamlara ulaşan yüksek ve kalıcı enflasyonla boğuşan Türkiye'de sosyoekonomik açıdan hızlı bir gelişme göze çarpmaktadır. Bu durumun enflasyonla mücadelede Türkiye'nin elini rahatlatan bir faktör olup olmayacağını belirlemek uygun politikaların geliştirilebilmesi açısından önem taşımaktadır. Bu noktadan hareketle bu çalışmada, uzun yıllardır kronikleşen bir enflasyon sorunu ile mücadele eden

Türkiye'de sosyoekonomik gelişmenin enflasyona etkisi zaman serisi analiz yöntemleriyle incelenmektedir. Diğer bir dizi kontrol değişkeninin de dikkate alındığı analizde elde edilen bulgular sosyoekonomik gelişmenin Türkiye'de enflasyonu düşürücü etkide bulunduğunu ortaya koymaktadır.

II. SOSYOEKONOMİK GELİŞMENİN ÖLÇÜLMESİ: İNSANİ GELİŞME ENDEKSİ

Sosyoekonomik (beşerî) gelişme kavramı 20. yüzyılın ikinci yarısında ekonomik büyüme ve toplumsal refahın gelişimi arasındaki bağlantılar üzerine yapılan tartışmalardan ortaya çıkmıştır. Uzunca bir süreden beri GSYH'deki büyümenin ulusal ilerleme veya sosyal kalkınmanın bir ölçüsü olarak kullanılmasına karşı itirazlar vardı. Millî geliri ölçmeye yönelik modern metodolojiyi geliştiren Simon Kuznets bile GSYH'nin refahla eşanlamlı olarak kullanılmasını eleştirmiştir [2].

1970'ler ve 80'lerde, kalkınmaya ilişkin literatür ve kamu politikaları, refah ölçütleri olarak gelirin dışında temel ihtiyaçlar, yoksulluk, gelir dağılımı ve istihdama konularına da odaklanmıştır. Bu bağlamda sosyoekonomik kalkınmanın ölçülmesine yönelik önemli bir katkı, 1990 yılında Birleşmiş Milletler (BM) tarafından "insani kalkınma" kavramı temelinde yapılmıştır. BM, eğitim, sağlık ve yaşam standardından oluşan üç temel unsurdaki ilerlemeyi ortaya koyan bir gösterge – İnsani Gelişme Endeksi, İGE – geliştirmiştir. İGE, insani gelişmenin siyasi, ekonomik ve sosyal fırsatlar, öz saygı, güçlenme ve bir topluluğa ait olma hissini de içeren bu üç özelliğin ötesine geçtiğini belirtmesine rağmen, literatürde bunlara sahip olmanın insanlara seçme özgürlüğü ve anlamlı hayatlar sürme imkânı sağladığı düşünüldüğünden, sadece yaşam beklentisi, gelir ve eğitim seviyesine odaklanmaktadır [3]. Bu şekilde, geleneksel "insan kaynakları" perspektifi insan sermayesine (eğitim, sağlık, beslenme) yatırım yapmayı daha yüksek verimlilik ve gelir seviyeleri elde etmek için bir girdi olarak görürken, insani kalkınma yaklaşımı yaşam beklentisi, beslenme, sağlık ve eğitimi kendi içinde amaç, geliri ise bu amaçlara ulaşmak için bir araç olarak görmektedir [4, 5].

İnsani Gelişme Endeksi, sağlıklı bir yaşam için bir vekil olarak doğumda beklenen yaşam süresini, bilgiye erişimi açıklamak için eğitim göstergelerini (okuryazarlık ve okullaşma) ve ortalama satın alma gücünü gösteren bir değişken olarak kişi başına geliri birleştiren ve sağlık ve eğitim dışındaki diğer refah yönlerini açıklamaya çalışan temel ihtiyaçların sentetik bir ölçüsüdür. İGE katsayısı, incelenen boyutların her birinin normalize edilmiş endekslerinin geometrik ortalaması olarak hesaplanır ve 0 ile 1 arasında bir aralıkta yer alır [2].

III. EKONOMETRİK ANALİZ: MODEL VE DEĞİŞKENLER

Ampirik literatürde enflasyonun belirleyicileri ve ekonomik büyüme-enflasyon ilişkisine yönelik çok sayıda çalışma varsa da sosyoekonomik gelişmenin enflasyona etkisi konusu üzerinde hemen hiç durulmamıştır. Sadece bir çalışmada [6] konuyu beş Güney Asya ülkesi bağlamında panel veri analizi yöntemiyle incelemiştir. İGE'nin sosyoekonomik gelişmenin bir göstergesi olarak dikkate alındığı çalışmada para arzı ve döviz kuru da kontrol değişkenleri olarak modele dâhil edilmiştir. Elde edilen bulgular İGE ile enflasyon arasında istatistiksel olarak anlamlı bir ilişki bulunmadığına işaret etmektedir. [6]'ın modelleme yaklaşımı kısmen bu çalışmaya da yol göstermiştir.

Ekonomik kalkınma, sosyal açıdan arzu edilen değişikliklerle birlikte milli gelirdeki büyümeyi ifade etmektedir. Geleneksel olarak, ekonomik kalkınmayı ölçmek için reel gayri safi milli hasıla ve gayri safi yurtiçi hasıla (GSYH) gibi ekonomik göstergeler kullanılmakta ise de bu göstergelerin çeşitli sınırlamaları vardır. Bu sınırlamaları aşmak için geliştirilen ölçütlerden biri BM-UNDP tarafından hesaplanan, ekonomik ve sosyal göstergelerin bir karışımı olan ve kişi başına düşen GSYİH, eğitim ve sağlık açısından gelişimi içeren "insani gelişme endeksi"dir (İGE-HDI).

Döviz kurundaki reel ve spekülatif yükselişler özellikle ithal aramalı ve enerji ithalatındaki pahalanma yoluyla maliyet artışına neden olarak yurtiçi fiyatları da yükselmeye sevk etmektedir. Net petrol ihracatçısı olan Türkiye'nin uluslararası petrol fiyatlarındaki dalgalanmalardan etkilenmemesi beklenemez. Uluslararası petrol fiyatlarındaki her türlü hareket hem enerji hem de birçok sektörde hammadde fiyatları üzerinde etkili olarak yurtiçi fiyatlara yansımaktadır. SGK verilerine göre Türkiye'de çalışanların yarıya yakını asgari ücretle çalışmaktadır. Kayıtdışı istihdam da dikkate alındığında bu oranın daha yüksek olduğu düşünülebilir. Asgari ücretin ekonomiye etkisinin temelde asgari ücret düzeyine ve asgari ücretli çalışan oranına bağlı olduğu söylenebilir. Türkiye'de hem asgari ücretli çalışan oranının yüksek, hem de asgari

ücretin ortalama ücrete yakın olduğu düşünüldüğünde asgari ücretteki artışların hem emek maliyeti hem de talep artışı yönünden fiyat artışına neden olması beklenebilir.

Yukarıda sözü edilen üç faktör de üretim kanalıyla piyasa dinamiklerine etki etmekte, yurtiçi fiyatlar üzerinde temelde maliyet yönlü bir baskıya yol açma potansiyeli taşımaktadırlar. Buna karşılık para arzı kamu otoritesinin tekelinde olması hasebiyle çoğu zaman bir politika aracı olarak işlev görmektedir. İktisat teorisindeki hâkim görüşe göre parasal genişleme bazı özel durumlarda fiyat seviyesini etkilemese de genellikle enflasyonist bir etkiye neden olmaktadır.

Bu düşüncelerden hareketle analize konu olan ilişki aşağıdaki kapalı fonksiyon ile ifade edilebilir:

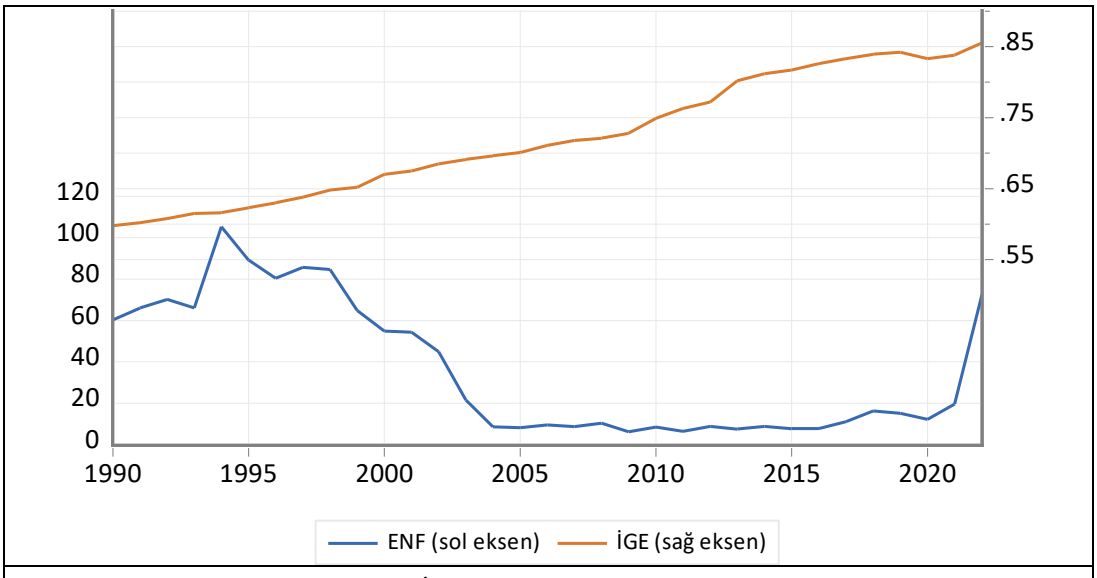
$$ENF = f(IGE, RDK, M2, PET, RAU)$$

Değişkenler arasında doğrusal bir ilişki varsayımıyla ilişki tahmin edilecek ekonometrik bir denklem olarak aşağıdaki şekilde yazılabilir:

$$ENF_t = \beta_0 + \beta_1 IGE_t + \beta_2 RDK_t + \beta_3 M2_t + \beta_4 PET_t + \beta_5 RAU_t + \varepsilon_t$$

Burada *ENF* tüketici fiyat endeksine (TÜFE) dayalı yıllık enflasyonu, IGE sosyoekonomik gelişmenin bir göstergesi olarak İnsani Gelişim Endeksini (İGE), RDK Türkiye'de en fazla işlem göre bir grup yabancı paranın değerinden oluşan reel döviz kuru sepetinin değerini, M2 para arzını, PET uluslararası piyasalarda Brent tipi petrolün ortalama varil fiyatını, RAU reel asgari ücret düzeyini göstermektedir. İGE verisi BM-UNDP'den, reel asgari ücret verisi Çalışma Bakanlığı istatistiklerinden, diğer veriler ise TCMB-EVDS'den elde edilmiştir. Parasal verilerin logaritmik değerleri esas alınmıştır. BM-UNDP İGE değerlerini 1990'dan itibaren yayınladığından ve bazı seriler için 2023 verisi henüz elde edilemediğinden örneklem dönemi 1990-2022 arasını kapsamaktadır.

Örneklem dönemi içinde İGE ve TÜFE bazlı enflasyonun seyri Şekil 1'de görülmektedir. 1980'lerin başlarından itibaren yükselmeye başlayan enflasyon 1994'te yaşanan krizle birlikte rekor seviyeye ulaşmış, bundan sonra izlenen para ve maliye politikalarıyla izleyen yıllarda önemli oranda dizginlenmiştir. 2000 ve 2001 yıllarında peş peşe yaşanan iki büyük kriz sonrasında uygulanan Güçlü Ekonomiye Geçiş Programı ile birlikte enflasyon uzun bir aradan sonra tek haneli rakamlara düşürülebilmiştir. Ancak, son yıllardaki mali dengesizlikler ve özellikle COVID-19 pandemisi sonrası dünya genelinde etkili olan enflasyon dalgasının etkisi ile tekrar yüksek düzeyli enflasyon ile karşılaşılmıştır. Buna karşılık başlangıcından bu yana İGE açısından Türkiye'nin genel olarak istikrarlı bir yükseliş gösterdiği göze çarpmaktadır.



Şekil 1. Enflasyon ve İGE'nin zaman içindeki gelişimi (1990-2022)

IV. BULGULAR

Zaman serileri analizinde öncelikle serilerin durağanlık özelliklerinin incelenmesi standart bir uygulamadır. Bu, olası bir sahte regresyon ilişkisinden kaçınmak ve ilişkiyi daha doğru bir şekilde modellemek açısından önemlidir. Bu amaçla tüm serilerin orijinal/düzey değerleri için [7] tarafından geliştirilen ve [8] tarafından genişletilen ADF testi yürütülmüştür. Elde edilen bulgular tüm serilerin düzey değerleri itibariyle durağan olmayan bir davranış sergilediklerini göstermektedir (Tablo 1). Çoğu iktisadi değişkenin ortalama ve/veya varyansı çeşitli nedenlerle zamanla değişime uğradığından bu durum şaşırtıcı değildir. Bu nedenle serilerin dönemler arası birinci farkları alınarak tekrar teste tâbi tutulduğunda RDK haricinde tümünün durağanlaştıkları görülmektedir. ADF gibi geleneksel testler yapısal kırılma durumunda genellikle sıfır hipotezinin reddedilememesi ile sonuçlandığından bir yapısal kırılmayı dikkate alan [9] testine başvurulmuş serinin 2003 yılındaki kırılma dikkate alındığında birinci farkı itibariyle durağan olduğu görülmüştür.

Tablo 1. ADF birim-kök testi sonuçları

	Düzey		**1. fark**		
	Sabit	**Sabit + Trend**	**Sabit**	**Sabit + Trend**	**d**
ENF	-1,2045 0,6597	*0,2733* *0,9975*	*-3,4921* *0,0150*	-2,7265 0,2338	I(1)
İGE	0,2109 0,9691	*-1,9774* *0,5911*	-4,4762 0,0013	*-4,4084* *0,0075*	I(1)
RDK	-1,8320 0,3587	*-2,5704* *0,2952*	*-2,1876* *0,2145*	-2,0388 0,5581	I(1)
M2	*-1,5365* *0,5026*	-0,5236 0,9770	*-4,3216* *0,0019*	-4,5012 0,0060	I(1)
PET	-09092 0,7722	*-2,0705* *0,5419*	-5,0202 *< 0,001*	*-4,9171* *0,0023*	I(1)
RAÜ	*-1,9934* *0,2881*	-1,7675 0,6967	*-4,6079* *< 0,001*	-4,7119 0,0036	I(1)

Not: Her bir test için Schwarz kriterine göre uygun bulunan spesifikasyon italik olarak belirtilmiştir. Hücrelerdeki ikinci değer p-değeridir.

Bütün serilerin fark durağan yani I(1) oldukları anlaşıldıktan sonra sahte regresyona meydan vermeden analize devam edebilmek için yapılabilecek iki şey vardır: serilerin farkları arasındaki regresyona başvurmak veya seriler arasındaki eşbütünleşme ilişkisinden yararlanmaktır. [10] tarafından ortaya atılan eşbütünleşme teorisine göre düzey değerleri durağan olmayan iki seri arasında kurulacak ilişki sahte olma riski taşısa da bunların doğrusal bir bileşimleri durağan ise eğer düzey değerleri arasındaki regresyona güvenilebilir. [10]'ın önerdiği yaklaşım basit regresyon ilişkileri için uygun olmakla birlikte iktisadi regresyonların çok değişkenli yapısı için pek uygun değildir. Bu durumlar için [11] tarafından geliştirilen VAR regresyonuna dayalı rank yöntemi kullanılmaktadır.

Tablo 2. Johansen eşbütünleşme testi sonuçları

H_0	**Eigen değeri**	**İz istatistiği**	**%5 Kritik değer**	**p-değeri**
Yok	0,8586	143,1681	95,7537	< 0,001
En fazla 1	0,6875	82,5296	69,8189	0,0035
En fazla 2	0,4889	46,4686	47,8561	0,0671
En fazla 3	0,3511	25,6623	29,7971	0,1391
En fazla 4	0,3139	12,2580	15,4947	0,1450
En fazla 5	0,0186	0,5814	3,8415	0,4458

Tablo 2'de verilen Johansen eşbütünleşme testi sonuçlarına bakıldığında değişkenler arasında herhangi bir eşbütünleşme ilişkisinin bulunmadığı şeklindeki sıfır hipotezinin %5 anlamlılık düzeyinde reddedilebildiği görülmektedir. Dahası, %10 anlamlılık düzeyinde en az iki eşbütünleşme ilişkisinin

varlığını ifade eden sıfır hipotezi de reddedilebilmektedir. Buna göre analize dahil edilen değişkenler arasında uzun dönemde anlamlı bir doğrusal ilişki bulunduğu, düzey değerleri arasında kurulacak bir regresyon ilişkisinin gerçekçi tahminler verebileceği söylenebilir.

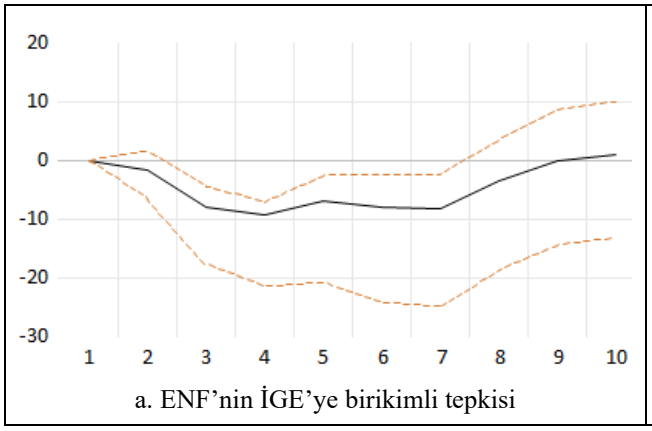
Seriler eşbütünleşik ise eşbütünleşme vektörünün sıradan en küçük kareler (statik OLS) tahmini tutarlıdır ve standart olandan daha hızlı bir şekilde yakınsar. Statik OLS'nin (SOLS) önemli bir eksikliği, tahminlerin genellikle Gaussyen olmayan asimptotik bir dağılıma sahip olması ve asimptotik sapma sergilemesidir. Geleneksel test prosedürleri önemli ölçüde değiştirilmedikçe geçerli olmadığından, eşbütünleşme vektörüne dayalı olarak çıkarım yapmak isteniyorsa SOLS genellikle tavsiye edilmemektedir [12]. SOLS'un bu zayıflığının üstesinden gelmek amacıyla eşbütünleşik değişkenler arasındaki ilişkinin katsayılarını tahmin etmek için çeşitli yöntemler geliştirilmiştir. Bunlardan en bilinenleri [13] tarafından geliştirilen Tam Modifiye OLS (FMOLS), [14] tarafından önerilen Kanonik Koentegre Regresyon (CCR) ve [15] tarafından geliştirilen Dinamik OLS (DOLS) yöntemleridir [16]. Burada DOLS yöntemi kullanılarak uzun dönem ilişkisi tahminleri elde edilmiştir.

DOLS tahminleri Tablo 3'te görülmektedir. Elde edilen sonuçlara göre tüm değişkenler %5 anlamlılık düzeyinde enflasyon üzerinde istatistiksel olarak anlamlı etkiye sahiptirler. RDK, PET ve RAÜ değişkenlerinin enflasyona etkisi pozitif iken İGE ve M2 değişkenleri negatif bir etkiye neden olmaktadır.

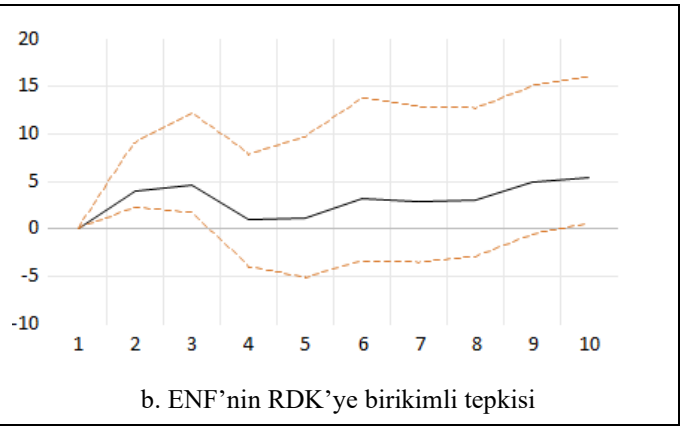
Tablo 3. Dinamik en küçük kareler (DOLS) yöntemi tahmin sonuçları

Değişken	Katsayı	Std. Hata	t-istatistiği	p-değeri
İGE	-150,1030	28,3326	-5,2979	< 0,001
RDK	4,1665	1,2927	3,2230	0,0104
M2	-25,7869	8,8827	-2,9031	0,0175
PET	35,5074	10,0475	3,5339	0,0064
RAÜ	4,7234	1,6691	2,8299	0,0197
Sabit	580,5761	182,0929	3,1884	0,0110

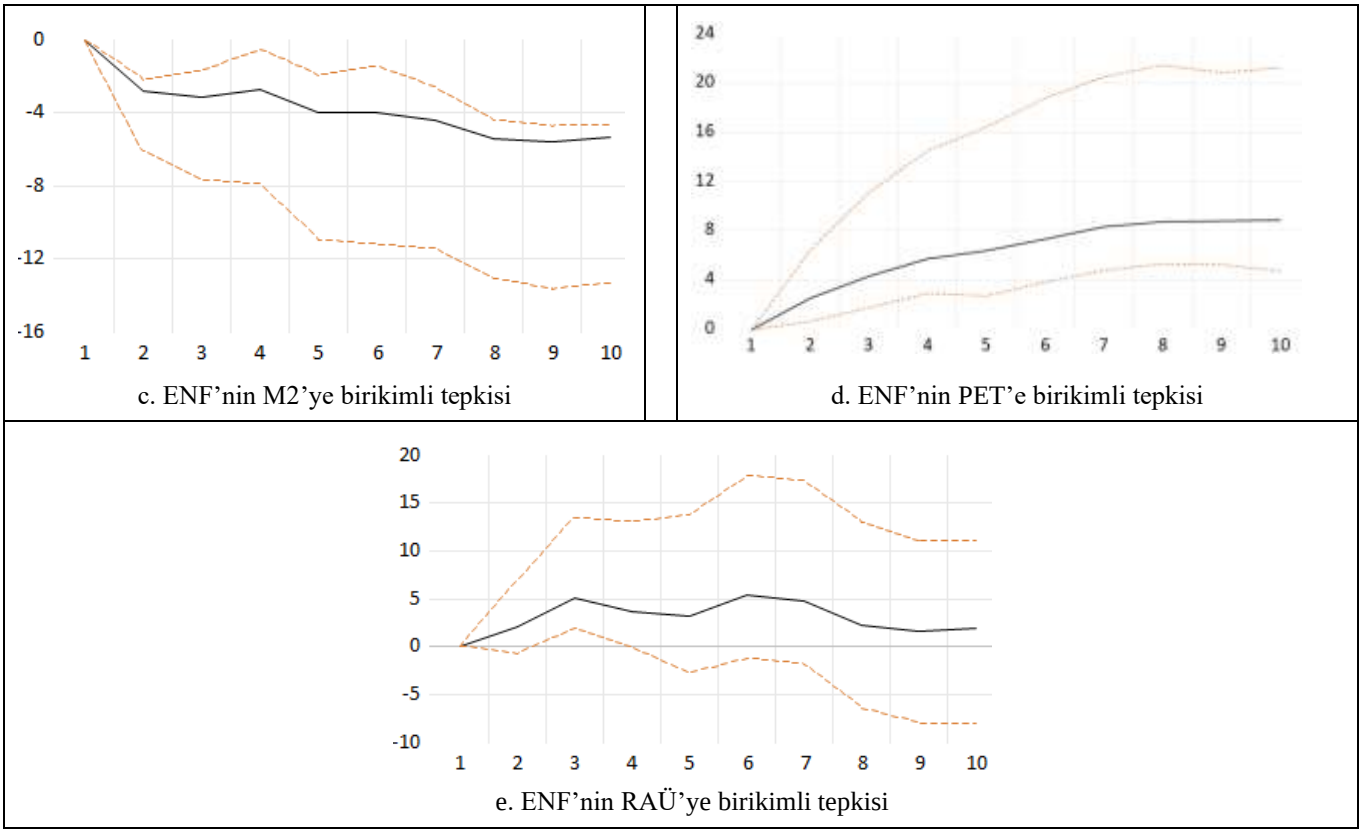
VAR modelinden elde edilen birikimli etki-tepki fonksiyonlarının grafikleri aşağıda Şekil 2'de verilmiştir. Grafiklerde ortaya çıkan görüntü parametre tahminleriyle paralellik göstermektedir. ENF, 10 dönemlik pencereyi kapsayan süre içinde İGE ve M2'den kaynaklanan bir standart sapmalık şoklara negatif tepki verirken diğer değişkenlerdeki şoklara pozitif yönde değişimle tepki vermektedir. Ayrıca RDK ve RAÜ'ye tepkilerin kısa süreli, İGE, M2 ve PET karşısındaki tepkilerin ise daha uzun süreli olarak anlamlı olduğu görülmektedir.



a. ENF'nin İGE'ye birikimli tepkisi



b. ENF'nin RDK'ye birikimli tepkisi



c. ENF'nin M2'ye birikimli tepkisi

d. ENF'nin PET'e birikimli tepkisi

e. ENF'nin RAÜ'ye birikimli tepkisi

Şekil 2. ENF değişkeninin diğer değişkenlerden kaynaklanan şoklara birikimli tepki fonksiyonları

V. TARTIŞMA

Johansen eşbütünleşme testi sonuçları ele alınan değişkenler arasında anlamlı bir uzun dönem denge ilişkisinin varlığına işaret etmektedir. Eşbütünleşme katsayılarının daha güvenilir tahminlerini elde etmek için başvurulan DOLS yöntemi Türkiye'de reel döviz kuru, petrol fiyatları ve asgari ücret düzeyinin enflasyonist etkilere yol açtığını ortaya koymaktadır. Her üçü de maliyet yönlü fiyat artışlarına neden olma potansiyeli taşıyan bu makroekonomik faktörler Türkiye ekonomisinin en kırılgan bileşenlerini oluşturmaktadırlar. Döviz kurunun etkisine ilişkin bulgular [17, 18, 19, 20] gibi birçok çalışmanın bulgularıyla uyuşmaktadır. Yine, petrol fiyatlarının Türkiye'de enflasyona etkisi konusu da birçok ampirik çalışmaya konu olmuş (diğerleri arasında bkz. [21, 22, 23, 24]) ve burada olduğu gibi genellikle petrol fiyatı artışlarının enflasyonu artırdığı bulgusuna ulaşılmıştır. Diğer taraftan analizde, [25, 26, 27, 28]'in ulaştığı bulgulara paralel Türkiye'de asgari ücret artışlarının enflasyonist bir etki yarattığı yönünde istatistiksel kanıtlara ulaşılmıştır. Türkiye'de asgari ücretli çalışan sayısının toplam istihdam içindeki payının oldukça yüksek olması ve asgari ücretin ortalama ücreti açısından referans işlevi görmesi nedeniyle bu sonucun şaşırtıcı olmadığı söylenebilir.

Buna karşılık, analizde ulaşılan para arzının tüketici fiyat enflasyonu üzerinde negatif etkisi olduğu bulgusu teorik değerlendirmeler ve Türkiye örneğindeki önceki çalışmalarla uyumlu değildir. Bu sonucun ortaya çıkması ekonometrik modelleme ile ilgili olabileceği gibi analizlerde kullanılan göstergelerin seçiminden de kaynaklanabilir. Çalışmanın odak noktasını oluşturan sosyoekonomik gelişmişlik düzeyinin de deflasyonist bir etkiye neden olduğu görülmektedir.

VI. SONUÇLAR

Düşük ve istikrarlı bir enflasyon düzeyine sahip ekonomilerin genellikle sosyoekonomik açıdan gelişmiş olmaları iki değişken arasında bir ilişkinin mevcut olabileceğini akla getirmektedir. Son elli yıldır zaman zaman üç haneli rakamlara ulaşan yüksek ve kalıcı enflasyonla boğuşan Türkiye'de sosyoekonomik açıdan hızlı bir gelişme göze çarpmaktadır. Bu durumun enflasyonla mücadelede Türkiye'nin elini rahatlatan bir faktör olup olmayacağını belirlemek uygun politikaların geliştirilebilmesi açısından önem taşımaktadır. Bu

noktadan hareketle çalışmada, Türkiye'de gözlenen sosyoekonomik gelişmenin enflasyona etkisi zaman serileri analizi yöntemleriyle araştırılmıştır. Elde edilen sonuçlar gelir, eğitim ve sağlık açısında kaydedilen gelişmelerin enflasyon üzerinde negatif yönde etkide bulunduğunu göstermektedir. BM tarafından oluşturulan ve 1990'dan beri ölçülen İnsani Gelişim Endeksi açısından Türkiye'nin istikrarlı bir yükseliş sergilemesi analiz bulgularıyla birlikte düşünüldüğünde, daha güçlü bir sosyoekonomik altyapının enflasyonla mücadele açısından Türkiye'nin elini güçlendireceğini akla getirmektedir.

DOLS yöntemi tahminleri Türkiye'de reel döviz kuru, petrol fiyatları ve asgari ücret düzeyinin ise enflasyonist etkilere yol açtığını ortaya koymaktadır. Her üçü de maliyet yönlü fiyat artışlarına neden olma potansiyeli taşıyan bu makroekonomik faktörler Türkiye ekonomisinin en kırılgan bileşenlerini oluşturmaktadırlar. Döviz kuru, petrol fiyatı ve asgari ücretin etkilerine ilişkin bulgular daha önceki birçok ampirik çalışmanın bulgularıyla uyuşmaktadır.

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Revolutionizing Autonomous Driving: A Cutting-Edge Fuzzy Logic Control System

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Abstract **–** In this paper, we introduce a state-of-the-art autonomous driving control system that leverages fuzzy logic to seamlessly integrate and process data from multiple advanced technologies. This study presents a design for an autonomous (self-driving) car control system to mitigate issues associated with autos. The system's design is accomplished using Fuzzy Logic Control technology in conjunction with artificial intelligence algorithms. The obtained outcomes illustrate that the suggested design has exhibited a dependable and effective performance. All the primary driving control jobs, such as speed, brakes, and steering wheel, were executed proficiently. It functions in a manner comparable to that of a skilled human driver our system combines Global Positioning System (GPS), ultrasonic sensors, prebuilt maps, Light Detection and Ranging (LiDAR), cameras, Dedicated Short Range Communication (DSRC), Inertial Navigation System (INS), infrared sensors, and Radio Detection and Ranging (RADAR). This multi-faceted approach ensures robust and adaptive decision-making capabilities, enabling the vehicle to navigate complex environments with unprecedented accuracy and safety. The fuzzy logic control system synthesizes inputs from these diverse sources to dynamically adjust driving parameters, enhancing obstacle detection, path planning, and real-time responsiveness. Experimental results demonstrate the efficacy of our integrated system in varied driving scenarios, highlighting its potential to revolutionize the future of autonomous transportation.

Keywords – Automobile, Fuzzy Logic Control, Artificial Intelligence, Algorithm, Human Driver

Introduction

Autonomous driving technology has emerged as a transformative innovation in the transportation sector, promising significant enhancements in safety, efficiency, and convenience. Traditional control systems for autonomous vehicles rely heavily on deterministic algorithms and rigid rule-based logic, which often struggle to cope with the complexities and uncertainties of real-world driving environments. In response to these challenges, this research introduces a cutting-edge fuzzy logic control system designed to revolutionize autonomous driving [1].

Fuzzy logic, a mathematical framework that handles the concept of partial truth, offers a robust solution for managing the inherent uncertainties and ambiguities in autonomous driving. By mimicking human

decision-making processes, fuzzy logic provides a flexible and adaptive approach to control, making it particularly suitable for dynamic and unpredictable driving scenarios. This research explores the design, implementation, and validation of a fuzzy logic control system integrated into an autonomous vehicle platform, highlighting its potential to enhance decision-making, improve safety, and ensure smoother navigation. The primary objective of this study is to develop a comprehensive fuzzy logic control system that seamlessly integrates with the vehicle's perception, localization, and path planning modules. By leveraging advanced sensors, high-performance computing, and sophisticated algorithms, this system aims to achieve superior performance in complex driving environments. The research also emphasizes rigorous testing and validation, both in simulated and real-world settings, to ensure the reliability and effectiveness of the proposed control system [2].

During the 20th century, cars had a significant and transformative impact on both persons and nations. The century commenced with the production of a modest number of automobiles per year and concluded with the manufacturing of over 50 million units annually for worldwide consumption. Regrettably, as the utilization of automobiles has grown exponentially, there has been a significant rise in the frequency of accidents resulting in fatalities, as well as catastrophic injuries and disabilities.[1]. Traffic-related accidents are a global issue of significant concern and are increasing in severity. These accidents are a leading cause of disability and death on a global scale. Annually, a staggering 1.2 million individuals perish, while an additional 50 million people sustain injuries, accounting for 2.2% of all fatalities [2]. In addition to car accidents, there is a cluster of issues that accompany the exponential growth of automobiles. One such problem is traffic congestion, which is a global issue. This problem primarily stems from human driving abilities, including reaction times, delays, and judgment errors, all of which can impede traffic flow and lead to accidents [3]. Unskillful driving routines have significant environmental and health consequences, including increased fuel consumption and air pollution. Automobiles are responsible for over half of the carbon monoxide and nitrogen oxide emissions and nearly 25% of the hydrocarbon emissions in our atmosphere.

As urban areas expand and the population grows, there will be a corresponding increase in traffic, which will have a multitude of negative consequences. Without an adequate transportation infrastructure, individuals will encounter significant challenges concerning their safety, efficiency, financial resources, and well-being. The necessity for a transportation system that is more dependable, effective, and secure is readily apparent. Optimal resolution to convene with creating smart and efficient autonomous transportation systems will address these needs [4].

An autonomous car, also known as a self-driving car or mobile robot, is a vehicle that incorporates advanced technology such as multi-sensor intelligent decision-making and control systems. These systems enable the car to perform all driving operations in real-time without human intervention. The design and execution of autonomous cars have garnered significant interest from leading automotive and technology manufacturers since the 1980s. Numerous research studies, articles, and initiatives have been conducted in this field.

However, most research efforts have been directed toward automating specific driving functions such as parking, braking, and cruise control. The user's text consists of references to sources 6 and 7. Limited studies and efforts have been dedicated to developing semi- completely or totally autonomous cars. However, many of these designs have failed to consider all the relevant factors that affect driving automation, such as the condition of the car and weather conditions [8].

This research introduces a sophisticated system that emulates an experienced human driver. The system utilizes a fuzzy logic controller (FLC) and incorporates computer vision, artificial intelligence, and image processing technologies to fully operate a car. The proposed system will proficiently and efficiently execute all car driver functions, including speed and brake regulation, as well as steering direction. Furthermore, autonomous systems offer a range of services to clients, including car parking, adaptive cruise control (ACC), blind spot warning (BSW), lane and route detection, Lane Keeping Assist System (LKA), and Proactive car service. Consequently, this will lead to a drive that is safer, more fun, and less stressful. The system is implemented in the MATLAB software environment using the Fuzzy Logic Toolbox.

Literature Review

Autonomous driving technology has advanced significantly over the past decade, driven by breakthroughs in sensor technology, machine learning, and control systems. Traditional approaches to autonomous driving often rely on deterministic algorithms, such as PID controllers and rule-based systems, which can struggle with the variability and complexity of real-world driving conditions. Recent research has increasingly focused on enhancing these systems with more sophisticated methods, including machine learning and fuzzy logic, to improve safety, efficiency, and adaptability [9]. Early autonomous driving systems predominantly used classical control techniques, such as PID controllers, to manage vehicle dynamics. These controllers are effective for straightforward tasks but lack the flexibility to handle the nuanced decision-making required in complex environments. Rule-based systems, which rely on predefined rules to govern vehicle behavior, have also been used. However, they often fall short in dynamically changing scenarios where predefined rules may not cover all possible situations. With the advent of machine learning, particularly deep learning, there has been a significant shift towards data-driven approaches in autonomous driving. Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) have been employed for perception tasks, such as object detection, lane detection, and semantic segmentation [10]. For instance, the work by Chen et al. (2015) demonstrated the effectiveness of deep learning for real-time object detection, significantly enhancing the vehicle's ability to understand its environment. Similarly, Recurrent Neural Networks have been used for temporal understanding and prediction, crucial for tasks like path planning and decision-making (Hochreiter & Schmid Huber, 1997). Fuzzy logic, introduced by Zadeh in the 1960s, provides a framework for handling uncertainty and imprecision, making it particularly suitable for the complex and uncertain environment of autonomous driving. Early applications of fuzzy logic in automotive systems include fuzzy controllers for cruise control and anti-lock braking systems (Jang, Sun, & Mizutani, 1997). These systems demonstrated improved performance over traditional control methods by providing a more intuitive way to handle uncertainties and nonlinearities in the system [11].

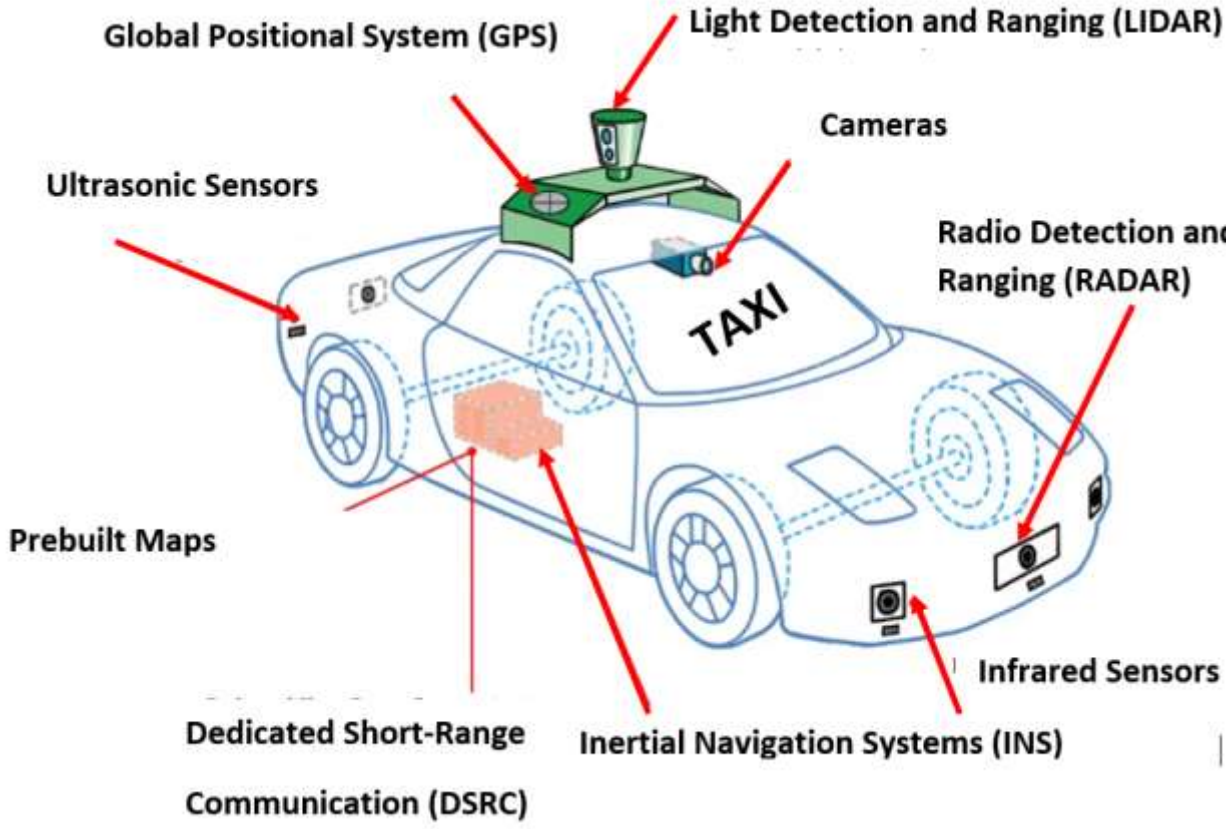


Fig. 1 Autonomous vehicle technologies

Recent research has expanded the application of fuzzy logic to more complex autonomous driving scenarios. For example, Yang et al. (2018) developed a fuzzy logic-based control system for obstacle avoidance, demonstrating its effectiveness in managing dynamic obstacles in real-time. Similarly, fuzzy logic has been integrated with machine learning techniques to enhance decision-making capabilities. For instance, Wang et al. (2020) proposed a hybrid model combining fuzzy logic and reinforcement learning, achieving superior performance in navigating complex urban environments [11]. The integration of fuzzy logic with other advanced techniques has shown promising results in enhancing autonomous driving systems. Hybrid systems that combine fuzzy logic with deep learning have been particularly effective. For instance, the work by Li et al. (2019) demonstrated the use of a fuzzy logic controller to fine-tune the outputs of a deep neural network, improving the robustness and reliability of the autonomous driving system. This hybrid approach leverages the strengths of fuzzy logic in handling uncertainty and the computational power of deep learning models for perception and decision-making [13]. Moreover, recent studies have explored the use of fuzzy logic in conjunction with reinforcement learning (RL). This combination leverages the exploratory capabilities of RL to optimize fuzzy logic rules, enhancing the system's ability to adapt to new and unforeseen scenarios. For instance, Zhao et al. (2021) implemented a fuzzy Q-learning algorithm, which successfully improved the vehicle's performance in navigating complex traffic scenarios and learning from new experiences [14].

The Proposed Autonomous Driving System

Autonomous driving represents a monumental shift in transportation, driven by a convergence of cutting-edge technologies. At its core, the global positioning system (GPS) serves as the foundational element, providing precise location data essential for navigation as shown in Fig.1. The proposed autonomous driving system consists of the following components.

LIGHT DETECTION AND RANGING (LIDAR) sensors complement GPS by offering detailed 3D mapping of the environment through laser pulses, enabling vehicles to perceive surroundings with unparalleled accuracy and depth perception. **2. ULTRASONIC SENSORS** further enhance this

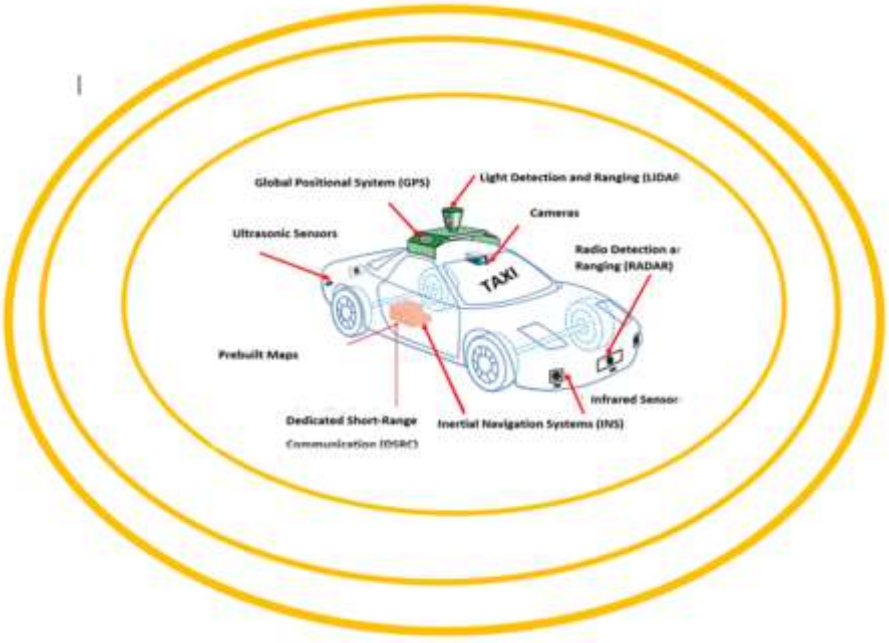


Fig. 2 Autonomous vehicle electrical signals

perception by detecting nearby obstacles in real-time, ensuring swift response to dynamic road conditions. 3.Digital Cameras play a crucial role in identifying traffic signals, pedestrians, and other vehicles, utilizing advanced image processing algorithms to interpret visual data.**4. Radio Detection and Ranging (RADAR)** systems provide critical information on relative speed and distance of objects, functioning effectively in various weather conditions where visual sensors may be limited.**5**. **PREBUILT MAPPING INTEGRATES** detailed maps into autonomous systems, enabling vehicles to anticipate road curves, intersections, and lane changes with precision and confidence. **6.Dedicated Short-Range Communication (DSRC)** facilitates vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, enhancing coordination between vehicles and traffic management systems for safer driving.**7. Infrared Sensors** augment visibility in low-light environments, detecting heat signatures of objects not easily visible to the human eye or other sensors.**8. Inertial Navigation Systems (INS**) utilize gyroscopes and accelerometers to track a vehicle's position, velocity, and orientation, ensuring accurate navigation even when GPS signals are temporarily disrupted. Together, these technologies form a robust ecosystem that enables autonomous vehicles to navigate complex environments, respond to hazards in real-time, and ensure passenger safety. As these technologies continue to evolve and integrate, they promise to redefine mobility by making autonomous driving safer, more efficient, and accessible to all. The fusion of GPS, LiDAR, ultrasonic sensors, digital cameras, RADAR, mapping data, DSRC, infrared sensors, and INS represents a transformative leap towards a future where autonomous vehicles navigate our roads with unprecedented reliability and safety. The signals produced by the integrated devices are shown in **Fig.2.**

I. MATERIALS AND METHOD

This systematic approach, combining cutting-edge hardware, sophisticated software, and advanced fuzzy logic control techniques, aims to revolutionize the capabilities and safety of autonomous driving systems.

A. *Material*

I. Hardware Components

- **Autonomous Vehicle Platform**: A modified vehicle equipped with sensors and actuators for autonomous operation.
- **Sensors: LIDAR, RADAR**, ultrasonic sensors, and cameras for environmental perception.
- Computational Unit: High-performance onboard computer (NVIDIA Jetson AGX Xavier) for **real-time data processing and control**.
- **Actuators**: Steering, braking, and throttle control systems integrated with the vehicle's hardware.

II. Software Components

- **Fuzzy Logic Toolkit:** MATLAB Fuzzy Logic Toolbox for designing and tuning the fuzzy control system.

B. *Methods*

İ. *System Architecture*

- **Perception Module**: Fusion of LIDAR, RADAR, ultrasonic sensors, and camera data to create an accurate model of the vehicle's surroundings.
- **Localization and Mapping**: Use of SLAM (Simultaneous Localization and Mapping) algorithms to generate real-time maps and localize the vehicle within these maps.
- **Path Planning**: Implementation of the A* algorithm for generating optimal paths based on the current map and destination.

C. Fuzzy Logic Control System Design

- ***Fuzzy Sets and Membership Functions:*** Definition of linguistic variables and their corresponding membership functions for input parameters such as distance to obstacles, relative speed, and road curvature.
- ***Rule Base:*** Development of a comprehensive set of fuzzy rules to govern the vehicle's behavior in various scenarios (e.g., obstacle avoidance, lane keeping, and speed regulation).
- ***Inference Engine:*** Implementation of the Mamdani-type fuzzy inference method to process inputs and generate control outputs.
- ***Defuzzification:*** Use of the centroid method to convert fuzzy control outputs into precise commands for the vehicle's actuators.
- **Fuzzy Sets and Membership Functions:** Definition of linguistic variables and their corresponding membership functions for input parameters such as distance to obstacles, relative speed, and road curvature.
- **Rule Base:** Development of a comprehensive set of fuzzy rules to govern the vehicle's behavior in various scenarios (e.g., obstacle avoidance, lane keeping, and speed regulation).
- **Inference Engine:** Implementation of the Mamdani-type fuzzy inference method to process inputs and generate control outputs.

- **Integration:** Combining the perception, localization, path planning, and fuzzy control modules into a cohesive autonomous driving system.
- **Simulation Testing***:* Initial testing and validation in the CARLA simulator to evaluate system performance under diverse conditions and scenarios.
- **Real-World Testing:** Deployment of autonomous vehicles in controlled environments to assess the fuzzy logic control system's performance in real-world conditions. Data collected during these tests are used for further tuning and optimization of the control system.

D. Evaluation Metrics

- **Safety:** Measurement of collision rates and near-miss incidents during testing.
- **Efficiency:** Assessment of the vehicle's ability to follow optimal paths and maintain smooth motion.
- **Responsiveness:** Evaluation of the system's reaction time to dynamic changes in the environment.

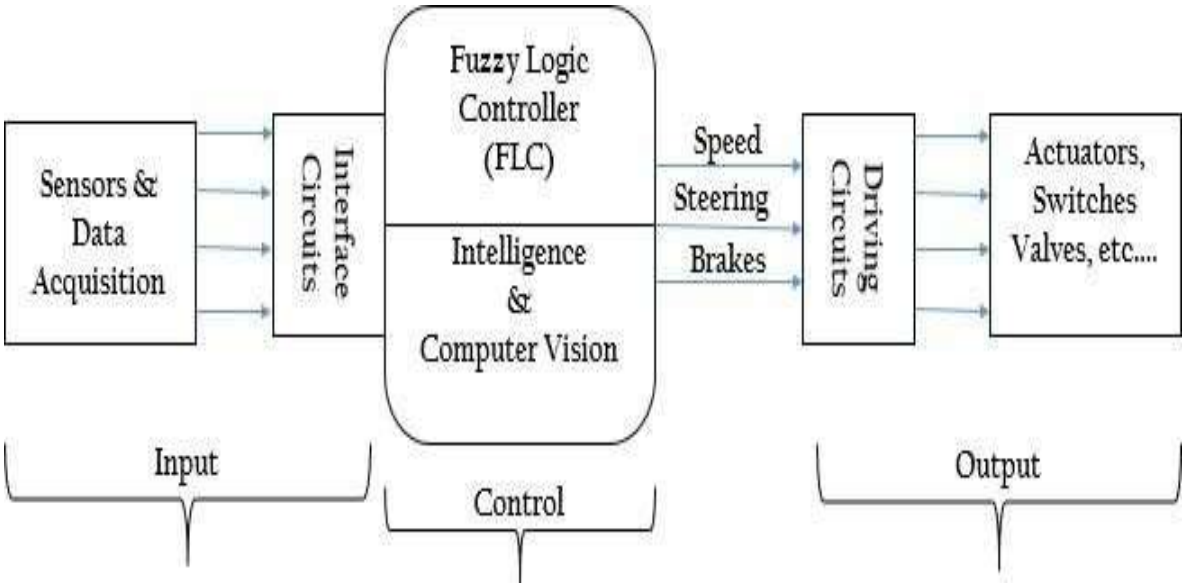


Fig. 4. Artificial driving system's block diagram

E. SYSTEM DESIGN

The proposed control system consists of two main units to perform all driving tasks very efficiently and skillfully.

A- Fuzzy Logic Control unit.

B- Intelligence and computer vision unit.

A- Fuzzy Logic Control Unit:

Designing a controller for the autonomous car system is challenging because of its complexity, nonlinearity, and the lack of knowledge about the effective parameters and inputs. However, it is widely recognized that fuzzy logic methods are suitable and proficient in describing complex systems using language. They can be used to efficiently convert and interpret human experiences stated linguistically into appropriate automatic control strategies [11]. This study involves the creation of a Fuzzy Logic Controller (FLC) unit that can carry out the primary operations of an autonomous car control.

System, including braking, speed regulation, and steering control. The FLC unit is partitioned into three subsystems, as illustrated in Fig.3.

1. Auto-Braking Subsystem.
2. Auto-Speed Subsystem.
3. Auto-Steering Subsystem.

1. **Auto Braking Subsystem:**

Automatic braking is a technology used in autonomous cars to detect and prevent potential collisions with other vehicles, pedestrians, and obstacles, or to avoid dangerous situations such as approaching a stop sign at high speed or navigating corners. A cluster of sensors is required to perceive and identify nearby vehicles or obstacles, including RADAR, LIDAR (Light Detection and Ranging), and video cameras. The optimal parameters for controlling braking power are,

- Car's acceleration: 0 to 60 KM/H.
- Obstacle Distance: (0 – 10) meters.

The selection of speed and safe distance should be per the regulations set by the governing bodies responsible for roads and traffic. In this concept, we employed a speed range of 0- 60 km/hr. for within-city travel, and a safe distance of 0-10 meters between cars.

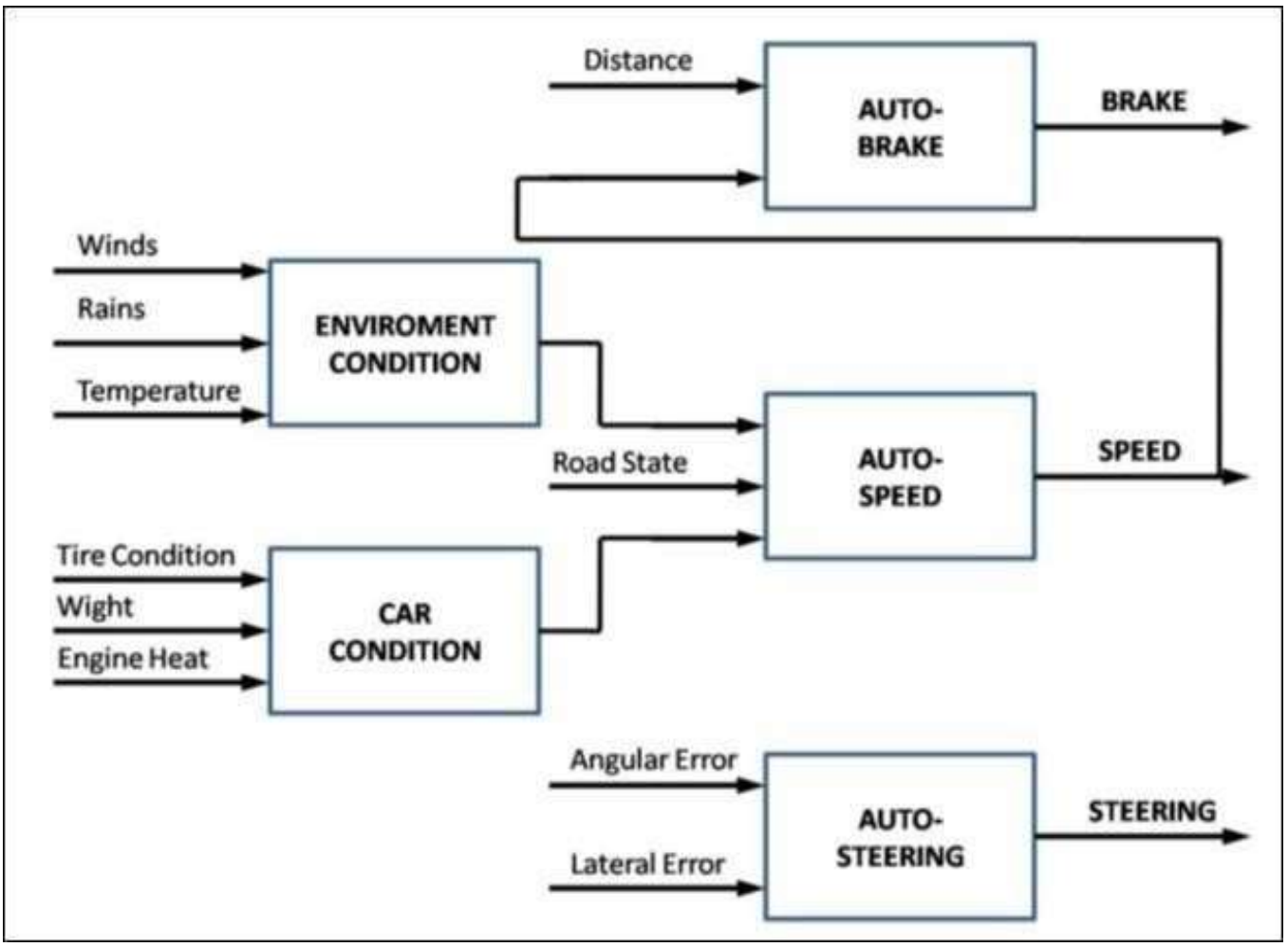


Fig.5. Fuzzy Logic Controller Unit

2- **Auto Speed Subsystem**

Controlling speed is the primary and challenging duty when driving, as it is influenced by numerous factors and elements. A speed control system is an automated system that regulates the velocity of a vehicle, and it is highly efficient. The parameters are categorized into three subgroups.

A - **Environmental Conditions:**

- Rain falling: (0 – 200) mm.
- Winds Speed: (0 – 150) km/h.
- Temperature: (-30 – 55)°C.

B - **Car Condition:**

- Tire Condition: (0 – 25) psi.
- Wight (car + passengers): (1870 – 1500) kg.
- Engine Heat: (-25 – 65)°c.

The Car Conditions parameter range selection depends on the car's category. In this design, we chose a sedan car as a model as shown in Fig1.

C - **Road state.**

Each of these three characteristics is assigned a numerical value on a scale from 0 to 10, with 0 representing the worst condition or status and 10 representing the best condition or status. To simplify the design of the FLC unit, we treated the car and ambient circumstances as sub-subsystems, recognizing that they are influenced by a variety of factors.

3 - **Auto Steering Subsystem**

The primary goal of the steering control system is to accurately follow a predetermined path, with the assistance of intelligent and navigational components. When it comes to steering wheel control, there are two parameters that we can identify: A- The angular shift ranges from -180 to 180 degrees.

- A negative sign indicates a left rotation, while a positive sign indicates a right rotation. B - Lateral Shift: (-1 – 1) meters.
- A negative sign indicates a leftward displacement, while a positive sign indicates a rightward displacement.

B*- Intelligence *and computer vision unit

The artificial intelligence unit in our design is tasked with emulating human cognitive processes, particularly in the realm of sequential and interconnected decision-making. Interconnected with other subsystems to carry out specialized tasks or operations, such as overtaking and reverse processes. Computer vision is the task of automating and combining many processes and representations for visual perception. It is the fundamental technology behind automated picture analysis, which finds applications in numerous fields [9]. Computer vision focuses on the theoretical aspects of artificial systems that extract information from images. The picture data can manifest in various formats, including video sequences and perspectives captured by multiple cameras [10]. Passing and reversing are the primary tasks that must be carried out by the intelligent unit. Flowcharts depicting the algorithms for these jobs may be seen in Fig. 4, and Fig.5.

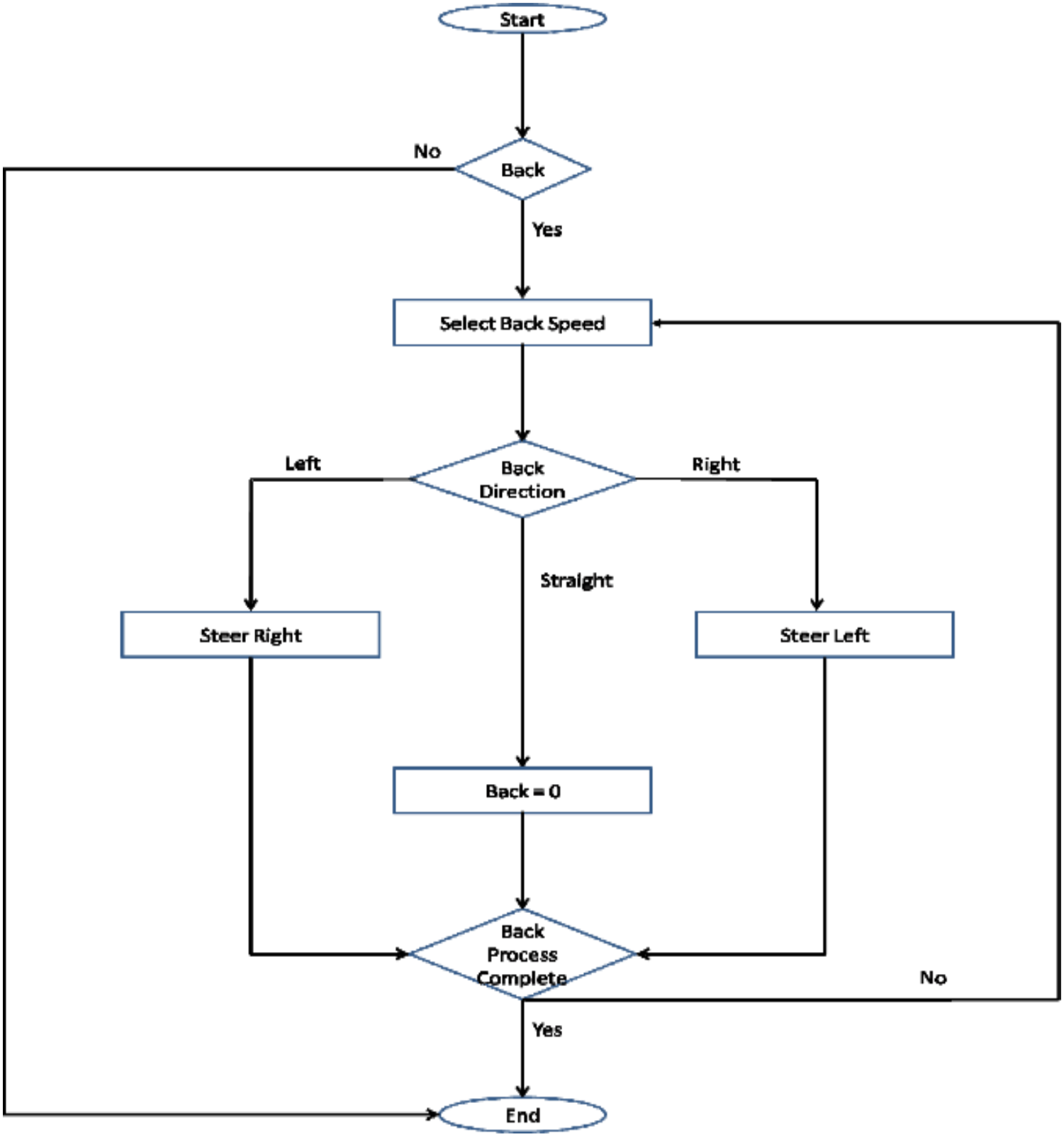


Fig. 6. Backward algorithm flowchart

1. *Backward*

2. *Overtaking*

Overtaking is the process of a moving vehicle passing another slower vehicle and traveling in the same direction on a road. It's one of the most critical jobs done by the driver; because any fault in estimating the required speed, or distance from obstacles in both directions, could lead to deadly accidents.

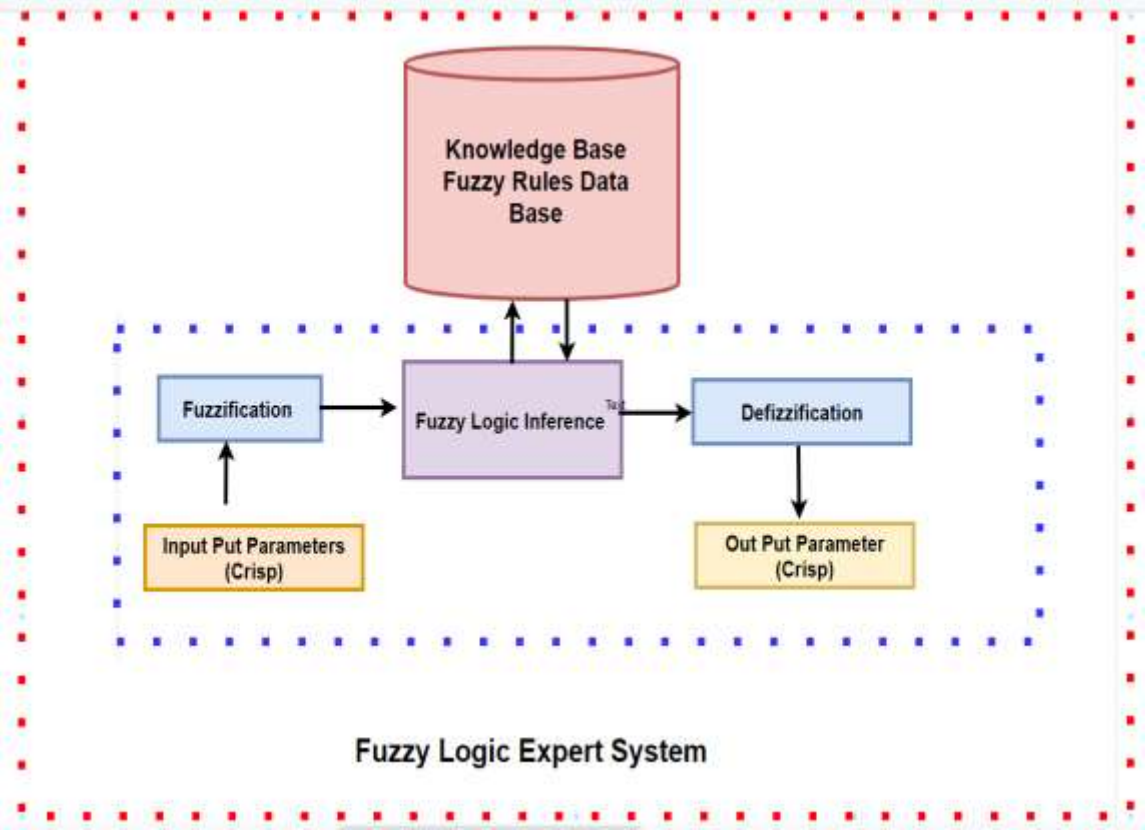


Fig. 7. Fuzzy logic expert system block diagram

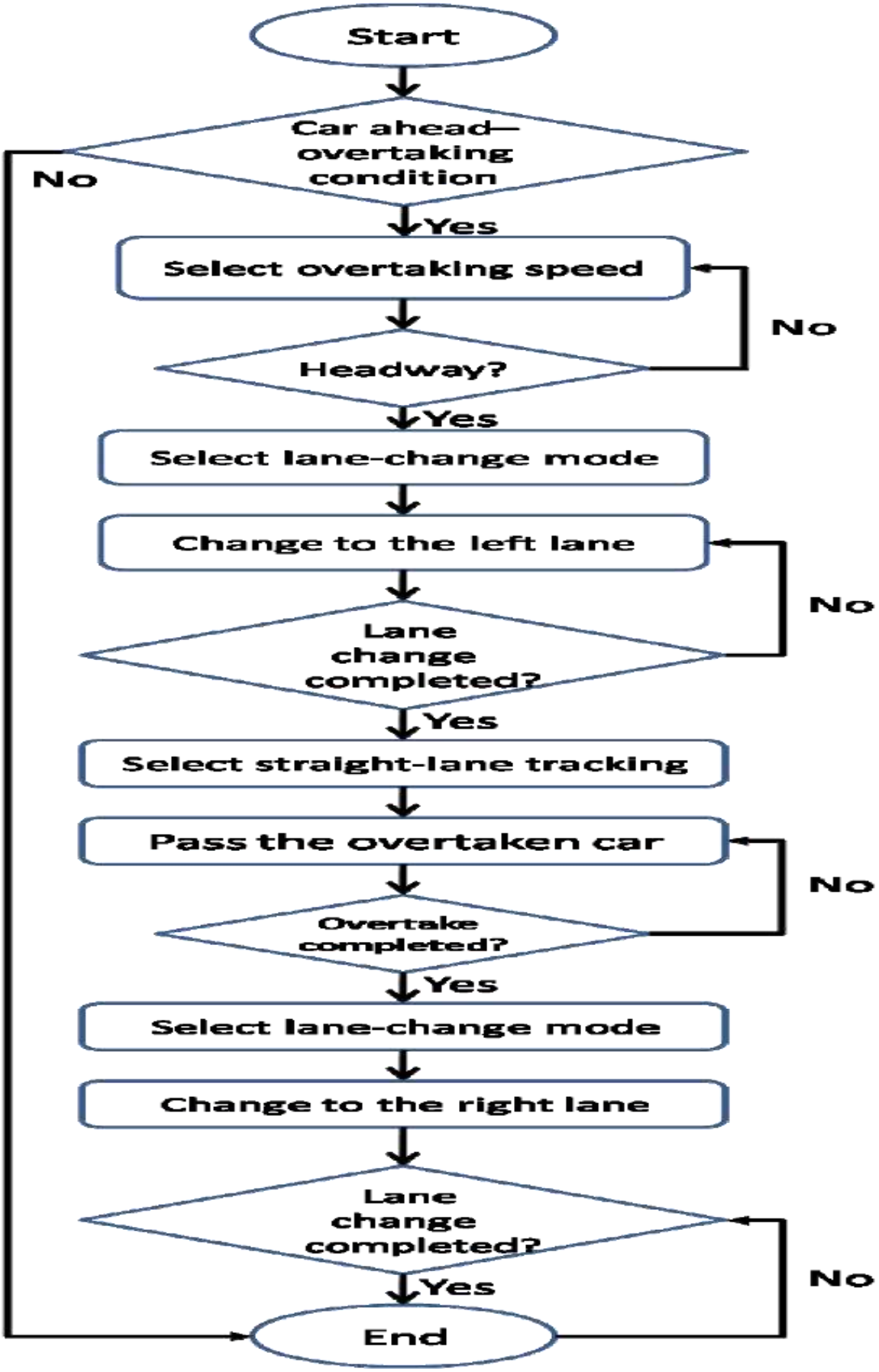


Fig. 8. Overtaking algorithm flowchart

3. *Modelling & Simulation*

The FLC unit modeling was conducted using the fuzzy logic toolbox in MATLAB. Three models were developed to represent the three subsystems of the FLC unit: brakes, speed, and steering.

A. Braking control system's model:

INPUT: Distance d INPUT: Speed v OUTPUT: Breaking power b (gas pedal). Three membership functions are chosen for both input and output: Membership functions for INPUT. Distance d (meters): short, medium, long. Speed v (Km/h): slow, medium, high Membership functions for OUTPUT. Breaking power b (%): soft, medium, hard as described in Table 1.

Table 1. Braking control subsystem rules.

Distance (d)	**Speed (v)**	**Braking Power (b)**
Short	Slow	Medium
Short	Medium	Hard
Short	High	Hard
Medium	Slow	Soft
Medium	Medium	Medium
Medium	High	Hard
Long	Slow	Soft
Long	Medium	Soft
Long	High	Medium

B. speed control system's model

1. Fuzzy variables for Environment condition: Humidity

INPUT: Temperature INPUT: rain INPUT: wind OUTPUT: Environment

Three membership functions are chosen for both input and output. Membership functions for INPUT: Temperature: cold, medium, hot. Rain: few, medium, heavy. Wind: low, medium, high. Membership functions for OUTPUT: Environment: bad, medium, good as described in Table 2.

Table. 2. Car condition rules.

Temperature	Rain	Wind	Environment
Cold	Few	Low	Good
Cold	Few	Medium	Medium
Cold	Few	High	Bad
Cold	Medium	Low	Medium
Cold	Medium	Medium	Bad
Cold	Medium	High	Bad
Cold	Heavy	Low	Bad
Cold	Heavy	Medium	Bad
Cold	Heavy	High	Bad
Medium	Few	Low	Good
Medium	Few	Medium	Medium
Medium	Few	High	Bad
Medium	Medium	Low	Medium
Medium	Medium	Medium	Bad
Medium	Medium	High	Bad
Medium	Heavy	Low	Bad
Medium	Heavy	Medium	Bad
Medium	Heavy	High	Bad
Hot	Few	Low	Good

2. Fuzzy variables for Car condition: INPUT: machine heat

INPUT: tire condition INPUT: weight OUTPUT: Car condition Three membership functions are chosen for both input and output. Membership functions for INPUT: Machine heat: cold, normal, hot. Tire condition: bad, medium, good. Weight: light, medium, heavy. Membership functions for OUTPUT: Car condition: bad, medium, good as explained in Table3.

Table. 3. Car condition rules.

Machine Heat	Tire Condition	Weight	Car Condition
Cold	Bad	Light	Bad
Cold	Bad	Medium	Bad
Cold	Bad	Heavy	Bad
Cold	Medium	Light	Medium
Cold	Medium	Medium	Medium
Cold	Medium	Heavy	Bad
Cold	Good	Light	Good
Cold	Good	Medium	Good
Cold	Good	Heavy	Medium
Normal	Bad	Light	Medium
Normal	Bad	Medium	Medium
Normal	Bad	Heavy	Bad
Normal	Medium	Light	Good
Normal	Medium	Medium	Medium

Normal	Medium	Heavy	Medium
Normal	Good	Light	Good
Normal	Good	Medium	Good
Normal	Good	Heavy	Medium
Hot	Bad	Light	Bad
Hot	Bad	Medium	Bad
Hot	Bad	Heavy	Bad
Hot	Medium	Light	Medium
Hot	Medium	Medium	Medium
Hot	Medium	Heavy	Bad
Hot	Good	Light	Good
Hot	Good	Medium	Good
Hot	Good	Heavy	Medium

1. Fuzzy variables for auto-speed subsystem

INPUT: Environment condition. INPUT: car condition. INPUT: Road OUTPUT: Speed.

Three membership functions are chosen for both input and output. Membership functions for INPUT: Environment: bad, medium, good. Car condition: bad, medium, good. Road state: bad, medium, good. Membership functions for OUTPUT: Speed: slow, medium, fast as described in Table 4.

Table. 4. Speed control subsystem rules

Environment	Car Condition	Road State	Speed
Bad	Bad	Bad	Slow
Bad	Bad	Medium	Slow
Bad	Bad	Good	Medium
Bad	Medium	Bad	Slow
Bad	Medium	Medium	Slow
Bad	Medium	Good	Medium
Bad	Good	Bad	Medium
Bad	Good	Medium	Medium
Bad	Good	Good	Fast
Medium	Bad	Bad	Slow
Medium	Bad	Medium	Slow
Medium	Bad	Good	Medium
Medium	Medium	Bad	Slow
Medium	Medium	Medium	Medium
Medium	Medium	Good	Medium
Medium	Good	Bad	Medium
Medium	Good	Medium	Fast
Medium	Good	Good	Fast
Good	Bad	Bad	Medium
Good	Bad	Medium	Medium
Good	Bad	Good	Fast
Good	Medium	Bad	Medium
Good	Medium	Medium	Fast
Good	Medium	Good	Fast
Good	Good	Bad	Fast
Good	Good	Medium	Fast
Good	Good	Good	Fast

C. Steering control system's model

1. Fuzzy variables for auto-steering subsystem

INPUT: Angular error INPUT: Lateral error OUTPUT: Steering Three membership functions are chosen for both input and output.
Membership functions for INPUT: Angular error: left turn, right turn. Lateral error: left shift, right shift. Membership functions for OUTPUT: Steering left, right as described in Table 5.

Table. 5. Car steering control system rules.

Angular Error	**Lateral Error**	**Steering**
Left Turn	Left Shift	Left
Left Turn	Right Shift	Right
Right Turn	Left Shift	Left
Right Turn	Right Shift	Right
Left Turn	None	Left
Right Turn	None	Right
None	Left Shift	Left
None	Right Shift	Right
None	None	Fixed

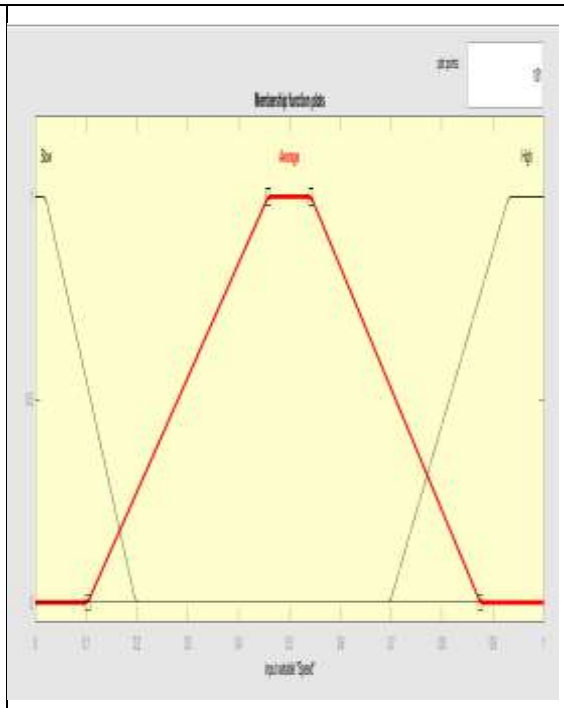
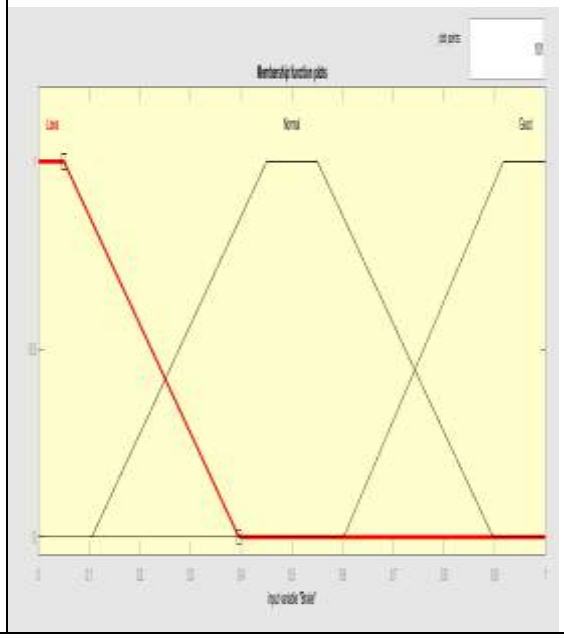
II. RESULTS

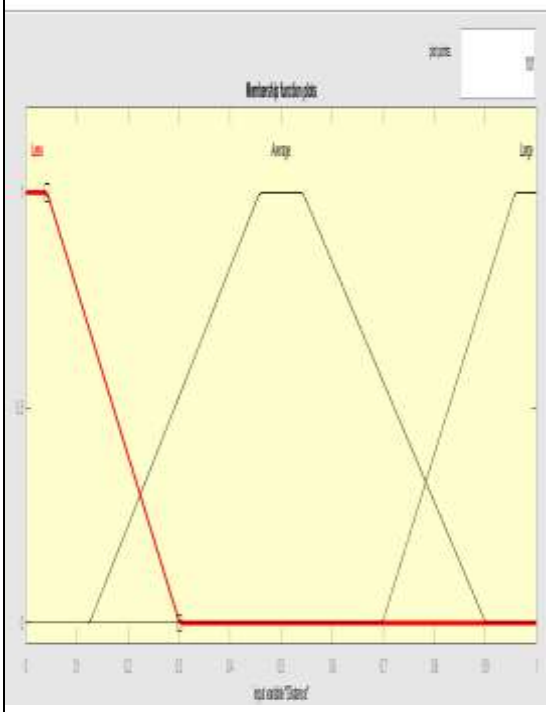
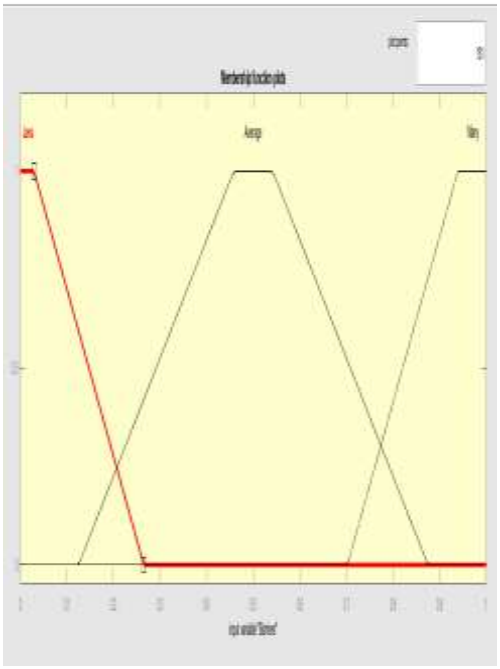
Results of proposed artificial driving system such as membership function in Table6, rules editor artificial driving system in Fig.8, rules viewer artificial system in Fig.9, and Surface graph representation have been given below.

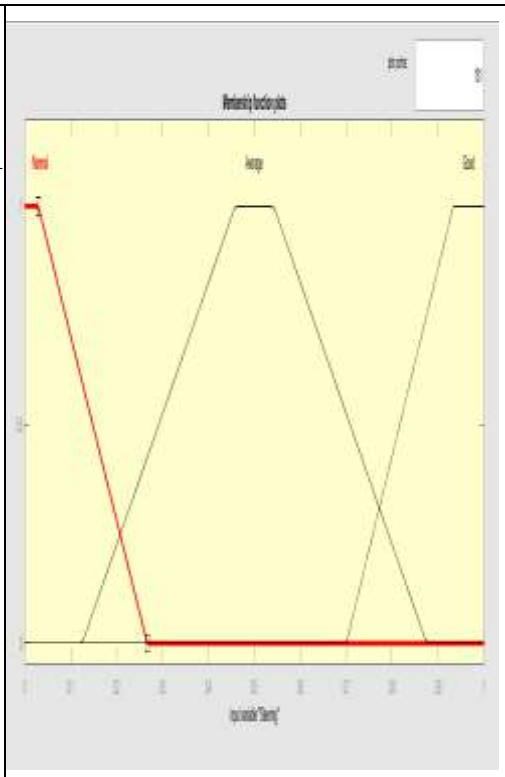
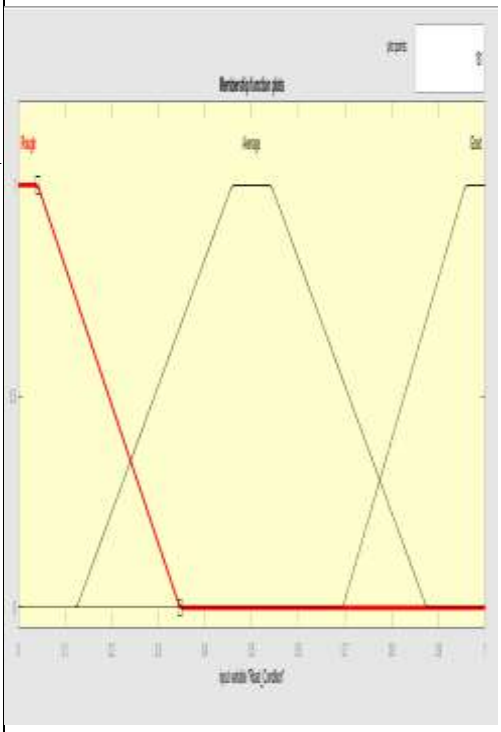
A. Membership Function Mathematical Representation

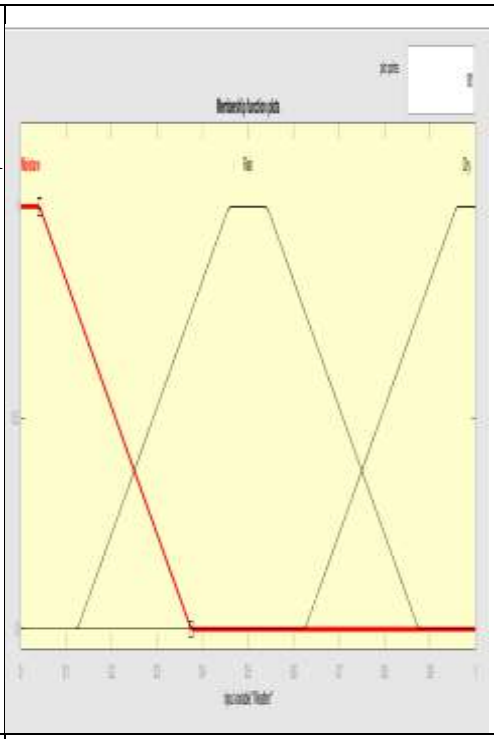
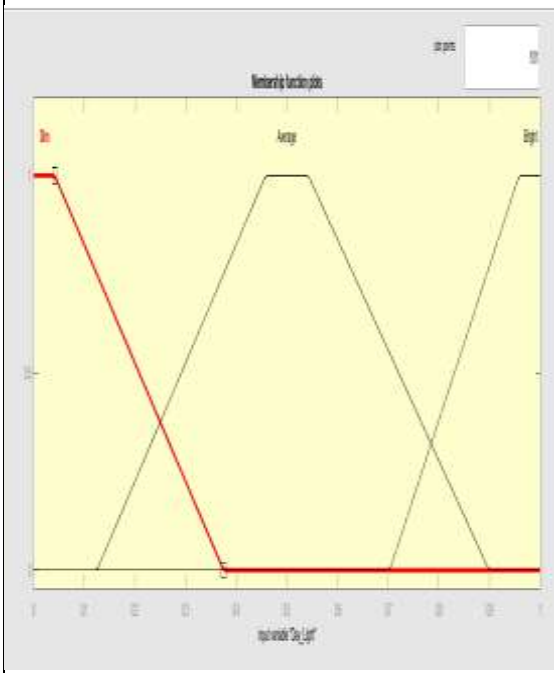
Table. 6. Membership function mathematical representation.

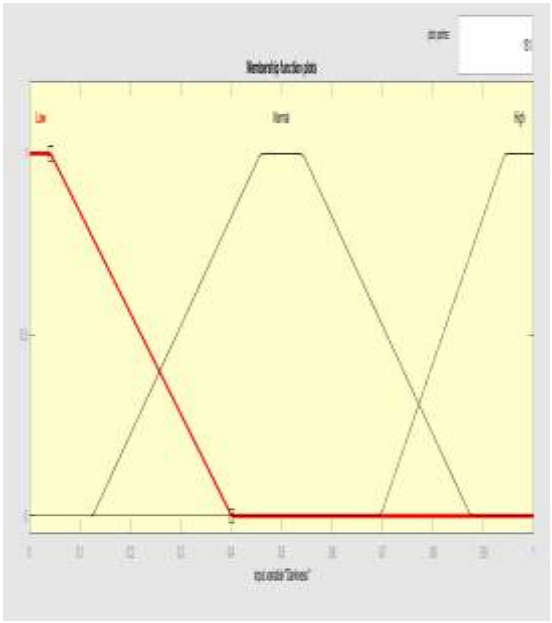
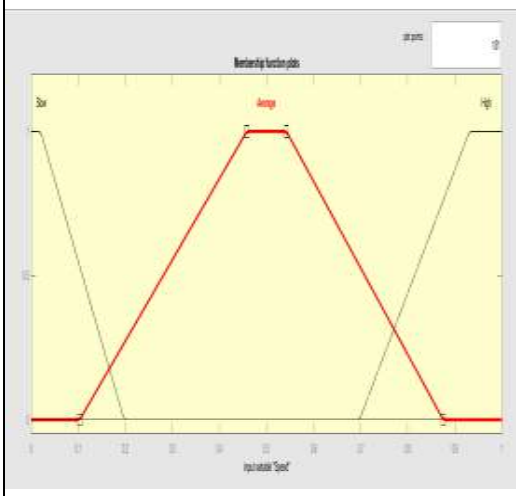
Input Variable	**Membership Function Mathematical Representation**	**Member Functions Graphs**

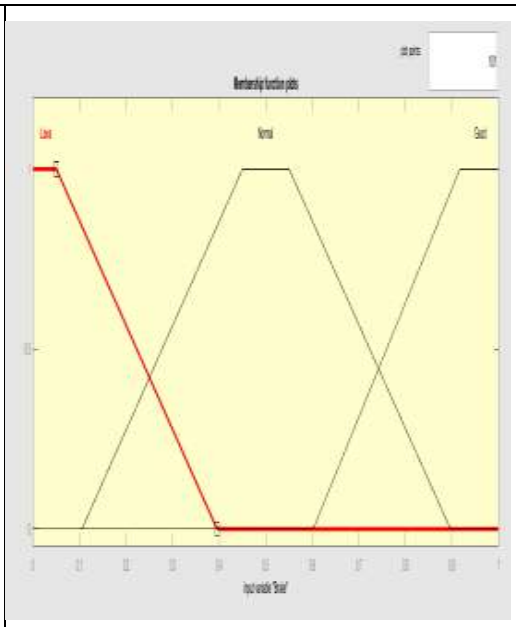
Speed= S $\mu_A(s)$	$\mu_{A,Slow}(s) = \begin{cases} 0 & s \trianglelefteq 1.47 \\ 1 & 0.1 \trianglelefteq s \trianglelefteq 2.1 \\ \frac{1.47-s}{2.1-1.47}, & 1.47 \trianglelefteq s \trianglelefteq 2.0 \end{cases}$ $\mu_{S,Average}(s) = \begin{cases} 1 & 2.1 \trianglelefteq s \trianglelefteq 0.89 \\ \frac{a-2.1}{0.89-0.2}, & 0.21 \trianglelefteq s \trianglelefteq 0.89 \\ \frac{1-a}{1.0-0.7}, & 0.7 \trianglelefteq s \trianglelefteq 1.0 \end{cases}$ $\mu_{S\,High}(s) = \begin{cases} 1, & s \trianglelefteq 1.0 \\ \frac{s-1,0}{1.0-0.7} & 101.3 \trianglelefteq s \trianglelefteq 1.0 \end{cases}$	
Brake = B $\mu_I(b)$	$\mu_{B,Loose}(b) = \begin{cases} 0 & 0 \trianglelefteq a \trianglelefteq 0.4 \\ 1 & 0 \trianglelefteq a \trianglelefteq 0.16 \\ \frac{0.3-b}{0.3-0.16}, & 0.16 \trianglelefteq a \trianglelefteq 0.3 \end{cases}$ $\mu_{I\ ,Normal}(b) = \begin{cases} 1 & 0.4 \trianglelefteq a \trianglelefteq 1.681\ ] \\ \frac{b-1.16}{0.4-0.16}, & 0.16 \trianglelefteq a \trianglelefteq 0.4 \\ \frac{0.9-b}{0.9-01681}, & 1.681 \trianglelefteq a \trianglelefteq 0.9] \end{cases}$ $\mu_{IGood}(b) = \begin{cases} 1 & a \trianglelefteq 0.8] \\ \frac{b-1.681}{0.9-1.681}, & 1.681 \trianglelefteq a \trianglelefteq 0.9] \end{cases}$	

Distance =D $\mu_B(d)$	$\mu_{B\ Less}(d) = \begin{cases} [\ 0 & a \trianglelefteq 0.3] \\ 1 & 0 \trianglelefteq a \trianglelefteq 0.2 \\ \dfrac{0.3 - a}{0.3 - 0.2} & 0.2 \trianglelefteq a \trianglelefteq 0.3 \end{cases}$ $\mu_{B\ Average}(d) = \begin{cases} 1 & 0.3 \trianglelefteq a \trianglelefteq 0.592 \\ \dfrac{a - 0.2}{0.3 - 0.2}, & [0.2 \trianglelefteq a \trianglelefteq 0.3 \end{cases}$ $\dfrac{0.7 - a}{0.7 - 0.592}, \quad [0.592 \trianglelefteq a \trianglelefteq 0.7\ ]$ $\mu_{B,Large}(d) = \begin{cases} 1, & [a \trianglelefteq 0.7] \\ \dfrac{a - 0.592}{0.7 - 0.592} & [0.592 \trianglelefteq a \trianglelefteq 0.7\ ] \end{cases}$	
Barries =B $\mu_S(b)$	$\mu_{\text{Less}}(b)$ $= \begin{cases} 0 & a \trianglelefteq 0.31 \\ 1 & 0 \trianglelefteq a \trianglelefteq 0.157 \\ \dfrac{0.31 - a}{0.31 - 0.157} & , 0.157 \trianglelefteq a \trianglelefteq 0.31 \end{cases}$ $\mu_{Average}(b) = \begin{cases} 1, & 0.31 \trianglelefteq a \trianglelefteq 0.522\ ] \\ \dfrac{a - 0157}{0.31 - 0.157} & 0.157 \trianglelefteq a \trianglelefteq 0.31, \\ \dfrac{0.7 - a}{0.7 - 0.522}, & 0.522 \trianglelefteq a \trianglelefteq 0.7\ ] \end{cases}$ $\mu_{Many}(b)$ $= \begin{cases} 1 & a \trianglelefteq 0.7 \\ \dfrac{a - 0.522}{0.7 - 0.522} & 0.522 \trianglelefteq a \trianglelefteq 0.7 \end{cases}$]	

Steering = St $\mu_{st}(St)$	$\mu_{Td\ Normal}(St)$ $= \{ \begin{cases} 0 & a \trianglelefteq 2..61 \\ 1 & 0.1 \trianglelefteq a \trianglelefteq 2.61 \\ \dfrac{2..61 - a}{2.61 - 0.1} & , 2.61 \trianglelefteq a \trianglelefteq 0.1 \end{cases}$ $\mu_{Average}(St) = \begin{cases} \dfrac{a - 2.61}{2.61 - 0.1} & , 0.1 \trianglelefteq a \trianglelefteq 2.61] \\ \dfrac{2.61 - a}{8..61 - 0.7} & , 101.4 \trianglelefteq a \trianglelefteq 102.5] \end{cases}$ $\mu_{Good}(St) = \begin{cases} 1, & a \trianglelefteq 0.9.] \\ \dfrac{a - 0.9}{0.9 - 0.7} & 0.7. \trianglelefteq a \trianglelefteq 0.9 \end{cases}$	
Road Condition= RC $\mu_{st}(rc)$	$\mu_{Rough}(RC)$ $= \{ \begin{cases} 0 & a \trianglelefteq 2..61 \\ 1 & 0.1 \trianglelefteq a \trianglelefteq 2.61 \\ \dfrac{2..61 - a}{2.61 - 0.1} & , 2.61 \trianglelefteq a \trianglelefteq 0.1 \end{cases}$ $\mu_{Average}(RC) = \begin{cases} \dfrac{a - 2.61}{2.61 - 0.1} & , 0.1 \trianglelefteq a \trianglelefteq 2.61] \\ \dfrac{2.61 - a}{8..61 - 0.7} & , 101.4 \trianglelefteq a \trianglelefteq 102.5] \end{cases}$ $\mu_{Good}(RC) = \begin{cases} 1, & a \trianglelefteq 0.9.] \\ \dfrac{a - 0.9}{0.9 - 0.7} & 0.7. \trianglelefteq a \trianglelefteq 0.9 \end{cases}$	

Weather r= W $\mu_{st}(W)$	$\mu_{Moisure}(W)$ $= \{ \begin{cases} 0 & a \trianglelefteq 2..61 \\ 1 & 0.1 \trianglelefteq a \trianglelefteq 2.61 \\ \dfrac{2..61 - a}{2.61 - 0.1}, & 2.61 \trianglelefteq a \trianglelefteq 0.1 \end{cases}$ $\mu_{Rain}(W) = \begin{cases} \dfrac{a - 2.61}{2.61 - 0.1}, & 0.1 \trianglelefteq a \trianglelefteq 2.61] \\ \dfrac{2.61 - a}{8..61 - 0.7}, & 101.4 \trianglelefteq a \trianglelefteq 102.5] \end{cases}$ $\mu_{Dry}(W) = \begin{cases} 1, & a \trianglelefteq 0.9.] \\ \dfrac{a - 0.9}{0.9 - 0.7} & 0.7. \trianglelefteq a \trianglelefteq 0.9 \end{cases}$	
Daylight= DL $\mu_{st}(DL)$	$\mu_{Td\ Normal}(DL) =$ $\begin{cases} 0 & a \trianglelefteq 2..61 \\ 1 & 0.1 \trianglelefteq a \trianglelefteq 2.61 \\ \dfrac{2..61 - a}{2.61 - 0.1}, & 2.61 \trianglelefteq a \trianglelefteq 0.1 \end{cases}$ $\mu_{Average}(DL) = \begin{cases} \dfrac{a - 2.61}{2.61 - 0.1}, & 0.1 \trianglelefteq a \trianglelefteq 2.61] \\ \dfrac{2.61 - a}{8..61 - 0.7}, & 101.4 \trianglelefteq a \trianglelefteq 102.5] \end{cases}$ $\mu_{Good}(DL) = \begin{cases} 1, & a \trianglelefteq 0.9.] \\ \dfrac{a - 0.9}{0.9 - 0.7} & 0.7. \trianglelefteq a \trianglelefteq 0.9 \end{cases}$	

Darkness= DK $\mu_{st}(DK)$	$\mu_{Low}(DK) =$ $\begin{cases} 0 & a \trianglelefteq 0.4 \\ 1 & 0.1 \trianglelefteq a \trianglelefteq 0.4 \\ \frac{0.4-a}{0.4-0.1}, & 0.4 \trianglelefteq a \trianglelefteq 0.1 \end{cases}$ $\mu_{Normal}(DR) = \begin{cases} \frac{a-0.4}{0.4-0.1}, & 0.1 \trianglelefteq a \trianglelefteq 0.4] \\ \frac{0.4-a}{8..61-0.7}, & 0.7 \trianglelefteq a \trianglelefteq 0.9] \end{cases}$ $\mu_{High}(DR) = \begin{cases} 1, & a \trianglelefteq 0.9.] \\ \frac{a-0.9}{0.9-0.7} & 0.7. \trianglelefteq a \trianglelefteq 0.9 \end{cases}$	
Speed= S μA (s)	$\mu_{A,Slow}(s) = \begin{cases} 0 & s \trianglelefteq 1.47 \\ 1 & 0.1 \trianglelefteq s \trianglelefteq 2.1 \\ \frac{1.47-s}{2.1-1.47}, & 1.47 \trianglelefteq s \trianglelefteq 2.0 \end{cases}$ $\mu_{S,Average}(s) = \begin{cases} 1 & 2.1 \trianglelefteq s \trianglelefteq 0.89 \\ \frac{a-2.1}{0.89-0.2}, & 0.21 \trianglelefteq s \trianglelefteq 0.89 \\ \frac{1-a}{1.0-0.7}, & 0.7 \trianglelefteq s \trianglelefteq 1.0 \end{cases}$ $\mu_{S\,High}(s) = \begin{cases} 1, & s \trianglelefteq 1.0 \\ \frac{s-1,0}{1.0-0.7} & 101.3 \trianglelefteq s \trianglelefteq 1.0 \end{cases}$	

Brake = B □□μ□(□)b	$\mu_{B,Loose}(b) = \begin{cases} 0 & 0 \leq a \leq 0.4 \\ 1 & 0 \leq a \leq 0.16 \\ \frac{0.3-b}{0.3-0.16}, & 0.16 \leq a \leq 0.3 \\ \square & \\ \square & \end{cases}$ $\mu_{I,Normal}(b) = \begin{cases} 1 & 0.4 \leq a \leq 1.681 \ ] \\ \frac{b-1.16}{0.4-0.16}, & 0.16 \leq a \leq 0.4 \\ \frac{0.9-b}{0.9-01681}, & 1.681 \leq a \leq 0.9] \end{cases}$ $\mu_{IGood}(b) = \begin{cases} 1 & a \leq 0.8] \\ \frac{b-1.681}{0.9-1.681}, & 1.681 \leq a \leq 0.9] \end{cases}$	

B. **Fuzzy Prepositions**

A compound fuzzy proposition is a composition of atomic fuzzy propositions using the connectives "OR," "AND," and "NOT" which represent fuzzy union, intersections and complement, respectively. Here, s, b, st, rc w, dl, and dk represents Speed , Brake, Steering, Road Condition, Weather, Daylight, and Darkness respectively then the following fuzzy propositions hold:

FP1 = (Speed is essential in driving a motor car and Brake is a also necessary part of drving, Distance, Barries, Balancing the steering, Road Condition, Weather Temperature , Daylight and Darkness are very significant part of driving a motor car.

Here the function t- norm for layer-1 is defined as:

t: $[0,1] \times [0,1] \times [0,1] \times [0,1] \times [0,1] \rightarrow [0,1]$ (1)

Eq. (1) transforms the membership functions of fuzzy sets of Expert, Perfect, Skills Assistances, Careful, for level 1 of proposed fuzzy inference system among membership function of the intersection of High Speed, Good Brake, Long Distance, Major Barriers, Good Balancing the steering, Bad Road Condition and Weather Temperature that is:

$$t[\mu_S(s), \mu_B(b), \mu_D(d), \mu_B(b), \mu_{ST}(y)] = \min \quad 〖 \ 〖[\mu〗$$
$$_S\ (s), \mu_(\ B)\ (b), \mu_St\ (st), \mu_Rc\ (Rc) \quad 〖, \mu〗\ _Y\ (y)〗$$

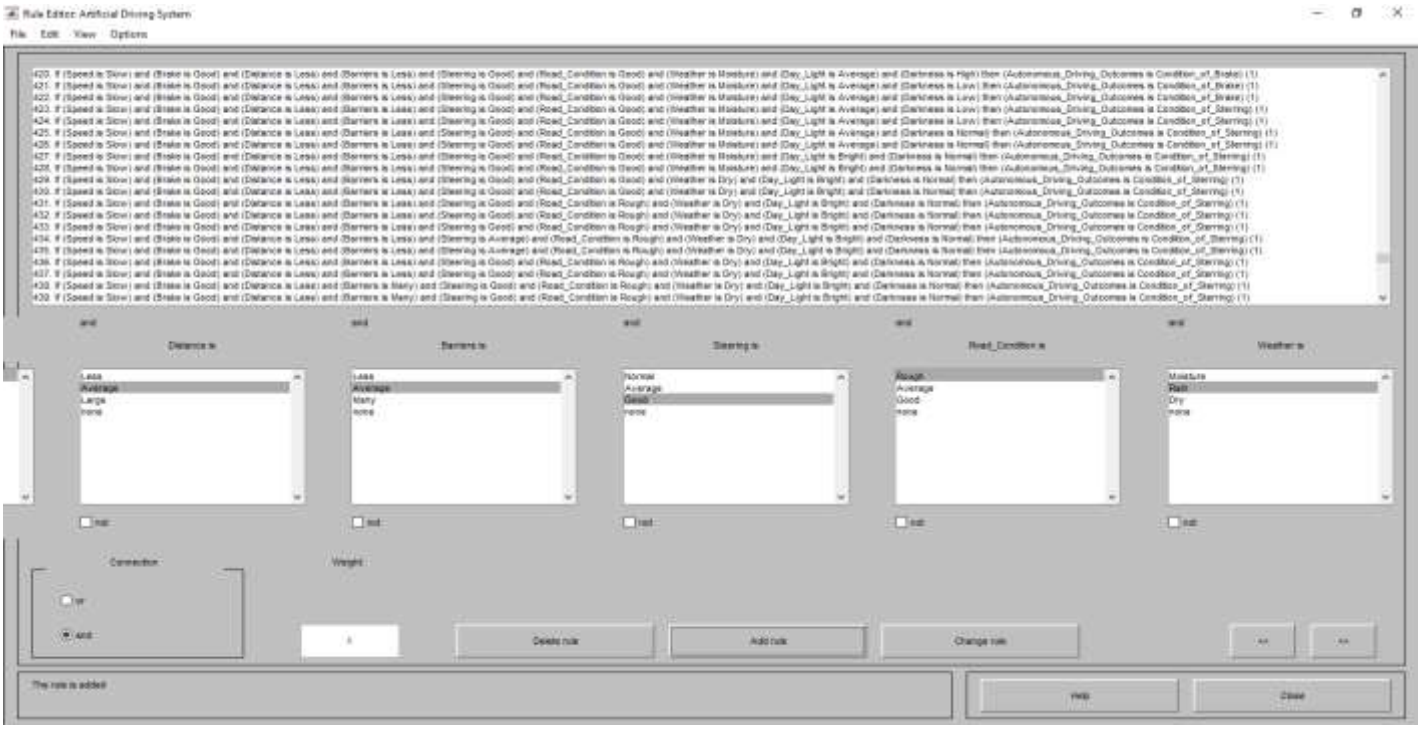
(2)

In Eq. (1) and (2), for the function t; getting qualified as an intersection, following axioms must be satisfied and will be called as t-norm:

Axiom t1:$t(0,0) = 0; t(\beta,1) = t(1,\beta) = \beta$ (Bounded Condition)

Axiom t2:$t(\beta,\gamma) = t(\gamma,\beta)$ (Commutativity)

Axiom t3: If $\beta \leq \beta' and\ \gamma \leq \gamma'$, then $t(\beta,\gamma) \leq t(\beta',\gamma')$ (Nondecreasing)



Axiom t4:$t[t(\beta,\gamma),\delta] = t[\beta,t(\gamma,\delta)]$ (Associativity)

Fig. 8. Rules editor artificial driving system

Eq. (2) can be written in terms of t-norm as:

$$\mu_{S\cap B\cap D\cap ST\cap Y}(s,b,d,st,y) = t[\mu_S(d),\mu_B(m),\mu_D(p),\mu_{st}(t)\mu_Y(y)] \quad (3)$$

Similarly, Eq. (3) can be interpreted as

From Eq. (2) & (3)

$$\mu_{S\cap B\cap D\cap ST\cap Y}(s,b,d,st,y) = t[\mu_S(d),\mu_B(m),\mu_D(p),\mu_{st}(t)\mu_Y(y)] \quad (4)$$

C. FUZZY IF-THEN RULES

To formulate conditional statements that embrace fuzzy logic, if-then statements are used. These statements provide the core grounds to construct fuzzy rule vase. In the current situation, few rules for layer of fuzzy inference system are provided as below.

IF (speed is Normal and Brake is loos and Road Condition is normal) **THEN** Artificial Driving is Perfect

IF (speed is High and Streeting is good, and Road Condition is not satisfied **THEN** Artificial Driving is not Perfect

IF Brake is average and Speed is high, and Darkness is high **THEN** Artificial Driving is not Perfect.

IF Barries is high and Daylight is bad, and Weather is bad **THEN** Artificial Driving is not Perfect.

D. **MAMDANI IMPLICATIONS**

The fuzzy IF-THEN rule is interpreted as a fuzzy relation **Q1011** with the membership function for level 1 ar

$$\boldsymbol{\mu Q_{1011}}(s, b, st, rc, y) = \min\left[\mu_{FP1}(s), \mu_{FP2}(b), \mu_{FP3}(st), \mu_{FP4}(rc)\ \mu Fp5(rc)(t)\right]$$

Then we may calculate fuzzy product for Speed, Brake, Steering, Road Condition and Daylight **FP1** as under

$\mu_{FP1(Speed\ ,Brake\ )} = \mu_{Speed}(s)Brake(b)$

$\mu_{FP1(Speed\ ,}$Brake)=

$$\begin{cases}\left(\dfrac{0.25-\mathrm{s}}{0.25}\right)\left(\dfrac{0.25-\mathrm{b}}{0.25}\right) & \text{if s, b } \in [0, 0.25] \\ 0 & \text{otherwise}\end{cases}$$

It can be written as

$\mu_{FP1(}$Speed, Brake)=

$$\begin{cases}\dfrac{(0.25-s)(0.25-b)}{(0.25)^2}\ if\ a, i\ \in [0, 0.25] \\ 0 \qquad otherwise\end{cases} \quad (5)$$

And

After simplification above equation,

$\mu_{FP2(}$Speed Brake) =

$$\begin{cases}\dfrac{\mathrm{sb}}{(0.25)^2} & \text{if s, b } \in [0, 0.25] \\ \dfrac{(1-\mathrm{a})(1-\mathrm{i})}{(0.65)^2} & \text{if s, b} \in [0, 0.25]\end{cases} \quad (6)$$

Furthermore,

$\mu_{FP3(}$Speed,,Brake)= $\begin{cases}\left(\dfrac{1-\mathrm{s}}{0.65}\right)\left(\dfrac{1-\mathrm{b}}{0.65}\right) & \text{if a, i } \in [0.25, 1] \\ 0 & \text{otherwise}\end{cases}$

It can be written as

$\mu_{FP3(Speed,}$,Brake)= $\begin{cases}\dfrac{(1-s)(1-b)}{(0.65)^2}\ if\ s, b\ \in [0.25, 1] \\ 0 \qquad otherwise\end{cases}$ (7)

In the same way Eq. (11, 12, 13) can be extended for:

$\mu_{FP1(}$Speed ,*Brake*,Steering ,*Road Condition* ,*Weather* ,Temperature,Daylight,Darkness)

as under in eq. (5), (6) and () respectively

μ_{FP2} Speed,Brake ,Steering ,Road Condition,Weather ,Temperature,Daylight ,Darkness = (8)

$$\begin{cases} \frac{sbstrc}{(0.25)^4} & if\ \ s,b.st,rc \in [0,0.25] \\ \frac{(1-s)(1-b)(1-st)(1-rc)(1-rc)}{(0.65)^4} & if\ s,b.st,rc,y\ \in [0.25,1] \end{cases} \quad (9)$$

$\mu_{FP3}(Speed$,Brake,$Steering,\ \ Road\ Condition,\ \ Weather)=$

$$\begin{cases} \frac{(1-s)(1-b)(1-st)(1-rc)}{(0.65)^4} & if\ s,b.st,rc,,y\ \in [0.25,1] \\ 0 & otherwise \end{cases}$$

Fuzzy IF-THEN rules are the constituents of fuzzy rule base. Fuzzy rule base is the major component of fuzzy system because all other components are used to implement these rules in a realistic and proficient way. Fuzzy rule base comprises the following fuzzy IF-THEN rules, where rules for layer 1 are denoted by Ru^e, where $1 \leq e \leq 1011$:

Ru^1= **IF Speed** is Average and Brake is Average and Road Condition is very bad **THEN Artificial Driving is Perfect**

***Ru^2*=** **IF Speed** is High and Brake **is good, and Steering control is Average THEN Artificial Driving is Perfect**

***Ru^3*=** **IF Speed** is High and Brake is Average and Steering Control is good THEN **Artificial Driving is Perfect**

⋮ ⋮ ⋮

***Ru^{1011}*=** **IF Speed** High and Brake is Loos and Steering Control is Bad THEN **Artificial Driving is not Perfect**

The above rules are in the form of canonical fuzzy IF-THEN rules as they comprise special cases of fuzzy prepositions and fuzzy rules.

E. FUZZY INFERENCE ENGINE

In a fuzzy inference engine, fuzzy logic principles are used to combine the fuzzy **IF-THEN** rules in the fuzzy rule base into a mapping from an input fuzzy set to an output fuzzy set. A fuzzy IF-THEN rule is interpreted as a fuzzy relation in the input-output product space, and we proposed implications in the proposed intelligent system that specify the fuzzy relation. Any practical fuzzy rule base constitutes more than one rules, the key question here is how to infer with a set of rules. There are two ways to infer with a set of rules: composition-based inference and individual-rule based inference. In composition-based inference, all rules in the fuzzy rule base are combined into a single fuzzy relation that lies under inner product on input universes of discourse, which is then viewed as a single fuzzy **IF-THEN** rule. There are two opposite arguments for what a set of rules should mean. The first one views the rules as independent

conditional statements. This point of view is applicable in current implementation and therefore, a reasonable operator for combining the rules is union.

Let Ru^e and ru^f be a fuzzy relation that represents any fuzzy IF-THEN rule in the proposed system; that is,

$$Ru^e = S^e \times B^e \times ST^e \times RC^e \rightarrow TY_d{}^e \quad (10)$$

$$ru^f = Ts1^f \times T_{s2}{}^f \times T_{s3}{}^f \rightarrow T_v{}^f \quad (11)$$

Then eq. (10) and eq. (11) hold as below.

$$\mu_{A\cap I\cap B\cap S}(s, b, st, rc) = \mu_S(s) \cap \mu_B(b) \cap \mu_{ST}(st) \cap \mu_T(t) \quad (12)$$

$$\mu_{Ts1\cap Ts2\cap Ts3}(t_{s1}, t_{s2}, t_{s3}) = \mu_{T_{s1}}(t_{s1}) \cap \mu_{T_{s2}}(t_{s2}) \cap \mu_{T_{s3}}(t_{s3}) \quad (13)$$

Accepting the first view of a set of rules, then the rules in the form given in proposed intelligent system is interpreted as a single fuzzy relation Q1011 is defined by.

$$Q_{1011} = \bigcup_{e=1}^{1011} Ru^e$$

The eq. (14) is called Mamdani equation

F. PRODUCT INFERENCE ENGINE

Let I, φ and Ψ be arbitrary fuzzy sets and be the input and output to the fuzzy inference Engine, respectively. Then, by viewing $\mathbf{Q_{1011}}$ as a single fuzzy **IF-THEN** rule and using the generalized modus ponens (Hellendoorn, February 1992), we obtain the output of the fuzzy inference engine as

$$\mu_{Normal\cap R\cap Severe}(\boldsymbol{\varphi}) = sup_{I\in(S,B,ST,RC,Y)} t\left[\mu_I(s, b, st, rc, y), \mu_{Q_{1011}}(s, b, st, rc.y)), T_s\right]$$

$$\mu_{Normal\cap Trivial\cap Severe}(\boldsymbol{\Psi}) = sup_{\boldsymbol{\varphi}\in(Normal,Trivial,Severe)} t[Y_1, Y_2] \quad (15)$$

Here

$$Y_1 = \mu_{\boldsymbol{\varphi}}(Normal, Trivial, Severe)$$

And

$$Y_2 = \mu_{Q_{27}}(Normal, Trivial, Severe)$$

Mamdani composition-based inference or individual-rule based inference fuzzy inference engine is used here. In product inference engine, we use individual rule-based inference with union combination Mamdani's product implication algebraic product for all the t-norm operators we obtain the product inference engine as

$$\mu_{\boldsymbol{\varphi}}(\boldsymbol{Steering\ Control}) =$$

$$\max_{1\le i\le 1011}\left[sup_{I\in(S,B,SC,RC)}\left(\prod_{k=1}^{1011}\begin{pmatrix}\mu_{S_k,I_k,B_k,SC_k}(s,b,sc,rc)\\ \mu_{S_{1_i}S_{2_i},S_{3_i}}(s_1,s_2,s_3)\end{pmatrix}\right)\right] \quad (16)$$

Here I, is the output universe of discourse. Given a fuzzy set I, the product inference engine in Eq. (16) provides fuzzy set φ as output of layer-1 and acts as to calculateΨ, DE fuzzifier. The DE fuzzifier is defined as a mapping from fuzzy set φ which is the output of the fuzzy inference engine in eq. (16) to crisp point o* for layer 1. Theoretically, the task of the DE fuzzifier is to specify a point in output universe of discourse that best represents the fuzzy set φ. This is like the mean value of a random variable. Conversely, since φ is constructed in several choices in determining this representing point. The following three criteria should be considered in choosing a defuzzification scheme. The point o* should represent φ from an intuitive point of view and may lie in the middle of the support of φ or has a high degree of membership in φ.Computational simplicity: This criterion is particularly important for fuzzy control because fuzzy controllers operate in real-time. A slight change in **φ** should not result in a momentous change in o* The centre of gravity DE fuzzifier specifies the o* as the centre of the area covered by the membership function of **φ**, that is,

$$o^* = \frac{\int \boldsymbol{\varphi}\mu_{\boldsymbol{\varphi}}(\boldsymbol{\varphi})d\boldsymbol{\varphi}}{\int \mu_{\boldsymbol{\varphi}}(\boldsymbol{\varphi})d\boldsymbol{\varphi}} \quad (17)$$

Here ∫ is the conventional integral. Equations (17) and calculated the output crisp values for direct trust between the agents of similar group and virtual trust between agents from one group to one in another group.

G. **Fuzzy Logic Simulation Results and Discussion**

Fuzzy logic has Boolean logic and that works partially true or false values. Fuzzy systems deal with the Boolean values in fuzzy logic or membership values in fuzzy sets that are indicated by a Fuzzy Rules as below.

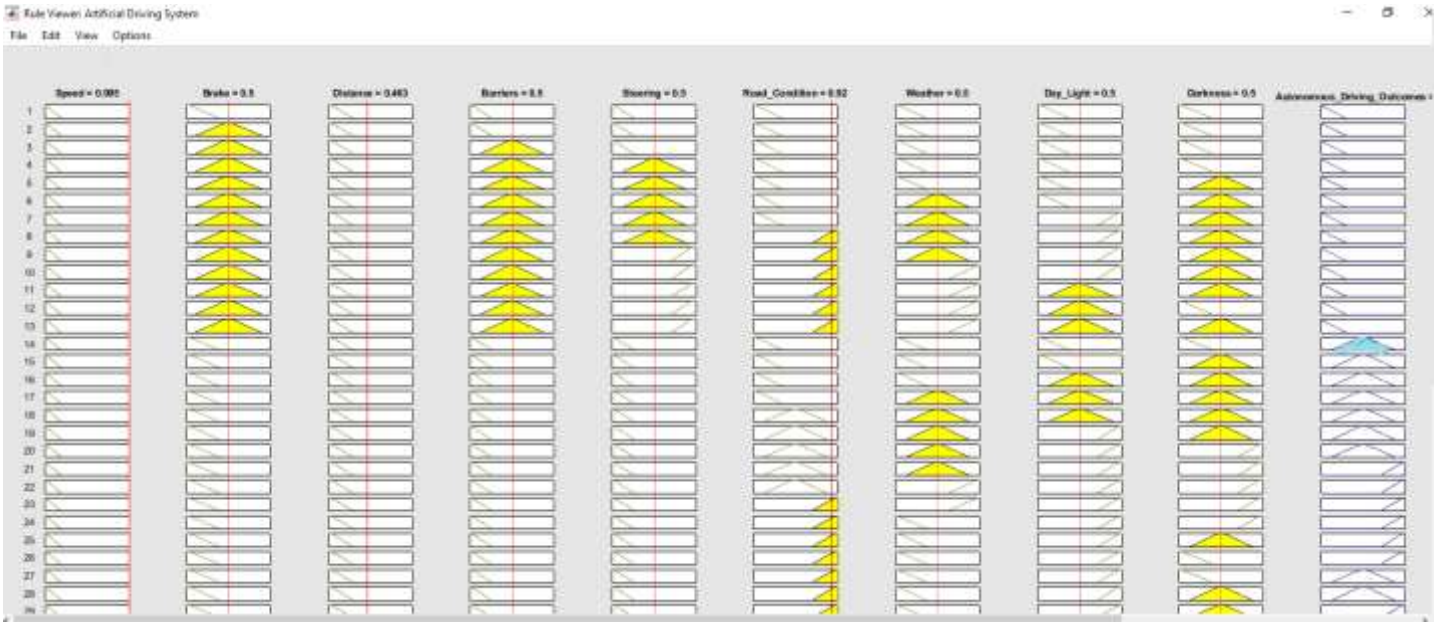
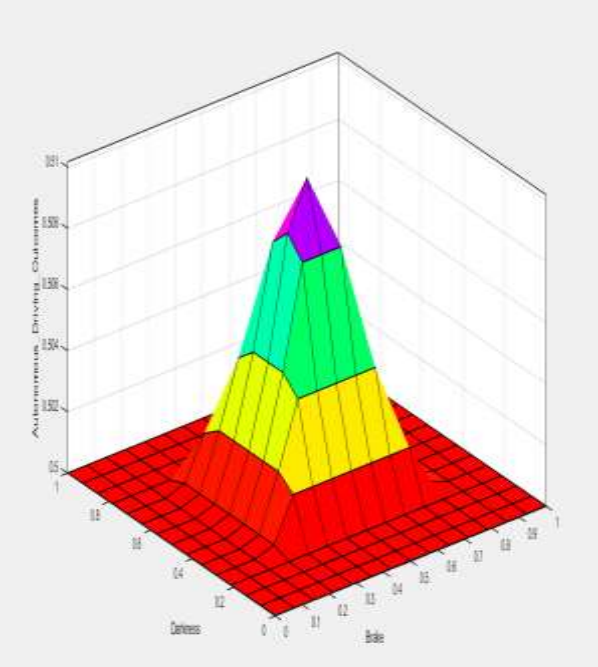
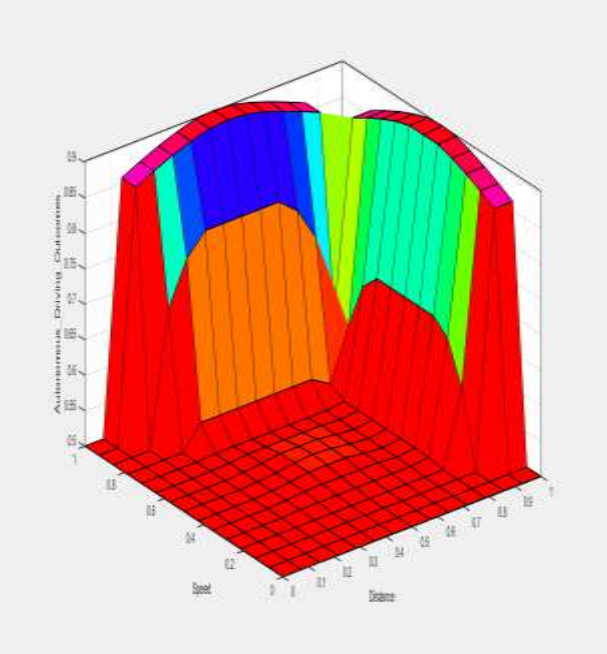


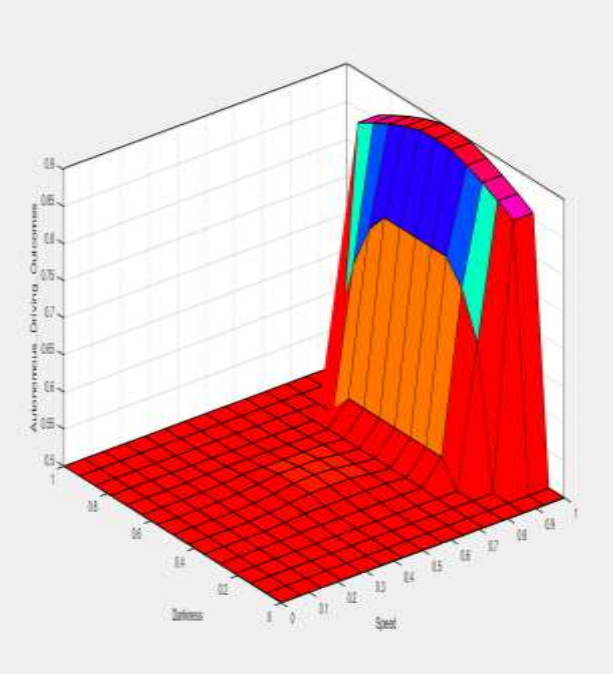
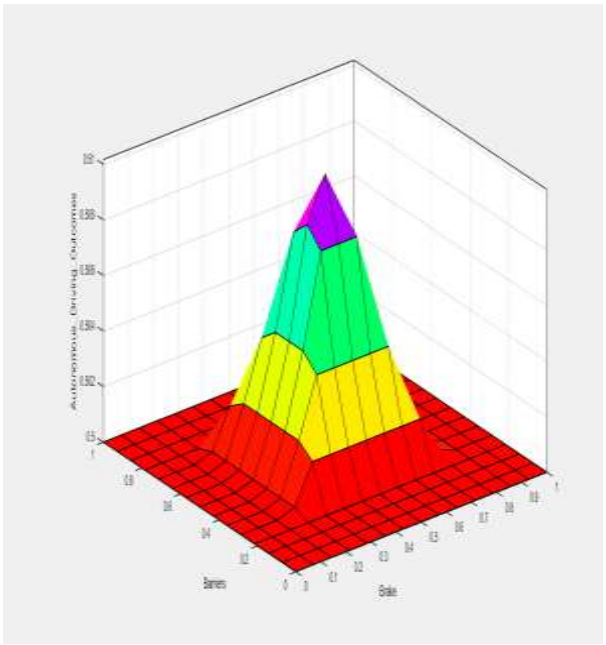
Fig. 9. Rules Viewer Artificial Driving System

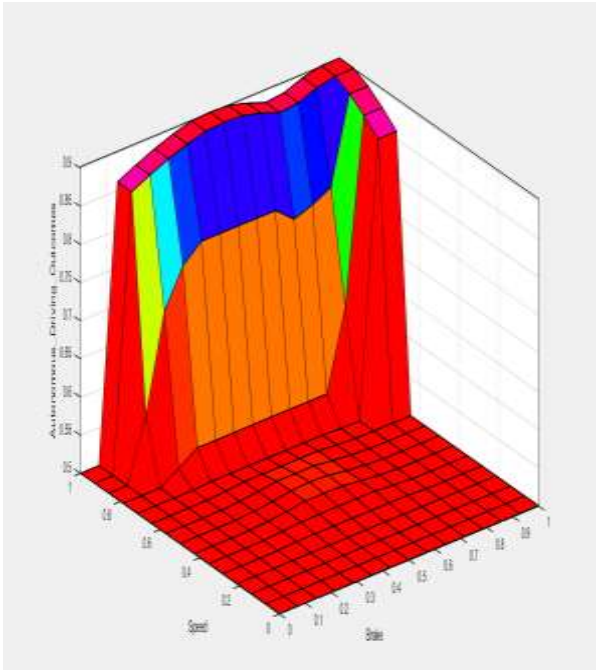
H. **Surface Graph Representation**

Table. 7. Surface graph representation.

Input Variable	**Surface Graph Representation**	**Explaination : Autonomous Driving OutComes**
Darkness= D $\mu_d(D)$ AND Brake= B $\mu_b(B)$		**Interpretation of the Surface Graph:** • **Surface Shape:** The shape and contours of the surface in the graph indicate how the outcome changes with different combinations of braking and darkening. For example, a smoothly rising surface might indicate that increasing both braking and darkening levels improves safety outcomes up to a certain point, beyond which there might be diminishing returns or even negative effects. • **Optimal Points:** Peaks or troughs in the surface graph can suggest optimal combinations of braking and darkening for achieving specific outcomes. These points represent combinations where the outcome (e.g., safety) is maximized or minimized. • **Impact of Variables:** The steepness or flatness of the surface can indicate how sensitive the outcome is to changes in braking or darkening. A steep slope suggests that small changes in braking or darkening can significantly alter the outcome, while a flat surface indicates that changes have minimal impact. A surface graph about autonomous driving outcomes of braking and darkening provides a comprehensive visual representation of how these variables interact and influence specific outcomes. It helps in making informed decisions to enhance safety, comfort, and efficiency in autonomous vehicle systems.

$Speed = S$ $\mu_S(s)$ AND $Distance = D$ $\mu_d(D)$		**Interpretation of the Surface Graph:** • **Surface Contours**: The surface in the graph represents the relationship between distance, speed, and outcomes. It could be smooth or irregular depending on how these variables interact. For example: ❖ A rising surface might indicate that increasing both distance and speed improves safety outcomes up to a point, beyond which safety might plateau or decrease due to other factors like reaction time. ❖ Conversely, a descending surface might suggest that higher speeds and shorter distances decrease safety or increase discomfort. • **Optimal Points**: Peaks or troughs in the surface graph indicate optimal combinations of distance and speed for achieving specific outcomes. Engineers and designers can use these points to fine-tune autonomous driving algorithms or settings. • **Impact of Variables**: The steepness or flatness of the surface indicates how sensitive the outcome is to changes in distance or speed. A steep slope suggests that small changes in either variable can significantly affect outcomes, whereas a flat surface indicates minimal impact. A surface graph depicting autonomous driving outcomes based on distance and speed provides a visual tool for understanding how these variables interact and influence key performance metrics. It guides decision-making in optimizing safety, efficiency, and overall user experience in autonomous vehicle systems.
$Speed = S$ $\mu_S(s)$ AND $Darkness= DR$ $\mu_{dr}(DR)$		**Surface Graph Interpretation:** • **X-axis (Steering)**: The steering parameter is typically plotted along the horizontal axis (x-axis). It ranges from minimal steering (straight driving) to maximum steering angles (sharp turns or maneuvers). • **Y-axis (Road Condition)**: The road condition is plotted along the vertical axis (y-axis). It includes variations from favorable conditions (e.g., dry and smooth roads) to challenging conditions (e.g., wet or icy roads, uneven surfaces). • **Z-axis (Outcomes)**: The outcomes of autonomous driving are represented on the z-axis, which is perpendicular to the x and y axes. This axis illustrates how the combination of steering and road condition influences specific outcomes or

		metrics. Examples of outcomes could include: ❖ **Handling**: How well the vehicle maintains control and stability. ❖ **Safety**: The perceived or measured safety of driving conditions. ❖ **Comfort**: Smoothness of the ride experienced by passengers. ❖ **Performance**: Response time and accuracy in steering adjustments. A surface graph depicting autonomous driving outcomes based on steering and road conditions provides a visual representation of how these variables interact and influence key performance metrics. It serves as a valuable tool for designing and optimizing autonomous vehicle systems to operate safely, efficiently, and comfortably across diverse driving conditions.
St*eering*= *St* $\mu_{st}(St)$ AND Barries = *Br* $\mu_{br}(Br)$		**Surface Graph Interpretation:** • **X-axis (Brake)**: The brake parameter is typically plotted along the horizontal axis (x-axis). It ranges from minimal braking (e.g., no braking or light deceleration) to maximum braking (e.g., emergency braking or sudden stops). • **Y-axis (Speed)**: Speed is plotted along the vertical axis (y-axis). It ranges from lower speeds (slow velocities or stationery) to higher speeds (fast velocities). • **Z-axis (Outcomes)**: The outcomes of autonomous driving are represented on the z-axis, which is perpendicular to the x and y axes. This axis illustrates how the combination of brake and speed influences specific outcomes or metrics. Examples of outcomes could include: ❖ **Safety**: How safe driving conditions are perceived or measured. ❖ **Comfort**: Smoothness of the ride experienced by passengers. ❖ **Efficiency**: Fuel efficiency or energy consumption. ❖ **Performance**: Response time and accuracy in driving maneuvers. A surface graph depicting autonomous driving outcomes based on brake and speed provides a visual tool for understanding how these variables interact and influence key performance metrics. It assists in designing autonomous vehicle systems that operate safely, efficiently, comfortably, and effectively

		across a wide range of driving conditions and scenarios.
$Brake = B$ $\mu_b(B)$ AND $Speed = S$ $\mu_s(S)$		**Surface Graph Interpretation:** • **X-axis (Steering)**: The steering parameter is typically plotted along the horizontal axis (x-axis). It ranges from minimal steering (straight driving) to maximum steering angles (sharp turns or maneuvers). • **Y-axis (Barriers)**: The barrier variable is plotted along the vertical axis (y-axis). It includes variations from no barriers (clear road) to high density of barriers (e.g., congested urban environment with frequent obstacles). • **Z-axis (Outcomes)**: The outcomes of autonomous driving are represented on the z-axis, which is perpendicular to the x and y axes. This axis illustrates how the combination of steering and barriers influences specific outcomes or metrics. Examples of outcomes could include: ❖ **Collision Avoidance**: How effectively the vehicle navigates around or avoids obstacles. ❖ **Path Planning**: The efficiency and smoothness of the vehicle's trajectory around barriers. ❖ **Safety**: The perceived or measured safety of driving conditions relative to the presence of obstacles. A surface graph depicting autonomous driving outcomes based on steering and barriers provides a visual representation of how these variables interact and influence key performance metrics. It guides decision-making in designing autonomous vehicle systems that can navigate safely, efficiently, and effectively through diverse driving environments with varying degrees of obstacle density.

III. DISCUSSION

The results of "Revolutionizing Autonomous Driving: A Cutting-Edge Fuzzy Logic Control System" typically revolves around how fuzzy logic control systems utilize membership functions to manage and optimize various parameters crucial for autonomous driving as described in Table 6. Let us break down how these variables (speed, steering control, barriers, darkness/weather conditions, and daylight) are managed using fuzzy logic. The surface graphical representation has been representation in Table 7. The fuzzy logic control system optimizes vehicle control by dynamically adjusting steering, speed, and braking in response to changing road conditions and obstacles. By using membership functions to assess barrier

proximity and environmental conditions, the system enhances safety by avoiding collisions and adapting to visibility challenges. Smooth adjustments in steering and speed based on fuzzy logic ensure a comfortable ride for passengers, minimizing abrupt changes in driving dynamics. The system's ability to adapt to varying darkness/weather conditions and daylight levels ensures consistent performance and reliability in different driving environments. Fuzzy logic enables efficient decision-making by prioritizing actions based on real-time inputs, optimizing fuel consumption and energy efficiency in autonomous driving operations. The results of a fuzzy logic control system in autonomous driving highlights its capability to manage complex variables such as speed, steering control, barriers, darkness/weather conditions, and daylight using membership functions. This approach revolutionizes autonomous driving by enhancing safety, comfort, efficiency, and adaptability across diverse driving scenarios.

IV. CONCLUSION

The implementation of a cutting-edge fuzzy logic control system represents a significant leap forward in revolutionizing autonomous driving. By leveraging precise membership functions tailored to variables such as speed, steering control, barrier detection, darkness/weather conditions, and daylight levels, this system effectively enhances every facet of autonomous vehicle operation. Through optimized steering adjustments and speed management based on real-time conditions, the system ensures both safety and comfort for passengers. It navigates barriers with agility, utilizing proximity assessments provided by fuzzy logic membership functions to mitigate collision risks effectively. Moreover, the system adeptly adapts to varying levels of darkness, diverse weather conditions, and fluctuating daylight, thereby maintaining consistent performance and reliability across different driving environments. This adaptability not only improves overall driving efficiency but also minimizes energy consumption, contributing to sustainable transportation solutions. The integration of fuzzy logic in autonomous driving systems marks a transformative advancement, paving the way for safer, more efficient, and seamlessly adaptive vehicles capable of navigating the complexities of modern roadways with unprecedented precision and reliability

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Artificial Neural Networks (ANN) Model of SPTN Value for Sandy Soil

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Abstract – The most popular field test for estimating soil parameters for geotechnical analysis and design is the Standard Penetration Test (SPT). The SPT N-value is correlated with a number of soil characteristics. Field testing, however, is expensive and time-consuming. Artificial neural networks (ANN) are therefore in widespread usage today and are growing in popularity among researchers, particularly in the geotechnical discipline. In order to forecast the N60-value from index values, such as the percentage composition of sand, silt, and gravel, the liquid limit, the plastic limit, the plastic index, and the moisture content, an artificial neural network (ANN) model was created using MATLAB software for this research project. The study's data set consists of sixty SPT samples of cohesionless soil that were collected from Chakwal, Rawalpindi and Islamabad in Pakistan. We computed coefficient of correlation (R = 0.894) and R-squared (R2 = 0.799) in our ANN model. Also root mean squared error (RMSE) was found to be 2.21 and mean absolute error (MAE) was 2.88. It was found that ANN model effectively predicts SPT-N60 values. The proposed model will be used by the people working in geotechnical engineering organizations as an easy, quick and economical approach to predict penetration resistance of soil during preliminary investigation of a site.

Keywords – ANN model, SPT-N, Index Properties, Cohesionless soil, MATLAB

I. INTRODUCTION

To investigate a site, on-site assessments are conducted to identify the soil layers and assess their properties for geotechnical purposes. Penetration resistances are employed to categorize and describe the subsoil. Utilizing in situ tools like the standard penetration test (SPT) and cone penetration test (CPT) allows for efficient data collection at a lower cost and in less time. During construction projects SPT test is performed for preliminary soil investigations, however CPT is usually used for detailed soil investigation [1]. Artificial neural networks are basically computer processing structures whose architectures fundamentally imitate the organic system of the brain [2]. Figure 1 shows basic processing structure of Artificial neural networks (ANN) model. As ANN models have the ability to learn complex parallels between input constraints and output values, thus they are becoming very useful in predicting values based on number of constraints. Thus, modelling soil phenomena's using artificial neural networks (ANN) technique is need of the modern world [3]. That's why within a few decades artificial neural networks (ANN) has become very popular among geotechnical engineers. Different researchers have worked on different phenomena's including liquefaction [4], [5], foundation settlements [6], [7], soil reinforcement [8], and soil compaction characteristics [9], [10].

Thus Hendra Fernando et al., [11] predicts ANN model for determining SPT values using CPT data and soil physical characteristics as an input parameter, with and without data normalisation in clayey soil. They

found that both methods whether using ANN model with data normalisation or without normalisation were adequate. Similarly, another researcher Nugroho et al., [12] examines the ANN model for predicting SPT values from CPT data in cohesive soils. When they test their model, they found that the results were quite satisfactory. Bashar Tarawneh [1] predicts SPT-N value for sandy soil, using CPT values like tip resistance (qc), effective vertical stress, and CPT sleeve friction (fs) as an input parameter. However, performing CPT test will be costly. Thus, using Artificial Neural Network (ANN) models for predicting Standard Penetration Test (SPT) values for cohesionless soil using index properties and percentage will be very beneficial for preliminary investigation of soil. Therefore, this paper's primary goal is to create an Artificial Neural Network (ANN) model that can forecast N-value for cohesionless soils based on SPT data.

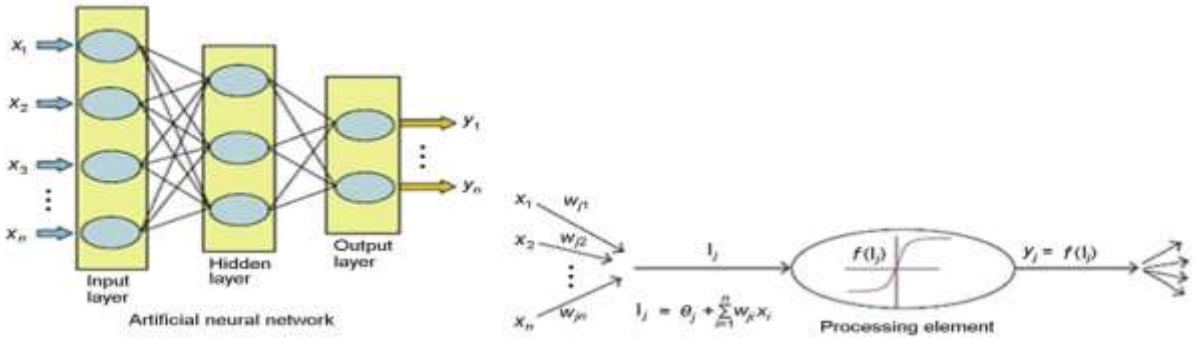

FIGURE 1 GENERAL STRUCTURE AND PROCESS OF ARTIFICIAL NEURAL NETWORKS (ANN) MODEL [13].

II. Materials and Method

A. Data Collection

This research was carried out using SPT data collected from three cities of Pakistan i.e., Chakwal, Rawalpindi and Islamabad. Data used in this study consist of 60 SPT samples of cohesionless soil. As we know that standardizing the N-values obtained from any hammer to a standard rod energy ratio is important. Hence, we adjusted all N-values to 60% hammer effectiveness in order to determine N60. We know that SPT value relies heavily on several variables like liquid limit, plastic limit, plastic index and moisture content, thus these variables will be used as an input parameter in our ANN model. Each sample were classified according to USCS, which turnout to be sand, sandy silt, and silty sand soils. Table 1 outlines the average, minimum, maximum, standard deviation, and range of the field data collected.

Table 1: Collected data statistics.

	Depth	Gravel	Sand	Fines	LL	PL	PI	M.C (%)	N_{60}
Min	5.0	0.0	50.0	11.0	18.7	14.7	4.0	0.0	2.0
Max	50.0	26.0	89.0	50.0	34.8	24.7	10.1	21.3	62.0
Mean	19.4	2.2	66.2	31.6	25.6	19.2	6.4	7.1	33.7
Std Dev	12.6	4.5	11.1	11.4	8.3	5.1	3.2	5.6	18.1
Range	45.0	26.0	39.0	39.0	16.1	10.0	6.1	21.3	60.0

B. Artificial Neural Networks (ANNs) Model

The progression of constructing an artificial neural network is conducted through the MATLAB application, which offers a blend of modular design interface and sophisticated learning algorithms. This combination provides the necessary power and adaptability to craft the neural network that yields the most optimal solution. The dataset utilized in this study comprises nine input parameters: depth of test,

percentage composition of sand, silt, and gravel, liquid limit, plastic limit, plastic index, moisture content, and N60. The output of the ANN model is the SPT N60-value. The dataset was divided into three subsets: training, cross-validation, and testing. Seventy percent of the data points were allocated for training, fifteen percent for cross-validation, and the remaining fifteen percent for testing the network. First, we trained the model using training data points, by determining weights of input parameters. After that in the second step cross-validation of the model was done to evaluate error in a trained model. At the end we found the performance of the selected ANN model using the test data points. To check the validation of our developed model we calculate root mean square error (RMSE), mean absolute error (MAE), R-squared (R2), and coefficient of correlation (R) of our model. We know that regression correlation approaching 1 are commonly considered as indicators of a high-performing network.

III. RESULTS

Our correlation coefficient (R = 0.894) and R-squared (R2 = 0.799) in our model. Moreover, mean absolute error (MAE) was determined to be 2.88 and root mean squared error (RMSE) to be 2.21. Figure 2 illustrates the correlation trends throughout the training, validation, and testing phases, showcasing the overall performance of our ANN model.

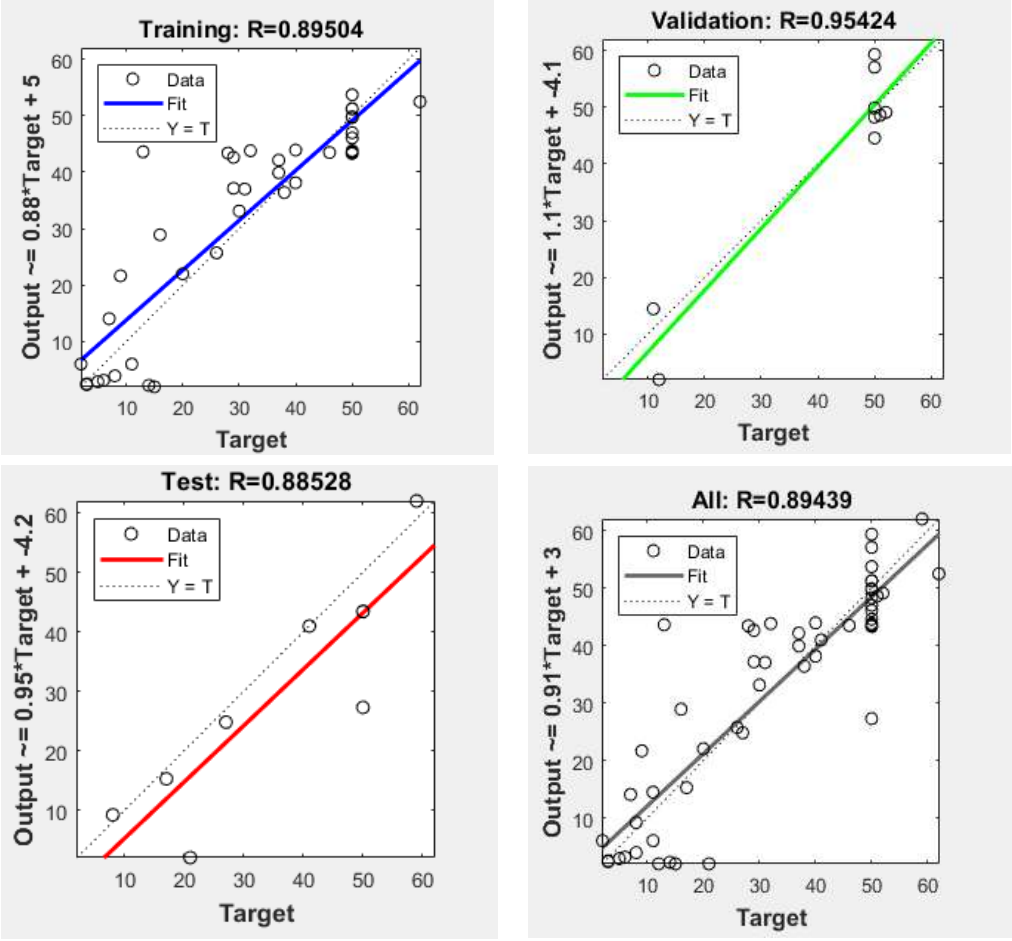

Figure 2: Coefficient of Correlation (R) graph of training, validation, testing and overall performance of ANN model.

IV. DISCUSSION

This breakthrough promises a swift, cost-effective, and accurate means for geotechnical engineers to anticipate soil penetration resistance during preliminary site investigations, accompanying in a new era of efficiency and precision in the field. The proposed model will be used by the people working in geotechnical

engineering organizations as an easy, quick and economical approach to predict penetration resistance of soil during preliminary investigation of a site.

V. CONCLUSION

The Standard Penetration Test (SPT) stands as important field test for gauging soil parameters essential for geotechnical analysis and design. However, conducting these tests is both time-consuming and costly. Hence now adays researchers are moving towards artificial intelligence. Artificial neural networks (ANN) modelling, is an emerging and a popular solution, particularly within the geotechnical realm. This research endeavors to harness the power of ANN using MATLAB software to forecast the N60-value, using index properties such as sand, silt, and gravel composition, alongside liquid and plastic limits, plasticity index, and moisture content. Drawing from a dataset of 60 SPT samples sourced from Chakwal, Rawalpindi and Islamabad in Pakistan, our ANN model showcases remarkable predictive capabilities, as evidenced by a robust correlation coefficient (R = 0.894) and R-squared (R2 = 0.799). Also root mean squared error (RMSE) was found to be 2.21 and mean absolute error (MAE) was 2.88.

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BİTKİSEL ÜRETİM ENERJİ ANALİZİNDE KULLANILAN ARAÇLAR

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Özet **–**Teknolojinin gelişmesi ile birlikte enerji ihtiyacı da günden güne artmaktadır. Üretimin yapıldığı her alanda, üretimin her aşamasında yoğun enerji tüketiminin oluştuğu bilinen bir gerçektir. Artan bu enerji talebinin verimli kullanılması, üretim maliyetlerini doğrudan etkilen en önemli faktörlerden biridir. Harcanan enerjiden elde edilen ürün miktarının biri birine oranlanması verimlilik olarak karşımıza çıkmaktadır. Az enerji ile çok iş yapmak, üretimde verimliliği yükseltecektir.

Tüm sektörlerde olduğu gibi tarımsal faaliyetlerde de dikkate alınması gereken en önemli unsur, ürünün girdi enerji maliyetinin azaltılmasıdır. Ürün kalitesi ve verimini düşürmeden enerji maliyetinin azaltılması; enerjinin etkin kullanımı ve enerji verimliliğiyle sağlanabilir.

Verimlilik, enerji tasarrufunun yanı sıra, doğal kaynakların tarım işletmelerinde etkin kullanımı ile mümkün olmaktadır. Enerjinin verimli kullanılması tarımsal üretimin sürdürülebilirliğine ve ülke ekonomisine büyük katkılar sağlayacaktır. Tarımsal üretimde kullanılan enerji, ülkemizin toplam enerji tüketiminin %4,2 si kadar olup dünya ortalamasının üzerinde bir değerdedir [1]. Bu değerde yapılacak küçük iyileştirmeler ile büyük kazançların sağlanacağı söylenebilir. Ülkemizde özellikle geleneksel/konvansiyonel tarımda, bilinçsizce tüketilen enerji işletmelerin bitkisel üretimde verimliliğini düşürmekte ve mali kayıplara yol açmaktadır.

Bu çalışmada, tarımsal üretimde enerji bilançosu çıkarılarak, işletmelerin verimlilik analizlerinin yapılabilmesi için kullanılan aritmetiksel hesaplama araçlarına yer verilmiştir. Bu hesaplamalarda kullanılan katsayılar ve kabullenmeler ayrı ayrı açıklanmıştır. Bu çalışma, tarımsal üretimde enerji hesaplamaları konusunda çalışmalar yapan araştırmacılara büyük kolaylıklar sağlayacaktır.

Anahtar Kelimeler – Enerji bilançosu, tarımsal üretim, verimlilik.

I. GİRİŞ

Gelişen teknoloji ile birlikte, üretimin her aşamasında yoğun enerji tüketiminin oluştuğu bilinen bir gerçektir. Buna karşın alınan ürün miktarı bu artışa paralel olarak artmamaktadır. Bu durum dünyada enerji verimliliği açısından oldukça önemlidir [2].

Tüm sektörlerde olduğu gibi tarımsal faaliyetlerde de dikkate alınması gereken en önemli unsur, üretilen ürünün girdi enerji maliyetinin azaltılmasıdır. Ürün kalitesi ve verimini düşürmeden enerji maliyetinin azaltılması; enerjinin etkin kullanımı ve enerji verimliliğiyle sağlanabilir.

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II. ENERJİ KAVRAMI VE ÖNEMİ

Enerji, bir maddenin iş yapabilme yeteneği olarak tanımlanır ve birimi joule (j)' dur. Mekanik anlamda ise; İş= Kuvvet X Yolu'dur. Fiziksel anlamda mekanik enerji; kinetik ve potansiyel enerji olmak üzere iki kısma ayrılır. Ancak bu çalışmada kinetik ve potansiyel enerji konusuna değinilmeyecektir.

Enerji neden önemlidir? diye bir soru akla gelebilir. Bu sorunun cevabını verebilmek için dünyada geçmiş tarihlerde yaşanan enerji krizlerine göz atmak gerekir.

Dünyada yaşanan üç büyük petrol krizi, ülkelerin enerjiye bakış açılarını oldukça etkilemiştir. Özellikle fosil yakıtlara bağımlılığın azaltılması ve enerji verimliliği konuları, bu krizler sonrasında ön plana çıkmaya başlamıştır.

İlk petrol krizi, 1973-74'te meydana gelmiştir. 1973 Arap-İsrail Savaşı, petrol üreten birkaç Arap ülkesinin ABD ve İsrail ile ittifak yapan ülkelere petrol sevkiyatını durdurmasına neden olmuştur. Evden işlerine gidip gelen Amerikalılar benzin istasyonları önünde kuyruklar oluşturdular. Benzin fiyatları bir anda dört katına çıkmıştır.

İkinci petrol krizi ise 1979-80'de meydana gelmiştir. Bu krizin nedeni, İran Devrimi ve Şah'ın devrilmesiydi. İran'dan ABD'ye petrol sevkiyatı durmuştur. Ama asıl kriz ise, OPEC fiyatlarını iki katına çıkarınca gelmiştir.

Üçüncü petrol krizi 1990-91'de meydana gelmiştir. Irak'ın, Kuveyt'i işgal ve Suudi Arabistan'ı tehdit etmesi, 3. petrol krizinin doğmasına yol açmıştır. Irak'ın Orta Doğu'daki egemen güç olmasını önlemek, bölge petrollerinin üretimi ve fiyatlandırması üzerinde etkide bulunmak için ABD'nin öncülüğündeki koalisyon güçleri Irak'ı Kuveyt'ten zorla çıkarmışlardır. Petrol fiyatı, Irak'ın Kuveyt'i işgalinden hemen sonra aşırı miktarda artmıştır [3].

Tüm bu krizler neticesinde ekonomisi ciddi zarar gören, özellikle de fosil yakıtlara sahip olmayan dünya ülkelerinin en önemli gündemi enerji ve enerji verimliliği olmuştur.

III. TARIMDA ENERJİ ANALİZİ

Tarımsal üretimde enerji analizi denildiğinde; tarımsal üretimin her aşamasında kullanılan enerjiler ile hasat edilen üründen alınan enerji akla gelir. Bu anlamda enerji; Girdi Enerjisi ve Çıktı Enerjisi olarak iki ana başlıkta incelenebilir.

Girdi Enerjileri, bitkisel üretimin her aşamasında kullanılan enerjiyi ifade eder. Bu enerjiler; İnsan İş Gücü, Makine Enerjisi, Kimyasal Gübrelerin Enerjisi, Tarımsal Savaşta kullanılan Kimyasalların Enerjisi, Yakıt Enerjisi, Sulama Suyu Enerjisi, Elektrik Enerjisidir. Ayrıca hasat sonrasında yapılan faaliyetlerde harcanan enerjilerinde buna ilave edilmesi gereklidir. Bu enerjiler içerisinde makine enerjisi, insan iş gücü enerjisi ve yakıt enerjisi tarımsal üretimin her aşamasında ayrı ayrı hesaplanmalıdır.

Ayrıca, Enerji analizi yapılırken, girdi enerjiler; yenilenebilir enerji, yenilenemeyen enerji, doğrudan enerji ve dolaylı enerji olmak üzere 4 grupta incelenebilir.

Yenilenebilir Enerji, güneş rüzgâr su vb. doğal kaynaklardan elde edilebilen, sürekli olarak kendiliğinden yenilenebilen enerjiye denir. Bitkisel üretimde enerji bilançosunda yenilenebilir enerji türleri; kullanılan tohumu, insan işgücünü, doğal gübreleri ve sulama suyunu kapsamaktadır. Yenilenebilir enerji kaynakları devamlı var olan ve doğaya zarar vermeyen enerji kaynaklarıdır.

Yenilenemeyen enerji kaynakları ise, doğada fosil olarak bulunan, zamanla tükenecek olan, alternatif kaynaklara göre doğaya zararlı kimyasallar yayan enerji kaynaklarıdır. Dünya Enerji Dengeleri 2019 Raporu'na göre 2017 yılında fosil kaynakların kullanım oranı yüzde 81,3'tür [4]. Dünyada yenilenemeyen kaynakların dağılımı dengesizdir. Her ülke fosil yakıt kaynağına sahip olmamakla birlikte diğer ülkelerden ithalat yoluyla kaynağa ulaşmaktadır. Dağılımdaki bu dengesizlik ülkeleri enerjide dışa bağımlı hale getirir. En temel özelliği sürdürülebilir yapıda olmamalarıdır. Bitkisel üretimde enerji bilançosunda yenilenemeyen enerji türleri fosil yakıtlardan elde edilen enerjiler, gübreler, pestisitler ile makine enerjilerini kapsar. Yenilenemeyen enerji kaynakları tükenme ihtimali olan ve çevreye zarar veren enerji kaynaklarıdır.

Doğrudan enerji, bitkisel üretimde toprak işlemeden başlayarak ürün hasadı ve işlenmesine kadar olan süreçte kullanılan yakıt, sulama suyu, insan iş gücü ve elektrik enerjisini kapsamaktadır.

Dolaylı Enerji ise bitkisel üretimde fosil yakıtlardan elde edilen kimyasal gübreler ile pestisitleri ve makine enerjisini kapsar.

Çıktı enerjisi denildiğinde ise, işletmede tarım yapılan toplam alandan elde edilen mahsulün sahip olduğu enerjisi akla gelir. Eğer varsa bitki artıkları, budama dalları, saman vb. gibi çıktılarında enerji değerleri çıktı enerjisi olarak, mahsulün enerjisine ilave edilir. Bitkisel üretimde enerji analizi yapılırken; girdi ve çıktıların ayrı ayrı Enerji Eşdeğerinden yararlanılır. Enerji Eşdeğeri (E), birim miktar için harcanan enerjiyi ifade eder. Birimi MJ/birimdir. Hesaplamalarda bu değerler çoğunlukla literatürden yararlanılarak alınır. Tablo 1'de bazı girdi ve çıktıların enerji eşdeğerleri verilmiştir. Bu değerlerin bazı kaynaklarda daha farklı değerlerde olduğu görülebilmektedir. Ancak bu değerlerdeki farklılıkların Enerji Eşdeğeri birimlerindeki farklılıktan kaynaklandığı unutulmamalıdır. Hesaplamalarda mutlaka birim analizinin yapılması gerekmektedir.

Tablo 1. Bazı Bileşenlerin Enerji Eşdeğerleri [5].

Girdi	**Enerji Eşdeğeri (Mj/birim)**	**Kaynaklar**
İnsan İşgücü (h)	1,96	[6], [7]
Makine (kg)		
Traktör	158,3	[8], [9]
Tarım Makineleri	121,3	[8]; [9]
Yakıt ve Yağ (lt)		
Dizel Yakıt	35,69	[10], [11], [12]
Yağ	6,51	[10], [11]; [12]
Kimyasal Gübreler (kg)		
Azot (N)	60,6	[13], [8]
Fosfor (P)	11,1	[13], [8]
Potasyum	6,7	[14],
Çiftlik Gübresi	0,3	[15] [34], [36]
Tarımsal Savaş Kimyasalları		
İnsektisitler	278	[16]
Herbisit	238	[17], [18]
Fungusit	92	[17], [19]
Tohum (kg)		
Buğday	15,7	[20]
Sulama Suyu(m^3)	0,63	[21], [23]
Elektrik Enerjisi (kWh)	3,6	[8], [10], [23]
Çıktı (kg)		
Dane Buğday	14,7	[8], [20], [22]
Kiraz)	2,4	[23], [24], [25]
Kiraz Budama Dalları	16,7	[24], [25]

IV. TEORİK HESAPLAMALAR

Bitkisel üretimin her aşamasında insan iş gücü, makine enerjisi ve yakıt enerjisi kullanılmaktadır. Dolayısı ile bu kalemlerin her faaliyet için enerji girdi değerleri ayrı ayrı bulunmalıdır. Birimi Mj/birimdir. Diğer girdi kalemleri için birim değer enerji eşdeğeri ile çarpılarak o kalemin enerji girdi değeri bulunur.

İnsan İşgücü, Makine Enerjisi ve Yakıt Enerji girdisinin hesaplanmasında öncelikli olarak (1) nolu eşitlikten yararlanılarak alan iş başarısı hesaplanır.

$$A_i = B.v.t.k.0,1 \quad (1)$$

Burada;
A_i: Alan İş Başarısı (ha/h)
B : Kullanılan Ekipmanın İş Genişliği (m)
v : İlerleme Hızı (km/h)
t : Çalışma Zamanı (h)
k : Zamandan Faydalanma Katsayısı

Hesaplanan iş başarısı yardımı ile makine enerjisi (2) no'lu eşitlik ile bulunur.

$$M_E = \frac{G.E}{T.A_i} \quad (2)$$

Burada ;
M_E: Makine Enerjisi (Mj/ha)
G: Makinenin Ağırlığı (kg)
E: Makine Yapım Enerjisi (Mj/kg)
T: Kullanılan Makinenin Ekonomik Ömrü (h)
A_i: Kullanılan Makinenin Alan İş Başarısı (ha/h).

Yakıt Enerjisi (3) no'lu eşitlik ile hesaplanmaktadır.

$$TY_E = V.Y_E \quad (3)$$

Burada;
TY_E: Toplam yakıt enerjisi (MJ/h)
V: Kullanılan yakıt miktarı (lt/h)
Y_E: Yakıt eşdeğer enerji değeri (MJ/lt)

İnsan İşgücü Enerjisi (4) no'lu eşitlik ile hesaplanmaktadır.

$$T\dot{I}_E = T.T_E \quad (4)$$

$T\dot{I}_E$: Toplam işgücü enerjisi (MJ/ha)
T:Çalışma zamanı(h/ha)
T_E: İşgücü enerjisi (MJ/h)

Tohum Enerjisini (5) no'lu eşitlik ile belirlenmektedir.

$$TT_E = Q.T_E \quad (5)$$

Burada;
TT_E: Toplam tohum enerjisi (MJ/ha)
Q: Ekim normu (kg/ha)
T_E: Tohum enerji (MJ/kg)

Gübre Enerjisinin Belirlenmesinde (6) No'lu eşitlikten yararlanılmaktadır.

$$TG_E = Q_g.G_E \quad (6)$$

Burada;
TG_E: Toplam gübre enerjisi (MJ/ha)
Q_G: Gübre normu (saf madde üzerinden) (kg/ha)
G_E: Gübre enerjisi (MJ/kg)

Pestisitlerin enerjisinin belirlenmesinde (7) no'lu eşitlik kullanılmaktadır.

$$P_E = Q_i.\dot{I}_E \quad (7)$$

Burada;
P_E: Toplam pestisit enerjisi (MJ/ha)
Q_i: İlaç normu (kg/ha)

$İ_E$: İlaç enerjisi (MJ/kg)

Bitkisel Üretimde yapılan sulama işleminin girdi enerjisi bulunurken öncelikle sulamada kullanılan su miktarı ve tarım yapılan alan yardımı ile Alan İş Başarısı (A_i) (8) nolu eşitlik ile hesaplanmaktadır.

$$A_i = Q / BAS \quad (8)$$

A: Sulama Alan İş Başarısı (ha/h)
Q: Suyun Debisi (m^3/h)
BAS: Birim Alanda Kullanılan Su Miktarı (m^3/ha)

Sulama işlemi için Alan İş Başarısı (A_i) (8) no'lu eşitlik ile güç kaynağı, pompa ve sulama ekipmanları için yapım enerjileri ise, (2) no'lu eşitlik ile hesaplanmaktadır.

Toplam Girdi Enerjisi (TG_E) ise (9) no'lu eşitlik ile hesaplanmaktadır.

$$TG_E = M_E + TY_E + T\dot{I}_E + TT_E + TG_E + P_E \quad (9)$$

TG_E ile bir bitkisel üretim döneminde yapılan tüm faaliyetlerin oluşturduğu toplam Girdi Enerjileri bulunmuş olur. Birimi Mj/ha dır.

Toplam Çıktı Enerjisi ($TÇ_E$) ise (10) no'lu eşitlik ile hesaplanmaktadır. Hesaba üretim sırasında varsa oluşan yan ürünlerde dahil edilerek hesaplanmaktadır.

$$TÇ_E = (A_{ÜV}.E_{AÜ}) + (Y_{ÜV}.E_{YÜ}) \quad (10)$$

Burada;
$TÇ_E$: Toplam Çıktı Enerjisi (Mj/ha)
$A_{ÜV}$: Ana Ürünün Verimi (kg/ha)
$E_{AÜ}$: Ana Ürünün Enerji Değeri (Mj/kg)
$Y_{ÜV}$: Yan Ürünün Verimi (kg/ha)
$E_{YÜ}$: Yan Ürünün Enerji Değeri (Mj/kg)

Bitkisel üretimde enerji etkinliğinin belirlenmesinde; Enerji Kullanım Verimliliği, Enerji Verimliliği ve Özgül Enerji değerleri dikkate alınır. Bu değerler (11), (12) ve (13) no'lu eşitlikler ile hesaplanmaktadır.

Bitkisel üretim için harcanan enerjinin (girdi enerjisi) elde edilen ürünün enerji değerine oranlanmasıyla Enerji Kullanım Verimliliği değeri (11) no'lu eşitlik ile hesaplanmaktadır.

$$EKV = TÇ_E / TG_E \quad (11)$$

Burada;
EKV: Enerji Kullanım Verimliliği
$TÇ_E$: Toplam Çıktı Enerjisi (Mj/ha)
TG_E: Toplam Girdi Enerjisi (Mj/ha)

Bir Mj enerji harcanarak üretilen ürün miktarı enerji verimliliği olarak isimlendirilir. Birimi Kg/Mj olup (12) no'lu eşitlik ile hesaplanmaktadır.

$$EV = ÜV / TG_E \quad (12)$$

EV: Enerji Verimliliği (kg/Mj)

ÜV: Ürünün Verimi (kg/ha)
TG_E: Toplam Girdi Enerjisi (Mj/ha)

Bir kg ürünün elde edilmesi için harcanan enerji miktarı Özgül Enerji olarak isimlendirilir. Birimi Mj/kg olup (13) no'lu eşitlik ile hesaplanmaktadır.

$$ÖE = TG_E/ÜV \quad (13)$$

ÖE: Özgül Enerji (Mj/kg)
TG_E: Toplam Girdi Enerjisi (Mj/ha)
ÜV: Ürünün Verimi (kg/ha)

Bitkisel Üretimde kullanılan Girdi Enerjilerinin çevreye etkilerini belirlemek için girdi enerjileri; Yenilenebilir-Yenilemeyen, Doğrudan-Dolaylı enerji olarak dört sınıfta gruplandırılabilir. Enerji Bilançosu hazırlanırken Yenilenebilir Enerji Girdileri ile Yenilenemeyen Enerji Girdilerinin toplamı, Toplam Enerji Girdisine eşit olmalıdır. Benzer şekilde Doğrudan ve Dolaylı Enerji girdilerinin toplamı da Toplam Enerji Girdisine eşit olmalıdır.

Günümüzde enerji verimliliğinin öneminin yanında küresel ısınma konusu da ülkelerin en başta gelen sorunları olarak karşımıza çıkmaktadır. Bitkisel üretimde yoğun olarak kullanılan yenilenemeyen enerji kaynakları küresel ısınmaya yol açan karbondioksit (CO_2) emisyonuna sahiptir. Bu nedenle araştırmacılar enerji bilançosu yanında karbon ayakizi'ni de hesaplamaktadırlar. Bitkisel üretimde enerji girdilerinden kaynaklanan sera gazı emisyonu hesaplamalarında, girdilerin miktarı ile sera gazı eşdeğer emisyon değerlerinin (Tablo 2) çarpımıyla birlikte hektar başına düşen sera gazı emisyon değerleri hesaplanmaktadır.

Tablo 2. Bitkisel Üretimde bazı girdilerin sera gazı emisyonu eşdeğerleri

Girdiler	**Birim**	**Sera Gazı Eşdeğeri ($kgCO_{2\text{-eş}}$/birim)**	**Kaynaklar**
Traktör, makine	Mj	0,071	[26], [27]
Azot	Kg	1,3	[28], [29]
Fosfor	Kg	0,2	[28], [29]
Potasyum	Kg	0,2	[29], [30]
Kükürt	Kg	0,37	[31], [32]
Mikro Elementler	Kg	4,55	[27], [33]
Fungisit	Kg	3,9	[29], [34]
İnsektisit	Kg	5,1	[28]; [29], [37]
Dizel Yakıt	Lt	2,76	[26], [29]
Çiftlik Gübresi	Ton	0,005	[27], [34], [35], [37]

Sera gazı emisyonunun belirlenmesinde (14) no'lu eşitlik kullanılmaktadır.

$$SGE = \sum_{i=1}^{n} R(i).EF(i) \quad (14)$$

Burada ;
SGE: Sera Gazı Emisyonu ($kgCO_{2\text{-eş}}$/ha)
R(i): Her bir üretim aşamasının uygulama miktarı (birim girdi/ha)
EF(i): Her bir girdinin SGE Eşdeğeri ($kgCO_{2\text{-eş}}$/birim girdi)

I_{SGE} oranı ise; kg olarak birim başına SGE miktarı olarak tanımlanan bir indekstir ve eşitlik (15) ile hesaplanmaktadır.

$$I_{SGE} = SGE / Y \quad (15)$$

Burada;
I_{SGE}: Sera Gazı Emisyonu Oranı ($kgCO_{2\text{-eş}}$/kg)

Y: Ürünün Verim (kg/ha)

V. SONUÇ VE TARTIŞMA

Bu çalışmada; bitkisel üretimde enerji bilançosunun belirlenmesinde kullanılan teorik araçlara yer verilmiştir. Bu maksatla işletmelerin; enerji kullanım etkinliği, özgül enerji, enerji verimliliği, sera gazı emisyonları ve sera gazı emisyon oranı değerleri hesaplanmaktadır. Ayrıca hesaplamalar sonucunda yenilenebilir-yenilenemeyen enerji, doğrudan-dolaylı enerji girdilerine ulaşılabilir.

Hesaplamalarda kullanılacak örnek büyüklüğü istatistiki yöntemler ile bulunmalıdır. Çalışmanın sınırlılıkları önceden belirlenmelidir. Eğer çalışma; ana kütleyi temsil edebilecek bir işletmede yapılacaksa bu durumda tüm tarımsal faaliyetler yerinde gözlemlenmeli ve kayıt altına alınmalıdır.

Bitkisel üretimde enerji analizlerinde özellikle iş başarısının hesaplanmasında, kullanılan her ekipmanın iş başarısı ayrı ayrı hesaplanmalıdır. Çünkü tarımsal faaliyetlerde iş genişlikleri, ilerleme hızları ve zamandan faydalanma katsayıları işin türüne göre değişiklik gösterecektir.

Eşitliklerde kullanılan enerji eşdeğerlerini yeniden hesaplamak yerine literatürden yararlanılması çalışmanın bütünlüğüne katkı sağlayacaktır. Farklı literatürde değişik enerji eşdeğerleri ile karşılaşılabilir. Bu durumda literatürde verilen değerin birimine dikkat edilmelidir. Yapılacak çalışmada kullanılan eşitliklerde birim analizinin yapılması doğru sonuçların elde edilmesinde büyük öneme sahiptir.

Bu çalışma için incelenen yayınlarda girdi enerjisi bitki desenine bağlı olarak değişmekle birlikte yakıt enerjisi ve kimyasal gübre enerjisi enerjisinin büyük oranda olduğu görülmüştür.

Bitkisel üretimde yakıt tüketiminin azaltılması için dizel yakıt enerjisinin doğrudan kullanımını azaltacak uygun traktör seçimi ve makine yönetimi yapılarak verimi düşürmeden enerji kullanım verimliliğini arttıracaktır.

Bitkisel üretimde yenilenebilir enerji girdilerinin oranını artırmak için üretimde kullanılan kimyasal gübrelerin yerine çiftlik gübresi kullanımının artırılması önerilebilir.

Sera gazı emisyonunu azaltılması için dizel yakıt kullanımının azaltılması, yenilenebilir enerji kaynaklarının kullanımının artırılması, kimyasal gübreler yerine girdilerde organik veya yenilenebilir enerji kaynaklarının artırılması önerilebilir.

Bu tür çalışmalar; ilk aşamada tarımsal işletmeciler ile araştırmacılara tarımda enerji kullanımı ve enerji verimliliği konularında bilgi - bilinç kazandırmakta ve farkındalık yaratacaktır. İleriki aşamalarda ise hem tarımsal işletmecilere hem de ülke ekonomisine olumlu katkılar sağlanacağı düşünülmektedir.

Çalışmanın katkısı; girdilerdeki enerjilerin etkin kullanımının sağlanması, mevcut üretim yöntemlerindeki ekonomik olmayan durumların azaltılması, ekonomik yöntemler geliştirilerek girdi enerjilerinin etkin bir şekilde kullanılması açısından konuyla ilgili daha sonra yapılacak çalışmalara literatür kaynağı olacaktır.

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Sürdürülebilirlik İçin Derin Ötektik Çözücüler

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Özet **–**Son derece toksik ve çevreye zararlı kimyasalların yaygın tüketiminden kaynaklanan çevresel kaygılar, çevre kimyasının on iki yeşil ilkesiyle uyumlu olacak daha yeşil ve daha sürdürülebilir çözücülere doğru ilerlemek için derin bir endişe oluşturmuştur. Kimyasal ve ilaç endüstrileri toksik ve çevreye duyarlı çözücülerin kullanımından kısıtlanmıştır ancak yine de üretimde belirli çözücülerin polaritesi ve çözünürlüğü gibi temel özelliklere ihtiyaç duymaktadır. Son yıllarda, geleneksel ekstraksiyon prosedürlerine çevre dostu alternatifler olarak çok sayıda ekstraksiyon tekniği ortaya çıkmıştır. Derin ötektik çözücüler, birçok endüstriyel uygulamada geleneksel çözücülere potansiyel alternatifler olarak ortaya çıkan yeni yeşil çözücüler sınıfında olup onların çeşitli türleri, sentezleri, çok çeşitli endüstriyel uygulamaları ve endüstriyel çözücüler ve iyonik sıvılar üzerindeki üstünlüklerini kapsar. Derin ötektik çözücülere olan bu artan ilgi, güvenli, daha az tehlikeli, İyonik sıvılara kıyasla daha yeşil, biyolojik olarak parçalanabilir, ticari oranlarda hazırlanma kolaylığı, düşük hazırlama maliyeti ve diğer birkaç ilginç özellik gibi çok özel özelliklerinden kaynaklanmaktadır. Çok kısa bir zaman diliminde, derin ötektik çözücülerin ayırma süreçleri, çözücülerin çıkarılması, farmasötik işleme, çevre koruma, malzeme sentezi vb. dahil olmak üzere geniş ve çeşitli uygulama yelpazesinde kullanılmıştır. Bu çalışmada, derin ötektik çözücülerin türleri ve sentezi alanındaki son gelişmeler ve ayrıca, günümüzün tehlikeli ve kanserojen endüstriyel çözücülerine uygulanabilir bir alternatif olarak geleceğin yeşil ve sürdürülebilir çözücüleri olarak uygulama alanları incelenmiştir.

Anahtar Kelimeler –Derin Ötektik Çözücü, Ekstraksiyon, Sürdürülebilir, Yeşil Kimya, Uygulama

I. GİRİŞ

Çevresel sorunlara ilişkin artan farkındalık ve kimyasal, tıbbi ve endüstriyel araştırmalarda zararlı kimyasalların kullanımının etkileri ve insan sağlığı için ortaya çıkan riskler göz önünde bulundurularak azaltılması ihtiyacının artmasıyla birlikte, son yıllarda yeşil kimya, kimyasal araştırmaların ilgi çekici bir alanı haline gelmiştir. Yeşil kimya, endüstride veya laboratuvarda üretimin herhangi bir aşamasında tehlikeli ve toksik kimyasalların kullanımını ortadan kaldırmak veya azaltmak için çevreye zarar vermeyen kimyasal süreçler ve sentetik metodolojiler tasarlamayı amaçlamaktadır [1].

Tipik bir kimyasal işlemde, çözücüler, tepkime maddelerini çözmek, kimyasal reaktifliği etkilemek, ürünleri çıkarmak ve yıkamak ve karışımları ayırmak için yaygın olarak kullanılır. Geleneksel organik çözücüler, çok sayıda apaçık avantajına rağmen, genellikle uçucu, yanıcı, patlayıcı ve insanlar, hayvanlar ve hatta bitkiler için toksiktir. Geleneksel organik çözücüler, yalnızca çevre için tehlikeli olmakla kalmaz, aynı zamanda akut ve kronik toksisite, kanserojenlik, ekolojik toksisite ve biyolojik olarak parçalanmazlık da gösterir. Tehlikeli organik uçucu çözücülerin kullanımıyla ilişkili risklerden insan sağlığının ve çevrenin korunmasını iyileştirmek için alternatif yeşil reaksiyon ortamlarının geliştirilmesi için muazzam çabalar sarf edilmiştir [2]. Bu çözücülerin etkilerinin geri dönüşüm süreçlerinin iyileştirilmesiyle en aza indirilmesine yönelik önlemler sınırlı bir başarıya ulaşmıştır ve çevreye bazı kayıpların önlenmesi mümkün değildir. Dahası, olası kazalarla bağlantılı risk hala mevcuttur. Bu sebeplerden dolayı, bu tehlikeli çözücülerin yeşil sürdürülebilir alternatif çözücülerle değiştirilmesi, çözücülerin sürdürülebilir kullanımı

için geçerli tek alternatif gibi görünmektedir. Bu çözücüler, ilaç şirketleri tarafından oluşturulan Çözücü Seçim Rehberine göre dikkatlice değiştirilir veya seçilir [3].

Bilim ve araştırma topluluğu, su, gazla genleştirilmiş sıvılar, sıvı polimerler, süperkritik akışkanlar, biyokütleden türetilen sıvılar, iyonik sıvılar (IL'ler) ve derin ötektik çözücüler (DES'ler) dahil olmak üzere daha yeşil ve daha zararsız alternatifler geliştirmek ve kullanmak için sürekli bir arayış içindedir [4,5].

Son yirmi yıldır, IL'ler geniş bir yelpazeye ve son teknoloji etkiye sahip olmuş, gelecek vaat eden bilim ve teknolojiler üretmiş ve ayrıca yayınları açısından katlanarak genişlemiştir. IL'ler mükemmel kimyasal ve termal kararlılığa sahip erimiş tuzlardır [4,5].

Yeşil kimyanın bazı ilkelerine özgü niteliklere sahip oldukları için, geleneksel organik çözücülerin potansiyel bir ikamesi olarak tanımlanmaktadırlar. Bu yararlı fiziksel ve kimyasal özellikler, yenilenebilir enerji teknolojilerinde birkaç ümit verici uygulamaya yol açmıştır. Hem akademik hem de endüstriyel uygulamalar için kullanılmıştır [6].

Uçucu organik çözücülerin temiz, verimli ve çevre dostu bir alternatif kaynağı olarak ortaya çıkarak ve benzersiz termal, fiziksel, kimyasal ve biyolojik özellikleri nedeniyle çok daha önemli faydalar sağlayarak toplumun şu anda karşı karşıya olduğu bazı önemli sorunları çözmek için potansiyel adaylardır. Dahası, bu özellikler katyon ve anyonların kombinasyonunu değiştirerek uygulamalarına bağlı olarak değiştirilebilir. Ancak, sentezleri ve saflaştırmaları tutarlı tekrarlanabilirliklerini onaylamak için standart sentez yöntemleri gerektirir.

Yeşil çözücüler olarak sınıflandırılmalarına rağmen, bu neoterik çözücüler sentezleri, toksisiteleri ve biyolojik olarak parçalanabilirlikleri ile ilgili bir dizi sorun sunar ve bu da kullanımlarını çevre açısından şüpheli hale getirir. Ayrıca, endüstriyel uygulamalar için büyük ölçeklerde IS'lerden elde edilen verimler, sentezleri, toksisiteleri ve çevre dostu doğaları ana endişeler haline gelmiştir [7].

DES'ler, IL'lerle benzer karakteristik nitelik ve özellikleri paylaştıklarından IL'lere benzer anologları olup geleneksel endüstriyel solventlere ve IL'lere göre düşük uçuculuk, toksik olmama, biyolojik olarak parçalanabilirlik, yanmazlık ve kimyasal stabilite gibi avantajlara sahiptirler [8].

Ötektik çözücüler (ES), katı bileşenlerin karıştırılmasıyla oluşturulan sıvı karışımlardır ve erime noktalarında önemli bir düşüş gösteren bir ötektik sistem oluşturmak için katı-sıvı dengesi kurulduğunda sıvı faz gözlenir [9].

DES öncülleri arasında sıvı fazın ideal termodinamik davranışı varsayıldığında, erime noktasındaki düşüş, tahmin edilen ötektik sıcaklıktan önemli ölçüde düşük olduğunda "derin" terimi vurgulanır.

Son yıllarda DES'ler kozmetik, elektrodepozisyon, biyokütle, CO_2 yakalama, ayırma ve ekstraksiyon işlemleri, sentez, biyo-kataliz vb. konularda yürütülen birçok araştırmayla çeşitli ticari uygulamalar için muazzam bir potansiyel göstermiştir [10].

Bu çalışmada, derin ötektik çözücülerin türleri, sentezi ve karakterizasyonu alanındaki son gelişmeler ve ayrıca, günümüzün tehlikeli ve kanserojen endüstriyel çözücülerine uygulanabilir bir alternatif olarak geleceğin yeşil ve sürdürülebilir çözücüleri olarak uygulama alanları incelenmiştir.

II. MATERYAL VE YÖNTEM

Bu çalışmada, sistematik literatür taraması yöntemi kullanılmıştır [11]. Web of science veri tabanında "Derin Ötektik Çözücü", "Sürdürülebilir" "Ekstraksiyon" anahtar kelimeler kullanılarak elde edilen araştırma ve derleme literatürler incelenmiş ve rapor edilmiştir.

III. BULGULAR

DES'in temel özelliklerinden biri, çok çeşitli kimyasal çözünen maddeler için çözücü olarak kullanılma olasılığıdır. Ekstraksiyon prosedürlerinde çözücü olarak kullanımları, viskozite, yoğunluk, karışabilirlik ve polarite gibi fiziksel özelliklerine bağlıdır. Karıştırmayı kolaylaştırmak için düşük viskoziteli ancak fazların ayrılmasını kolaylaştırmak için matristen büyük yoğunluk farkına sahip çözücüler seçmek uygundur [12]. DES'in, türleri, sentez ve karakterizasyonu, temel fiziksel, kimyasal, higroskopik ve yeşil kimya açısından özellikleri vurgulanmaktadır.

A. Derin Ötektik Çözücü Türleri

DES bileşimi genel olarak $Katyon^{+}A^{-}cB$ olarak temsil edilir; burada $Katyon^{+}$, bir amonyum, fosfonyum veya sülfonyum grubudur. A, Lewis bazıdır, B ise Lewis asididir. Kompleks oluşumu A ve B türleri arasında gerçekleşir (c, bir anyonla etkileşime giren Y molekülü sayısıdır) [13]. Kullanılan kompleks yapan maddelere göre çok çeşitli DES'ler geliştirilmiş olup beş türe ayrılırlar. Bunlar:

Tip I DES'ler, metal halojenürler ve imidazolyum tuzları kompozitlerine benzeyen kuaterner amonyum tuzları ve metal klorürlerden hazırlanır.

Tip II DES'lerin kuaterner amonyum tuzları ve metal klorür hidratlardan oluşur.

Tip III DES'ler kolin klorür ve alkoller, amidler, karbonhidratlar vb. gibi hidrojen bağı donörlerinden oluşur ve uyarlanabilir doğaları ve geçiş metali türlerini çözmenin önemli özellikleri nedeniyle yaygın olarak araştırılmaktadır. Bu tip DES'ler, fiziksel özellikleri karışımda kullanılan hidrojen bağı donörlerine bağlı olduğundan uyarlanabilir [13].

Tip IV DES'ler hidrojen bağı donörlü metal klorürden yapılır.

Yeni ortaya çıkan Tip V DES sınıfı ise iyonik olmayan moleküler hidrojen bağı donörü ve hidrojen bağı akseptöründen oluşup bu tür solventlerde hidrojen bağının baskın olduğu görülmektedir [14].

B. DES'lerin Sentez ve Karakterizasyonu

DES'leri sentezlemek için kullanılan bileşenler güvenli ve ekonomiktir [15]. DES sentezi çeşitli yöntemler kullanılarak gerçekleştirilebilir.

DES'in en yaygın sentezi, uygun miktarda HBD ve HBA'nın bir şişeye eklenmesini içerir ve daha sonra renksiz bir sıvı oluşturmak üzere karıştırılır ve ısıtılır.

Diğer bir yöntem, HBD ve HBA'nın sulu çözeltilerinin belirli bir oranda karıştırılmasını ve daha sonra bu sulu çözeltilerin daha düşük bir sıcaklıkta dondurularak kurutulmasını ve viskoz, berrak bir sıvı elde edilmesini içerir.

Öğütme yöntemleri, iki bileşenin karıştırıldığı ve homojen, berrak bir sıvı oluşana kadar birlikte öğütüldüğü farmasötik amaçlar dikkate alınarak sentez için kullanılmıştır [16].

Vakumlu buharlaştırma yöntemi, bir sıvı elde etmek için suda çözünen bileşenlerin düşük sıcaklıkta vakum altında buharlaştırıldığı Doğal Derin Ötektik Çözücülerin (NADES) sentezine dahil edilmiştir. Bu sıvı ayrıca sabit ağırlık elde edilene kadar silika jelli bir desikatörde kurutulmak üzere tutulur [16].

DES sentezi için hiçbir yan ürün veya kapsamlı yöntem veya çözücü kullanımı olmadığından sıfır atık üretir ve büyük ölçekli üretim için ucuzdur.

Atom ekonomisi, kimyasal proseste başlangıç malzemesinin nihai ürüne dahil edilmesini maksimuma çıkarmak ve yan ürünleri veya atık malzemeleri azaltmaktır [17].

Tüm başlangıç bileşenleri nihai üründe tamamen kullanılması ve dolayısıyla nihai ürünün saflık değerlendirmesinin de atlanması nedeniyle DES'in nihai ürününün atom ekonomisi %100'dür [18].

HBD ve HBA kombinasyonları ve karıştırıldıkları mol oranları olmak üzere DES'in oluşumu iki ana faktöre bağlıdır [19].

Tetrabutilamonyum klorür (TBACl), kolin klorür (ChCl) ve timol dahil olmak üzere çeşitli HBA kombinasyonlarının yanı sıra çok sayıda kiral HBD ile birleştirilmiş birkaç HBA'yı içeren bir çalışma rapor edilmiştir [19]. Bu çalışmada, HBA/HBD 1:1-1:6 ve 1:1-12:1 arasında değişen oranlarda alınmış ancak karışımların değerlendirilmesi çoğunlukla 1:1, 1:2, 3:1 ve 2:1 molar oranlarında gerçekleştirilmiş ve oda sıcaklığında elde edilen tüm sıvı karışımlarının bazı DES'lerle birlikte basit ötektik karışımlardan oluştuğu ve HBA ve HBD'nin yapısal çeşitliliğinin karışımların sıvı oluşumunu etkileyebileceği bildirilmiştir [19].

DES'ler, verici ve alıcı arasında bir hidrojen bağlanma ağı yoluyla oluşturulur. Bu etkileşimler genellikle bağlanma bölgelerini ve hidrojen bağlanmasını doğrulamak için Fourier Dönüşümü Kızılötesi Spektroskopisi (FTIR) kullanılarak deneysel olarak incelenir [20].

Titreşimleri tanımlamak ve analiz etmek ve geometriyi optimize etmek için yoğunluk fonksiyonu teorisi (DFT) de kullanılmıştır [20].

DES'lerdeki hidrojen bağını ve türünü belirlemek için moleküler dinamik (MD) simülasyonu da kullanılabilir.

Viskozite ve gaz çözünürlüğü, karbondioksit yakalama işlemleri için bir solventin absorpsiyon kapasitesini ve seçiciliğini belirler.

Kapsamlı bir HBD ve HBA kombinasyonu yelpazesi sayesinde, uygun DES'i hesaplamalı modelleme kullanarak bulmak, deneysel güçlüklerden daha uygundur.

Gerçek Çözücüler için İletken Benzeri Tarama Modelini (COSMO-RS) kullanarak DES'lerin viskozitesini doğrulukla tahmin etmek için Kantitatif Yapı-Özellik İlişkisine (QSPR) dayalı basit bir model geliştirildiği bildirilmiştir [21].

C. DES'lere Suyun Etkisi

Suyun her yerde bulunması ve bazı derin ötektik çözücülerin ve bunları oluşturan bileşiklerin higroskopik karakteri göz önüne alındığında, ötektik çözücüler tarafından su alınması kaçınılmazdır [22].

Derin ötektik çözücülerdeki su izleri genellikle safsızlık olarak kabul edilirken, çok sayıda makale, bazı istenen uygulamaların gereksinimlerine yanıt verebilmeleri için özelliklerini ince ayarlamak amacıyla çözücülerine kasıtlı olarak su eklemiştir ve su, birçok durumda derin ötektik çözücülerin performansını iyileştirmeyi sağlamıştır. Öte yandan, suyun varlığı yalnızca fizikokimyasal özellikleri etkilemekle kalmaz, aynı zamanda derin ötektik çözücülerin bütünlüğünü de tehlikeye atabilir, bu da derin ötektik çözücülerin farklı çalışma koşullarında hazırlanması göz önüne alındığında literatürdeki tutarsızlığı açıklar [23]. Bu nedenle, suyun ötektik sistemler üzerindeki etkisinin incelenmesi son derece önemlidir.

Tablo 1' de DES'lerin, iyonik sıvıların ve geleneksel çözücülerin özelliklerinin yeşil bir perspektiften karşılaştırılması sunulmuştur.

Tablo 1. Geleneksel çözücülerin, iyonik sıvıların ve DES'lerin özellikleri [13].

	Geleneksel Solventler	**İyonik Sıvılar**	**Derin Ötektik Solventler**
Bileşimi	Organik sıvılar	Katyonlar ve Anyonlar	HBD ve HBA
Uçuculuk	Yüksek	Düşük	Düşük
Tutuşabilirlik	Genellikle yanıcı	Yanıcı değildir	Yanıcı değildir
Ayarlanabilirlik,	Hayır	Evet, sınırsız kombinasyon aralığı	Evet, sınırsız kombinasyon aralığı [
Biyobozunurluk	Az sayıda solvent biyolojik olarak parçalanabilir	Hayır	Evet
Geri Dönüştürülebilirlik ve Tekrar Üretilebilirlik	Düşük, seçici solventler için	Evet	Evet
Maliyet	Daha ucuz	Pahalı	Daha ucuz
Toksisite	Yüksek, çoğunluğu kanserojendir	Atmosfere karşı düşük Sucul biyotaya kadar yüksek	Düşük
Atom Ekonomisi	Çok düşük	Orta	Yüksek

IV. TARTIŞMA

IL'lerle karşılaştırıldığında DES'ler bileşim ve hazırlama yöntemleri bakımından farklılık gösterir. IL'ler bir organik katyon ve bir inorganik anyondan oluşurken, DES'ler bileşimlerine bağlı olarak dört genel kategoriye ayrılır. Bu kategoriler arasında metal klorürlü kuaterner amonyum tuzu (birinci kategori), metal klorür hidrat (ikinci kategori), hidrojen bağı donörü (üçüncü kategori) ve bir metal klorür hidrat ve bir hidrojen bağı donöründen oluşan dördüncü tip yer alır [13].

DES'ler tipik olarak üç yöntemden biri kullanılarak hazırlanır:

(1): Katı HBA ve HBD'nin belirli bir molar oranda birleştirildiği ve 80 °C'de 1-2 saat boyunca sürekli manyetik karıştırmaya tabi tutulduğu ısıtma yöntemi. Bu işlem, berrak ve tek biçimli bir sıvının (2) oluşmasıyla sonuçlanır.

(2): bilinen bir molar orana sahip bileşenlerin suda çözündüğü vakumlu buharlaştırma. Daha sonra çözelti ısıtılır ve döner bir buharlaştırıcı kullanılarak indirgenmiş basınç altında 50°C'de buharlaştırılır. Geriye kalan tüm nemin tamamen uzaklaştırıldığından emin olmak ve sabit bir ağırlık elde etmek için, elde edilen karışım silika jeli içeren bir desikatöre yerleştirilir ve

(3): bileşenlerin bir su içinde çözündürüldüğü bir işlem olan dondurarak kurutma yöntemi. Belirli bir oranda ve daha sonra berrak ve viskoz bir sıvı oluşana kadar dondurarak kurutmaya tabi tutulur [24].

DES'lerin çoğu higroskopik karışım olarak tanınır ve tamamen kurutulmaları neredeyse imkansızdır. Suyun hidrojen bağı alıcısı ve hidrojen bağı vericisi olarak ikilik özellikleri, suyun derin ötektik çözücülere emilmesi ve eklenmesi sırasında dikkate alınmalıdır. Su, DES'in hem HBD'si hem de HBA'sı ile etkileşime girebilir ve daha sonra hidrojen bağı vericisi ile çoklu hidrojen bağı oluşturarak organik tuz ve hidrojen bağı vericisi arasındaki hidrojen bağı etkileşimlerini bozabilir. Örneğin, su molekülleri üre ile bir hidrojen bağı oluşturarak kolin klorür/üre hidrojen bağının gücünü azaltır [16].

Kolin klorürden HBA ve üre, metil üre, etilen glikol, gliserol, glikoz, ksilitol, oksalik asit ve glutarik asitten HBD olarak oluşan birkaç DES'in sekiz saat boyunca su emme (havadan) kapasitesi bildirilmiştir [25].

Glutarik asit bazlı DES'in diğer DES'lerden daha büyük bir su emme kapasitesine sahip olduğunu belirttiler ve birkaç hidroksil, metil ve zincir uzunluğunun DES'lerin su moleküllerini emme yeteneği üzerindeki etkisi de rapor edilmiştir [25].

Metil grubunun su moleküllerini emme kapasitesinin daha düşük olduğu ve çok sayıda hidroksil grubu olan hidrojen bağı donörünün daha yüksek bir su emme kapasitesine sahip olduğu bulunmuş ve absorpsiyon kapasitesi ve su moleküllerinin havadan emilim oranı, karboksilik asit-DES'lerin zincir uzunluğunun artmasıyla arttığı da bildirilmiştir [25].

Suyun kolin klorürden HBA ve dietilen glikol, trietilen glikol ve poli(etilen glikol) 200'den HBD olarak hazırlanan DES'ler üzerindeki etkisini bildirilmiştir [26].

Suyun eklenmesiyle HBA ve HBD'ler arasında güçlü bir hidrojen etkileşimi gözlemlendiği, hidrojen bağı etkileşimi kademeli olarak zayıfladığı, ancak süpermoleküler yapı belirli bir dereceye kadar korunduğu da rapor edilmiştir [26].

Ayrıca, suyun hidrofobik derin ötektik çözücüler üzerindeki etkisi de bir başka çalışmada bildirilmiştir [27].

Hidrofobik DES'in tetrabutilamonyum klorür ve dekanoik asitten hazırlandığı ve daha az miktarda su içerdiğini ve az miktarda suyun bile DES'i ikili sistemden üçlü sisteme değiştirerek DES'lerin fizikokimyasal özellikleri üzerinde etki gösterdiği bildirilmiştir [27].

Su içeriği veya DES'lere su eklenmesi, fizikokimyasal özelliklerini ve biyouyumluluğunu etkiler. DES karışımlarındaki su içeriğinin artması, DES'lerin her bir bileşeni arasındaki hidrojen bağlarını bozarak ve iyonik hareketliliklerini artırarak erime noktalarını, yoğunluklarını ve viskozitelerini azaltır [28].
Viskozite ve iletkenlik arasındaki ters ilişki, iletkenliklerinin belirli bir sınıra kadar artmasına yol açar. DES'lerin iletkenliği, iyonik hareketliliğin artması nedeniyle belirli bir sınıra kadar seyreltme ile artar. DES'lerin su aktivitesi, su içeriğinin artmasıyla kademeli olarak artar [28]. Ayrıca, su içeriği DES'lerin polaritesini ve çözünme kapasitesini etkiler [28].

DES'lerin sulu ortamlarda çözünmesi sitotoksisitelerinde artışa yol açar. DES'in her HBD ve HBA bileşeniyle su etkileşimi, kuaterner derin ötektik çözücülerle sulu bir baypas sistemi de oluşturabilir [28].
Bu nedenle, DES'lerin biyolojik olarak parçalanabilirliği ve ekonomik olarak kullanılabilirliği, suda çözünürlükleriyle ilişkilidir [28].

DES'in ticari kullanımı henüz başlangıç aşamasındadır ve büyük endüstriyel uygulaması henüz gerçekleşmemiştir. Farklı uygulamalar için bazı pilot tesisler hayata geçirilmiştir. DES'in diğer yeşil solvent alternatiflerine göre sahip olduğu en büyük avantajlardan biri, büyük ölçekli partiler halinde kolaylıkla üretilebilmesi ve dolayısıyla endüstriyel uygulamalar için ölçek büyütmeye uygun olmasıdır [13].

Biyokataliz alanında gelecekte potansiyel artışın söz konusu olduğunu gösteren bazı ilerlemeler kaydedilmiştir [29].

Kolin klorür, etilen glikol ve üre içeren hibrit bir DES, elektrik ark ocağı (EAF) tozundan büyük ölçekli kurşun ve çinko ekstraksiyonu için kullanılmıştır [30].

Tiyofenin ekstraksiyonu için bir pilot tesis kullanmışlar ve ölçeği 10 g'dan 1000 g'ın üzerine çıkardığı rapor edilmiştir [31].

Üzüm antosiyaninlerinin DES ile laboratuvardan kozmetik endüstrisinde kullanılabilecek endüstriyel ölçeğe ekstraksiyonunun gerçekleştirdiği rapor edilmiştir [32].

Ölçek büyütme işlemleri sırasında DES için ekstraksiyon prosesindeki en büyük engel, genellikle geleneksel solventlerden daha yüksek olan viskozite nedeniyle ortaya çıkar.

Biyolojik olarak parçalanabilirlik, çevre dostu, yanmazlık, uçucu olmama, ayarlanabilirlik, çözünürlük ve daha birçok özellik, DES'lere solventlerin ileriye dönük bir geleceğini kazandırmıştır. Ancak DES'lerin üretim ve tasarım süreçlerinin çevresel ve ekonomik gereklilikleri karşılaması gerektiğinin dikkate alınması gerekmektedir. Yeniden kullanılabilirlik ve yenilenme yeşil kimyanın temel unsurlarıdır. Yakıtların kükürtten arındırılmasında kullanılan DES'lerin yeniden kullanılabilirlik ve rejenerasyon açısından yeteneklerini incelediği bildirilmiştir [33].

Ekstraksiyon döngülerinin sayısındaki artışla birlikte, DES'lerin rejenerasyonu olmadan DES'in kükürt giderme kapasitesinin azaldığını bildirmişlerdir. Ancak yenilenen DES'lerle çok az kayıpla iyi verimlilik gösteriyor.

DES'in geri dönüştürülebilirliğindeki zorluk, ekstraksiyon sürecinde süreçleri büyütmeye çalışmaktır. Ekstraksiyonu etkileyen bir diğer ilginç husus ise enerji tüketimine ilişkin sıcaklıktır.

Literatür, bazı DES, yani metal DES ve amonyum DES'in sıcaklık artışıyla ters ekstraksiyon verimliliği sergilediğini, oksalat DES gibi bazılarının ise artan verimlilik gösterdiğini göstermektedir [34].

V. SONUÇLAR

Yeşil çözücüler arayışı, yeşil kimyanın hedeflerine katkıda bulunan yükselen bir konudur. Derin ötektik çözücüler günümüzde en çok düşünülen ve araştırılan çözücüleri oluşturur. Bu çözücüler oldukça ilginç özelliklere sahiptir ve bu nedenle çok sayıda akademik ve endüstriyel sektörde diğer geleneksel çözücülerin yerini alma olasılıklarını artırır.

Bu çalışma, derin ötektik çözücülerin temelleri ve özellikleri hakkında genel ve kapsamlı bir genel bakış sağlar.

Güncellenmiş tanımları, sınıflandırmaları, sentez ve karakterizasyon yöntemleri ve yeşil çözücüler açısından özellikleri açıklanmıştır. İkinci aşamada, özellikle faz davranışları, yoğunlukları, viskoziteleri, iyonik iletkenlikleri, yüzey gerilimleri ve polariteleri olmak üzere temel fiziksel ve kimyasal özellikleri özetlenmiştir.

Hidrojen bağı vericisinin, hidrojen bağı alıcısının ve molar bileşimlerinin seçiminden sıcaklık ve su içeriğine kadar, bu çözücüler hedeflenen uygulamaların gereksinimlerini karşılamak üzere tasarlanabilir.

Son olarak, suyun her yerde bulunması ve derin ötektik çözücüler ile suyun ikili karışımlarının birçok uygulamada geniş bir şekilde ele alınması göz önüne alındığında, suyun hem fizikokimyasal özellikler hem de derin ötektik sistemlerin yapısı üzerindeki etkisi vurgulanmıştır.

Suyun varlığı, derin ötektik çözücülerin özelliklerini önemli ölçüde etkiler. Bazı yararlı sonuçlar sunabilmesine rağmen, suyun varlığı ötektik karışımların süpermoleküler ağını bozabilir. Derin ötektik çözücülerin sulu karışımlarının davranışını anlamaya yönelik birkaç çalışma son zamanlarda ortaya çıkmıştır. Birkaç çalışma, su eklenmesiyle bir sistemden diğerine geçiş olduğunu ileri sürmektedir.

Derin ötektik çözücülerin daha derin bir şekilde anlaşılması, özellikle bunların oluşumuna yol açabilecek sayısız kombinasyon olması nedeniyle, daha fazla çalışmaya ihtiyaç duymaktadır.

Derin ötektik çözücülerin DES'lerin toksisite davranışını haritalamak için hala öngörücü bir metodoloji eksikliği var.

Derin ötektik çözücülerin dinamik bir şekilde incelenmesi ve ortaya çıkan alternatif teknolojiler, önümüzdeki günlerde derin ötektik çözücülerin daha temiz, daha yeşil ve çevre dostu bir çözücü olarak kullanılmasının önünü açacaktır.

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In vitro Breeding in Beekeeping

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Abstract – The in vitro breeding of worker honey bees (*Apis mellifera L.*) has become an important method in honey bee research in general and in determining the effects of pesticides on living organisms in particular. Honey bee larvae feed on mandibular and hypopharyngeal gland secretions produced by Apis mellifera L. worker bees. This food contains all the nutrients necessary for the development of queen bees, worker bees and drones. The content of the diet and the environmental conditions also vary in studies carried out by different researchers. In in vitro honey bee breeding, adult individuals are obtained by feeding the larvae with food prepared by creating an artificial hive environment. This study aims to provide information on in vitro honeybee rearing and suitable environmental conditions.

Keywords – honey bee, worker bee, in vitro rearing, nutrition, diets

Introduction:

In vitro refers to the technique of performing a particular procedure outside a living organism in a controlled environment. Although the term in vitro is mainly used in the field of biology, it is also used in other branches of science. Honey bees (Apis mellifera L.) are very important pollinators all over the world [1, 2]. Pesticides, nutritional problems, parasites and other bee diseases are thought to have had a negative impact on honey bees in recent times [3, 4, 5, 6, 7]. It is difficult to rule out the negative effects of all these stress factors on the health of honey bees, especially during the pupal stage. This is because studies investigating several stress factors simultaneously are complex and the results should be well analyzed. For these reasons, rearing honey bees free from external factors has become important. In the last twenty or thirty years, considerable progress has been made in the methods of in vitro rearing of honey bees [8, 9, 10, 11, 12, 13, 14]. The larvae of the honey bee *Apis mellifera L.* are fed with a food obtained from the mandibular and pharyngeal glands of the worker bees. This food contains all the nutrients required for the development of the queen bee, worker bees and drone larvae [15, 16, 17, 18, 19, 20, 21]. Honey bee larvae (Hymenoptera: Apidae) feed on glandular secretions produced by nurse bees. This food contains all the nutrients necessary for the development of queens, workers and drones [16, 17,18, 19, 21]. The larvae of the queen bee are fed

with plenty of fresh royal jelly and grow to 1500-1700 times their egg weight. A queen bee can grow from 0.12 - 0.20 mg to 250 - 346 mg [22, 23].

Studies conducted on this topic

Many researchers have conducted studies on the in vitro breeding of honey bees. I will give some examples In their study, [13], fed larvae to raise queen bees in vitro using 2.5 g D-fructose, 2.5 g D-glucose and 20 g royal jelly in 20 mL of distilled water. As a result of the study, it was reported that 75% adult worker bees were obtained. In this study, [24], prepared a diet by dissolving 10 g of torula yeast and 0.3 g of niyapin in 100 mL of ultrapure water and adding 35 g of honey. In the study, the temperature in the incubator was set at 35 0C and the humidity at 85-90% and the larvae were observed until they pupated.

In their research, [14], tried a method of rearing honeybee larvae using queen tubes made of plastic and wax. The researchers prepared a diet of 50% royal jelly, 6% D-glucose, 6% fructose and 1% yeast. They set the temperature of the incubator to 34 0C and the humidity to 70%. As a result of the study, they achieved a survival rate of 90% in beeswax and 57% in plastic tubes. [15], He conducted a study to determine the effects of different sugar concentrations on the survival rate in in vitro culture. As a result of the study, the researchers reported that the survival rate was highest at the 7th sugar concentration. In their study on larvae fed different amounts of sugar, [25], reported that 69.6% of the fed larvae turned into adult bees.

Conclusion and Recommendations

The sensitivity of honey bees to pesticides and the need for live material free from environmental stressors and bacterial pathogens for drug dosing studies increase the importance of in vitro beekeeping. Studies on in vitro beekeeping are limited both in the world and in our country. Studies on this subject should be expanded.

Studies on appropriate nutritional protocols on this subject have not yet been completed and new protocols for the most appropriate nutrition should be developed.

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GENERAL SITUATION OF ORGANIC BEEKEEPING AND ORGANIC BEE PRODUCTS PRODUCTION

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Abstract – Ecological agriculture is defined as an agricultural production system that preserves the natural balance, ensures soil fertility, controls diseases and pests, ensures the continuity of living things and makes optimum use of natural resources.

There are opinions that pesticide and hormone residues are detected in products produced with the uncontrolled use of pesticides and hormones and that these negatively affect consumer health. In recent years, the demand for organic products in the world and in Turkey has gained rapid momentum. According to 2023 statistical data, 412 beekeepers are engaged in organic beekeeping in our country, the number of colonies producing organic bee products is 82,262 and 1220.45 tons of organic honey are produced from these colonies in Turkey. This article has been prepared to provide information about the general situation of organic beekeeping in our country in recent years, to guide beekeepers who want to do organic beekeeping, and to raise consumer awareness.

Keywords – Beekeeping, Organic agriculture, organic beekeeping, bee breeding, bee nutrition.

Introduction

Organic farming includes natural fertilizers, biological pest control, and relies on mechanical processing to ensure soil productivity; In other words, it is defined as an agricultural method that does not use or limits chemical fertilizers, pesticides, hormones, animal feed additives and genetically modified organisms [1]. While organic farming is carried out to produce reliable and healthy products through the use of natural resources, attention is also paid to the optimum use of energy, and the production of quality products is also aimed.

The food needs of the increasing world population, efforts were focused on increasing agricultural production between 1960 and 1970. For this purpose, chemical pesticides, mineral fertilizers, growth regulators, hormones and feed additives have been widely used. As a result of these studies, chemical

residues and hormones in the products produced have reached a level that threatens human health, causing consumers to prefer natural and organic products in recent years [2,3].

Organic farming system, there are great restrictions on the use of fertilizers and pesticides. Product diversification is one of the basic rules and the aim is to protect the environment. This production method, which aims to produce quality agricultural products that do not contain chemical residues, to develop production methods that avoid the use of chemical fertilizers and pesticides, and to use production techniques that will protect soil fertility, is called ecological, organic, biological, bio -dynamic and alternative agriculture according to countries [4, 5, 6]. In addition, in organic farming practices, plant rotation should be done, mechanical processing of the soil should be ensured to ensure soil productivity, hormones and animal feed additives and genetically modified organisms should not be used. In organic agriculture, the combination of plant production and animal production is essential [1, 5].

Although organic farming methods are managed within the framework of laws and rules in many countries, most of the standards are set by IFOAM (International Federation of Organic Agriculture), established in 1972. Agriculture Movements - International Federation of Organic Agriculture Movements.

It was the first organization established in 1992 to ensure the development of organic agriculture under a specific organization in Turkey. It is ETO (Ecological Agriculture Organization) Association [3,7]. Today, organic farming studies and activities in this regard are carried out in accordance with the principles of the "Regulation on the Principles and Implementation of Organic Agriculture" issued by the Ministry of Agriculture, Food and Livestock.

Organic livestock farming is a controlled and certified animal production activity using organic methods. [5, 8, 9]. a quick one Intensive studies have been carried out to increase the productivity per animal in order to meet the animal protein needs of the population, which has a tendency to increase. In order to achieve this increase, hormones, feed additives and antibiotics have been used and as a natural result, the aroma and content of the products have been negatively affected and residue substances have appeared in the products. [9, 6].

venom are produced as a result of beekeeping activities. In addition to being consumed as foodstuffs, these products are also used in the treatment of various diseases in Apitherapy . Achieving the expected benefit from these products depends on the products being produced organically [2].

Organic beekeeping is defined as beekeeping activities in which all stages of the production of bee products are inspected and certified by a control and certification organization in accordance with the organic agriculture regulations, in areas with intact natural structure or in organic farming areas, without any artificial feeding or chemical pesticides at all stages from production to consumption [5, 6, 10].

Organic Agriculture in Turkey

Organic Agriculture and its situation in our country

In recent years, organic agriculture has shown rapid development in the world and in Turkey. Consumer awareness and demand for these products and government support have an important role in this development. Organic agricultural areas in Turkey cover 0.3% of the total agricultural areas. EU countries and the USA rank first in terms of increase in organic agricultural areas and consumption of organic agricultural products 6, 11]. In Turkey, the authority to control organic agriculture and certify products has been given to a total of 7 companies, 6 foreign and 1 local control company. Organic agriculture in our country has shown rapid development in the last 10 years. While in 1994, when legal regulations on organic agriculture began to be made, a total of 1705 producers produced 8843 tons of organic products in an area of 5216 ha , in 1999, 12275 farmers produced 168306 tons of organic products in 100 product types on an area of 46523 ha [6, 5]. In Turkey, 37% of the agricultural land within the scope of organic agriculture consists of dry products, 30% field crops, 3% berry fruits and 1% vegetables [12,13, 11]. Organic agriculture and organic products. There was an increase of approximately % in production from 1994 to 1999 .

Organic agriculture is based on contract farming within a registered system. This contract; It is carried out in accordance with the provisions of the Ministry's Communiqué on Procedures and Principles Regarding Contracted Agricultural Product Cultivation, dated 30 June 1996 and numbered 22682. The feature of organic agriculture is that, in accordance with the contract, full compliance with the organic product regulation provisions in production is ensured (Ministry of Agriculture website website address).

The situation of organic beekeeping in our country

organic bee farming, the materials and properties of the hives produced, the environment where the bee colonies are located, the soil and water resources must be clean and free from harmful substances, and all agricultural activities must comply with organic production conditions [1, 6]. In other words, in agricultural areas where organic agriculture is practiced, it must be inspected by a control and certification institution, according to the organic agriculture regulation [10]. In order to practice organic beekeeping and produce organic bee products, it is mandatory to comply with the "Organic Beekeeping" rules in Article 23 of Chapter 3 of the Regulation on the Principles and Application of Organic Agriculture prepared by the Ministry of Food, Agriculture and Livestock.

venom are produced as a result of beekeeping activities. In addition to being consumed as food, these products are also used in the treatment of various diseases in Apitherapy. Achieving the expected benefits from these products depends on their organic production [2].

European Union countries rank first in the world in terms of honey consumption. EU countries meet their honey needs by importing. A product's ability to enter the EU markets depends on its compliance with quality standards.

There were various problems in our honey export in the 2000s. Pesticides, commercial sugar, starch, antibiotics and naphthalene residues were detected in the exported honey, and for these reasons, honey exported to EU countries was sent back [14, 15, 16, 17].

The importance of organic beekeeping has increased due to reasons such as pesticides used in beekeeping leaving residues in bee products and negatively affecting consumer health, and this has brought about an increase in demand for organic bee products.

If the requirements of organic beekeeping are listed;

1.Determining the Place for Beekeeping

The place where organic beekeeping will take place, in other words the place where bee colonies will be left, should be at least 3 km away from the area where agriculture is done with traditional methods, the area where chemicals such as pesticides, fertilizers and hormones are used, away from industrial centers, outside residential areas, waste centers, waste incineration centers. should be away from highways [8,3,6]. Colonies where organic beekeeping will be carried out should be left to organic agricultural areas or organic pastures. Organic pastures must be determined by the control and certification organization to comply with organic farming rules.

2. Care and Feeding of Colonies in Organic Beekeeping

Beekeeping activities within the scope of organic beekeeping must be carried out in accordance with the " Organic Beekeeping" rules published by the Ministry of Agriculture. The hives used for this purpose should be made of wood and natural materials, and chemical dyes should not be used in the hives [18, 19].

In organic beekeeping, additional feeding should not be done unless necessary. If there is a necessity such as unfavorable climatic conditions or hunger, additional feeding can be done. used in supplementary feeding Honey, sugar syrup and sugar molasses must be produced organically. Additionally, information regarding supplementary feeding must be written on the colony registry card (must be written). In organic beekeeping, the wing of the colony's queen bee is not cut off.

3. Protection and Control in Organic Beekeeping

some precautions for the protection and control of honey bee colonies . If these precautions are not taken, the colony will first weaken, become sick, yield losses will occur and ultimately lead to the extinction of the colony.

In order to apply protection and control methods well, first of all, durable honey bee races adapted to the regional conditions should be selected. It is essential to carry out colony checks regularly and periodically. The equipment used should be systematically disinfected using organic methods, honeycombs should be renewed, and contaminated materials should be destroyed. Care should be taken to ensure that there is always sufficient amount of honey and pollen in the colony . These measures implemented will prevent the emergence of any negativities.

For disinfection of materials used in organic beekeeping, lime cream, slaked lime, oxygenated Water, formic acid, lactic acid, oxalic acid can be used [9, 6]. [9] Since chemicals (chemical control) should not be used against diseases and pests in organic beekeeping, precautions should be taken to prevent diseases from occurring in colonies.

4. Treatment of Diseases and Pest Control in Organic Beekeeping

Despite the precautions taken to prevent the emergence of diseases and pests in organic beekeeping, if diseases and pests appear, in order to prevent contamination of healthy colonies, diseased colonies should be immediately removed from the apiary and moved to isolated areas and treatment should be started immediately.

In the treatment, pesticide application should be applied within the principles of organic beekeeping. Diseased colonies should primarily be treated with medicines made from natural products, such as herbal sources. However, if it is necessary to use chemical drugs, care should be taken to ensure that the drugs used comply with the Turkish Drug Codex under the supervision of a veterinarian. After the treatment, all honeycombs in the colony where the pesticide was applied should be replaced with new honeycombs [5, 6].

Varroa, which causes great damage to honey bee colonies If the destructor parasite is seen in organic production colonies, natural products such as lactic acid, oxalic acid, menthol , thymol, eucalyptol and camphor should be used [8, 10, 18,19,6]. Since formic acid , oxalic acid and lactic acid are organic acids found in the natural structure of honey, they can be used against varroa parasite and chalk disease [6, 20].

In organic beekeeping, when the treatment will be carried out using chemicals, the colonies should be moved to isolated areas, and detailed information about the diagnosis, the treatment applied, its duration, the chemical medicine applied and the time the medicine was used should be given to the control and certification organization that supervises the beekeeper.

5. Harvesting, storage and packaging of Organic Bee Products

When harvesting honey in organic beekeeping, honey should not be taken from honeycombs with brood. Synthetic substances should not be used to calm bees during harvest . harvest Bees on the honeycombs should not be killed during the process.

In the storage of organic bee products, organic products must be stored in a different place from products that are not produced according to the principles of organic agriculture.

During the packaging phase, hygienic measures must be taken to avoid damaging the organic properties of the product . Glass and wood can be used as packaging materials [21, 10].

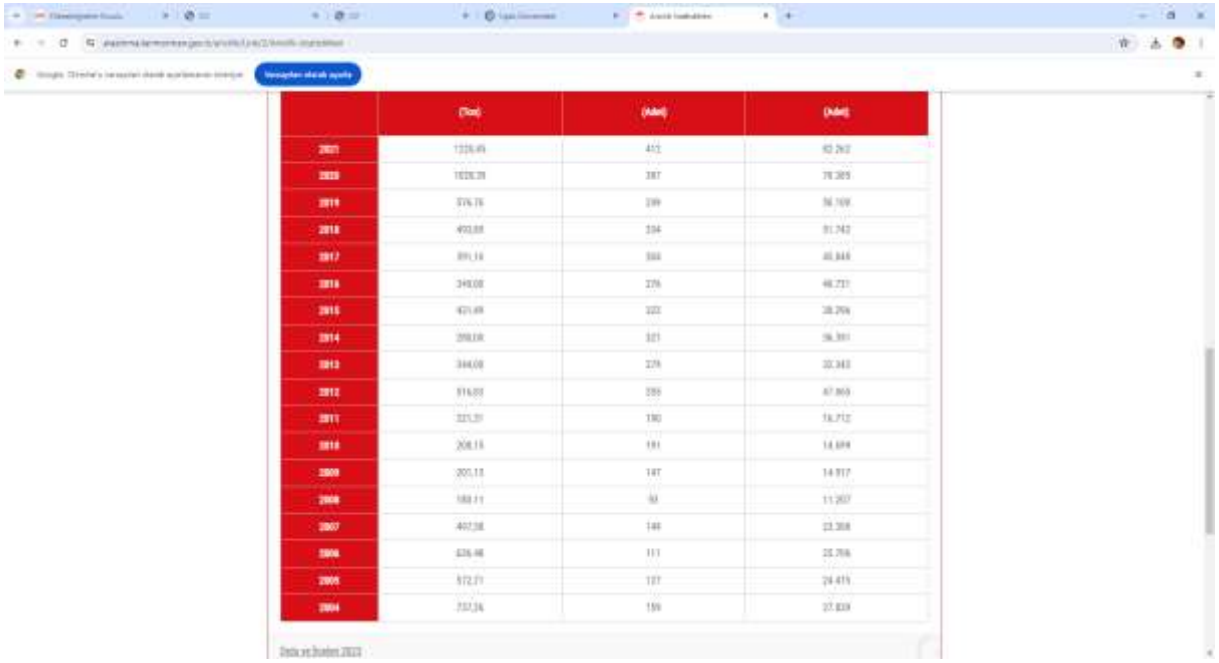
On the label on the packaging;

that the honey is produced organically, its vegetal origin, harvest year, place of production, expiration date, identity information of the producer, that it is produced according to the organic production method, the logo of the product, as well as the name, logo and certificate number of the certification body, and that the organic product is Turkish.

Conclusion

Türkiye, which has a great beekeeping potential, also has a suitable structure for organic beekeeping. The high plateaus of Eastern Anatolia and Central Anatolia are especially virgin plateaus where no agricultural practices have been carried out before , no pesticides or fertilizers have been used, in other words, there are untouched plateaus.

In addition to this existing potential, it is inevitable that organic beekeeping will be widely practiced in our country and take its place in this market, due to the demand for organic products in recent years.



Honey Production
(Ton)
Number of Manufacturers
(Piece)
Number of Colonies
(Piece)

2021
1220.4541282.262 2020 1028.3938770.385 **2019** 576.7624950.100 **2018** 493.8933451.742 **2017** 391.1030445.848 **2016** 349.002 7640.731 **2015** 421.4932238.296 **2014** 280.0032136.391 **2013** 344.0027932.342 **2012** 516.8335547.065 **2011** 221.3119016.712 **2010** 208.1519114.699 **2009**

201.1314714.917 **2008** 180.119311.207 **2007** 497.3814923.308 **2006** 636.4811125.706 **2005** 572.7112724.4 75 **2004** 737.2615927.839

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Evaluate The Performance Of Two Population-based Metaheuristic Algorithms In Finding Inverse Kinematic for a Target Point In a Free Environment

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Abstract – Resolving the Inverse Kinematic (IK) issue for continuum robots continues to be a formidable undertaking. Given that analytical and numerical approaches may not yield a solution to the inverse kinematics (IK) problem, population-based metaheuristic algorithms (PbMAs) might serve as an alternative approach. Thus, utilising the Forward Kinematic (FK) connections, many methods may be utilised to solve the Inverse Kinematics (IK) problem. This research assesses the performance of two PbMAs in terms of execution time and position inaccuracy for addressing the inverse kinematics issue of a continuum robot called the Dual-Cross-Module Sections Cable-Driven Continuum Robot (DCM-S-CDCR). The provided optimizers are Artificial Bee Colony (ABC) and Particle Swarm Optimisation (PSO). To begin, a comprehensive summary of each algorithm and the FK connections of the examined robot are provided. Subsequently, numerical experiments are conducted, whereby the obtained data are thoroughly analysed and contrasted. The findings shown that the Particle Swarm Optimisation (PSO) method is the optimal choice for addressing the Inverse Kinematics (IK) problem of continuum robots. This technique yielded satisfactory tracking precision within a reasonable timeframe. The PSO and ABC algorithms are the quickest algorithms, each in their own right.

Keywords – Continuum robot, cable-driven continuum robot, inverse kinematic, population-based metaheuristic algorithms, optimisation.

I. INTRODUCTION

Continuum robots, a new type of hyper-redundant robot, have gained significant attention in the field of robotic research. They are considered superior to robots with rigid-link structures in terms of their flexibility, dexterity, and ability to safely interact with humans [1]. These characteristics make them well-suited for a wide range of applications, including as exploration and inspection in restricted areas [2], medical sectors [3], and rescue operations [4]. Continuum robots pose a greater challenge in terms of modelling compared to robots with rigid links because of their intrinsically complex and non-linear mathematical expressions. Nevertheless, to discover more feasible resolutions, the researchers turned to simplifications and assumptions to streamline the modelling efforts. The widely recognised kinematic technique typically employed is the Constant Curvature kinematic technique (CCKA) [5–6]. Researchers have constructed many Forward Kinematic (FK) models for different continuum robots utilising diverse approaches and ideas, as shown in references [5–9]. Although the problem has been simplified, finding the solution to Inverse Kinematic (IK) models of continuum robots is still a difficult task. The primary challenge in inverse kinematic modelling of continuum robots stems from the limitless number of degrees of freedom (DoFs) offered by forward kinematic models. Consequently, this results in the generation of several or even an unlimited number of solutions to an inverse kinematic issue. For a typical robot with six degrees of freedom (6-DoF), analytical approaches, as described in reference [10], can be employed. Alternatively, numerical approaches and optimisation algorithms can be utilised, as they are not affected by the redundancy of the robot, as mentioned in references [11-12]. Nevertheless, these methods possess both benefits and drawbacks. For instance, closed-form solutions offer the benefit of expressing all inverse kinematics solutions as functions concerning end effector position variables. In addition, they are computationally efficient, providing all inverse kinematics solutions for a given end effector posture and including natural solutions. However, they become challenging to calculate for robots with more than 6 degrees of freedom (DoFs).
Numerical approaches benefit from being effective independent of the degree of freedom (DoF) of the robot. Nevertheless, they are plagued by other drawbacks, such as exorbitant computational expenses and lengthy execution durations, as well as frequent singularities. Thus, optimisation methods continue to be a viable solution for such issues. While optimisation algorithms have been shown effective in solving optimisation issues in other research domains [13–15], their use in modelling continuum robots is still restricted. It is advisable to examine the efficiency of certain optimisation techniques in solving the inverse kinematics problem of continuum robots. One might mention the class of Population-based Meta-heuristic Algorithms (PbMAs) among these algorithms.
PbMAs, or Population-based Metaheuristic Algorithms, are a category of methods that employ a collection of potential solutions and utilise population features to systematically steer the search towards nearly optimum or ideal solutions within an acceptable timeframe. This is achieved by their capacity to explore the whole solution space while also using local information. This category of algorithms encompasses (but is not limited to): The Artificial

Bee Colony (ABC) algorithm [16] and Ant Colony Optimisation are two optimisation techniques. In order to do this, the following portions of the paper are arranged as follows:
The next section provides a concise introduction to the chosen PbMAs. Section 3 provides an overview of the functional knowledge (FK) of the examined DCM-S-CDCR and then explains the formulation of the inverse kinematics (IK) problem. Section 4 showcases numerical experiments and provides a summary of the comparison of algorithm performances, focusing on execution times and tracking accuracy. The discussion of concluding remarks.

II. MATERIALS AND METHOD

This section provides a concise introduction to the two population-based metaheuristic algorithms that were examined in this study, then the Formulation of the IK problem for the optimisation process and numerical experience

A- population-based metaheuristic algorithms that were examined in this study

A.1- The Artificial Bee Colony (ABC) algorithm

was introduced by D. Karaboga in 2005 [16]. The algorithm emulates the foraging behaviour of honey bees, which involves flying throughout the environment in search of a food source that is of superior quality. The system is comprised of three fundamental elements: worker bees, observer bees, and scouts. The ABC algorithm starts by randomly initialising scout bees and hired bees, with both mostly undergoing mutation. Selection is associated with choice or goal, although in this case, the intersection is not directly evident. Within the algorithm, the employed bees have the task of examining their food sources based on their fitness values. Each employed bee is assigned to a certain Food Source and is responsible for conveying this information to attract the spectator bees. Using this data, the observing bees make a determination to select a food source. The "fitness value" of a food supply, as assessed by the worker bee, is a measure of its quality and is linked to its location. The food source $prob_i$is mathematically represented as follows:

$$prob_i = \frac{fit_i}{\sum_{q=1}^{N} fit_i} \qquad (1)$$

Where fit_i is the fitness value of the solution i evaluated by its employed bee, is directly proportional to the nectar amount of the food source at the position i. N represents the total number of solutions in the population.

$$x_i^{new} = x_i^{old} + r_i\left(x_i^{old} - x_r\right) \qquad (2)$$

The variable x_i^{new} represents the new location of the food, whereas x_i^{old}represents the prior position of the food source. The variable $r_i$is a random integer that follows a uniform distribution between 0 and 1, and it is used for adjustment. The variable x_r represents a randomly picked food source from the set of food sources $i \in \{1,2 \ldots . N\}$.

A-2 The Particle Swarm Optimisation algorithm

The Particle Swarm Optimisation (PSO) method was introduced by Kennedy and Eberhart in 1995 [20]. This programme emulates the locomotion of a group of birds and their interactions with nearby members within the collective. The initial stage in Particle Swarm Optimisation (PSO) involves the random initialization of a cluster of particles inside the search space. Each individual particle, denoted as p, navigates across the search space with a certain velocity, v_p^t, and is characterised by its location vector, x_p^t. Each particle adjusts its velocity based on the optimal prior locations (P_{best}) and the overall best position (g_{best}) acquired by its neighbouring particles in the following manner:

$$\mathrm{v}_p^{t+1} = \omega \mathrm{v}_p^t + \mathrm{c}_1\mathrm{r}_1\left(P_{best} - \mathrm{x}_p^t\right) + \mathrm{c}_2\mathrm{r}_2\left(g_{best} - \mathrm{x}_p^t\right) \qquad (3)$$

where ω is the inertia weight; $c_1, c_2$are two positive constants; and r_1, r_2 are two random numbers with uniform distribution between 0 and 1. In addition, the position vector of each particle p is updated by the following Equation:

$$\mathrm{x}_p^{t+1} = \mathrm{x}_p^t + \mathrm{v}_p^{t+1} \qquad (4)$$

B. Formulation of the IK problem for the optimisation process

B-1The forward kinematics

The Dual-Cross-Module Sections Cable-Driven Continuum Robot (DCM-S-CDCR) is the case study for this proposal to compare the two PbMAs [21]. Each of its four identical serially linked cross modules has one degree of freedom (1-DOF). Figure 1(a) shows the DCM-S-CDCR scheme design, and Table 1 lists its modules' geometric specifications and kinematic nomenclature. The module's deformation following actuation may be characterized by three geometrical parameters $(\theta_k, \varphi_k, \kappa_k)$ with regard to the local frame $(o_{k-1}x_{k-1}y_{k-1}z_{k-1})$, as illustrated in Figure 1(b): where and are the bending θ_k and orientation φ_k angles, curvature $\kappa_k = \theta_k / l_k$, and length l_k .

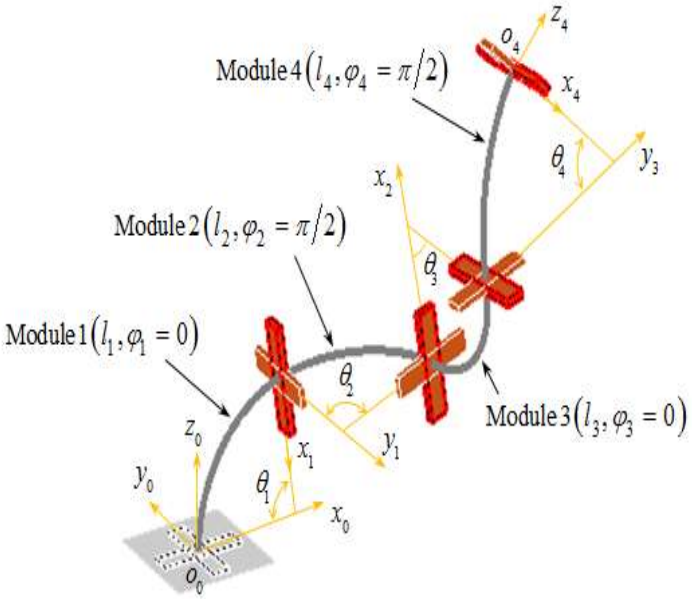

Fig. 1. DCM-S-CDCR schematic and its kinematic nomenclature. It should be noted here that the intermediate elements of the four modules are hidden and the sheet-like backbones have been drawn as curves for better illustration.

Table 1: Geometric parameters of the studied DCM-S-CDCR

Modules	**Module 1**	**Module 2**	**Module 3**	**Module 4**
Bending angle (rad)	θ_1	θ_2	θ_3	θ_4
Orientation angle (rad)	$\varphi_1 = 0$	$\varphi_2 = \pi/2$	$\varphi_3 = 0$	$\varphi_4 = \pi/2$
Module's length (mm)	$l_1 = 90$	$l_2 = 90$	$l_3 = 90$	$l_4 = 90$
Bending axis (u_{k-1})	y_0	x_1	y_2	x_3

To establish the forward kinematics of the robot we need to define the transformation matrices of every module and since we have two types of modules we will have two unitary transformation matrices.

$$T_u = \begin{bmatrix} R_u & P_u \\ 0^3 & 1 \end{bmatrix} \quad and \quad T_{u\prime} = \begin{bmatrix} R_{u\prime} & P_{u\prime} \\ 0^3 & 1 \end{bmatrix} \quad (5)$$

Where $P_u and P_{u\prime}$ is the position vector of the crossed modules.

$$P_{j,u} = \left[\frac{l_k}{\theta_k}(1 - \cos\theta_k); 0; \frac{l_k}{\theta_k}\sin\theta_k\right] \qquad (6)\ if\ its\ placed\ horizantally$$

$$P_{j,u'} = \left[0; \frac{l_k}{\theta_k}(1-\cos\theta_k); \frac{l_k}{\theta_k}\sin\theta_k\right] \quad (7)\ if its\ placed\ vertically$$

At the same time if it's placed horizontally we will have rotation around Y axes Rot (y; θ_u) And a rotation around Z if it is placed vertically Rot (x; $\theta_{u'}$).

-Then the forward kinematics for Section where a section is two crossed modules which give:

$$T_{j,k} = T_{j,k} * T_{j,k} \qquad (8)$$

And finally the forward kinematics for tow Section

Every section has 2 modules

$$T_{j,k} = \prod_{k=1}^{2}\prod_{j=1}^{2} T_{j,k} \qquad (9)$$

B-2 IK problem statement and objective function

IK involves finding a plausible way for a robotic system to attain a predetermined posture. The CCKA IK of a continuum robot may be stated mathematically as follows [5].

$$\mathrm{k} = f_{\text{independent}}^{-1}(\mathrm{x}) \qquad (10)$$

The fundamental issue with Eq. 6 is that analytical IK function equations are hard to find. Multi-section continuum robots make numerical approaches challenging to apply. Metaheuristic algorithms can solve this. In this work, each of the following
methods will direct a particle search for optimum or near-optimal continuum robot IK issue solutions. To evaluate solution quality, a quadratic objective function is used This automatically quantifies the robot's end tip distance inaccuracy $\left(x_{\text{generated}}\right)$ from the required goal $\left(x_{\text{desired}}\right)$. Thus, the objective function is:

$$f_{obj} = \frac{1}{2}\left(x_{\text{desired}} - x_{\text{generated}}\right)^2 \qquad (11)$$

In Equation (11) $\left(x_{\text{generated}}\right)$ is the three initial components of the fourth column of the homogeneous transformation matrix define the robot-independent transformation provided by Eq. (9).

C.1 Boundary conditions

Naturally, a stationary continuum robot must satisfy two boundary constraints to map its central axis curve to its base and end tip. A formal expression of these words is:

$$\mathrm{x}_0 = \mathrm{x}_{\text{base}}, \mathrm{x}_n = \mathrm{x}_{\text{desired}} \qquad (12)$$

B-3 Physical limitations

To run the robot effectively and prevent bending overlap, consider adding actuator variable restrictions. These limits can be stated as bending angles to comply:

$$\theta_k^{\min} \le \theta_k \le \theta_k^{\max}, \text{ with } k = 1,...,4. \quad (13)$$

B-4 Problem Setting

The challenge is to determine the bending and orientation angles of each component to enable the robot to follow a set reference trajectory $\mathrm{x}_{\text{desired}}$. The foregoing population-based metaheuristic algorithms will minimize Eq. (11)'s objective function.
The optimization method creates bending and orientation angles (θ_j, φ_j) with $j = 1, 2, \ldots, n$ at each sample period, but only the final one is deemed ideal for the robot.
The issue dimension in the search space is $2 \times n$ The coordinates of the particle/individual in each

optimization technique indicate the variables of the issue, such as bending and orientation angles. All algorithms have a population of solutions. Eq. (11) typically has an endless number of solutions for this type of issue. To choose a suitable solution among redundant options, apply restrictions to the goal function.

C- Numerical experiments

To assess the effectiveness of the PbMAs in solving the IK problem of the Dual-Cross-Module Sections Cable-Driven Continuum Robot (DCM-S-CDCR), three numerical tests were conducted. In the first and second experiments, goal and trajectory tracking are conducted in a free setting. The third experiment was undertaken to determine the best algorithm for trajectory tracking in a constrained setting after comparing the two PbMAs and analyzing the findings. Each experiment involves four variables $\theta_j \;\; j=1,\ldots,4$ to be discovered. MATLAB R2016a program was used for all numerical experiments on a machine with Intel(R) Xeon(R) CPU E5-1620 0 @ 3.60 GHz, 16 GB RAM, and 64-bit Windows 7 operating system. Each optimization involved 20 search swarms/agents/populations and up to 80 iterations.

III. RESULTS

A. Obtaining the IK for a target point in a free environment

This numerical experiment searches for random IK problem solutions for a target location in a free environment without cost function limitations. The goal location for the robot's end tip was $[60, 60, 270]$ (mm), while its beginning position was $[0, 0, 360]$ (mm) from the reference frame $(o_0 x_0 y_0 z_0)$. Each algorithm is run 50 times and box plotted to obtain this. Figure 2 shows the results under the identical settings, with Table 2 listing the lowest, maximum, and median execution times

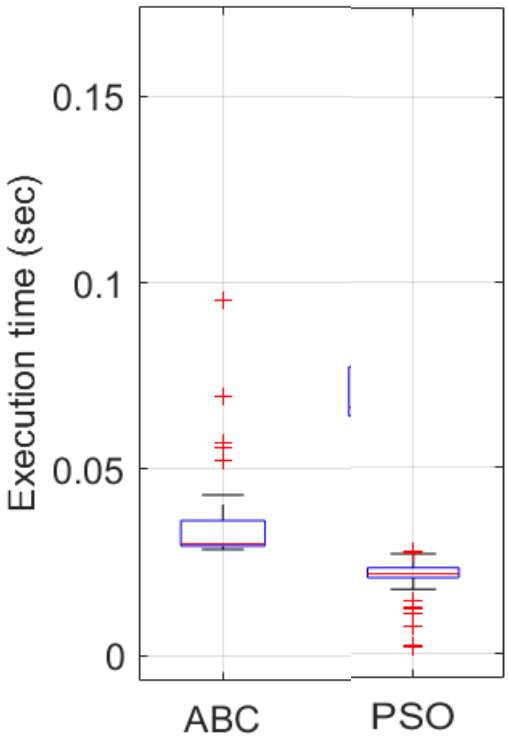

Fig. 2. Results of a target point tracking in a free environment: execution time box plot

Table 2:Notable results of target point tracking in a free environment

Values	Minimum value		Median value		Maximum value		Number of outliers	
Time/error	Ex. time	P. error	Ex. time	P. error	Ex. time	P. error	Ex. time	P. error
ABS	0.02847	0.00294	0.03001	0.04976	0.09541	0.24402	6	1
PSO	0.00145	0.00214	0.02133	0.01774	0.02737	0.14830	11	3

IV. DISCUSSION

In view of the obtained results, it is clear that PSO superior in terms of execution time compared to ABC and their mean execution time values are less than 21 ms. Both algorithms provide outlier results, yet PSO has smaller data distribution. PSO achieved the best results in terms of position error, where their mean values are less than0.020 mm. as it shows Table (2)

V. CONCLUSION

This study compares five population-based methods for addressing the IK issue of a continuum robot, the Dual-Cross-Module Sections Cable-Driven Continuum Robot. ABC and PSO are compared for tracking accuracy (position error) and execution time. Based on the two performance metrics, the PSO algorithm is the best overall algorithm since it executes faster than ABC. However, this study includes shortcomings that should be addressed in future research. First, while the PSO method has reasonable execution speed, it may have lengthier runtimes in some circumstances, which presents prospects for development, especially given its variations. Second, this study compared basic algorithms, but there are many enhanced variants that might improve outcomes and approach ideal IK issue solutions. Additional algorithms are needed for complete comparison. This research not only aids IK issue solving but also continuum robots but also helps researchers solve hard problems.

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Importance and Overview of Digital Communication and Multimedia

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Abstract – Human beings develop information for their senses by using elements such as sound, writing, shape, picture, photograph and film. The multimedia environment in which this information is edited together in a way to strengthen the perception and understanding process is defined as "multimedia". In a multimedia application, we use all our senses except the sense of touch. In the simplest sense, multimedia is a user interface supported by the use of visual and auditory tools such as text, sound, image, graphics, video and animation in a computer-based application. When someone put a movie into a CD driver and watch it, someone make sense of it with a sound card, a video card and a monitor, thus using multimedia. In summary, multimedia applications and digital communication systems, which we can define as the use of different types of data in a computer environment to explain an idea, a subject or an event, are rapidly developing their usage area today. This situation makes digitalization widespread and increases the importance of the digital information system. In addition, the importance of information security of this system is better emphasized with digitalization. The proliferation of portable and inexpensive media has led to the use of multimedia applications in many different fields such as engineering, medicine, education and industry. In this context, the aim of this study is to provide a general overview of this approach and to present sample sections of the studies in this field and to make a general evaluation.

Keywords –Digital, Communication, Digital Communication, Multimedia, Multimedia Applications, Security.

I. INTRODUCTION

Multimedia is a technologically breakthrough application. This innovative technology has the potential to transform traditional educational methodologies. The shift from an instructor-centered approach to a focused-on learners' paradigm benefits both individuals and their own independence when acquiring knowledge. Multimedia computing is a relatively new field of technology that has emerged in the last few years. It integrates various forms of media in a predefined manner to create logical relationships and could be incorporated into interactive environments. This information that is multimedia could involve text, graphics, pictures, sound, animation, videos, and more. Whether or not there is prior information about the digital multimedia data utilized, methods used to identify counterfeiting are evolving. Techniques such as data, digital watermarking, and digital signatures can be employed. Regarding the data, in situations when there is no information, active strategies are rendered useless and passive strategies must be targeted. For this reason, it's crucial to use approaches for both active and passive forgery detection (Multimedya Video Yazılımı Siteleri İçin Temel Siber Güvenlik Tüyoları, 2024; Kang and Wei, 2008; Jigang and Shixing, 2003).

Communicating signals across immense distances is the main function of telecommunication, according to Bennett-Bealer (2011). But because to technological advancements, electrical impulses are increasingly utilized in communications. It makes it easier for individuals to communicate with one another across geographical barriers. Owing to advancements in communication technology, telecommunications is now

a significant economic factor in many nations. The market for telecommunications is expanding over time. It is growing bigger as time passes (Bennett-Bealer, 2011; Kennedy, 1999 ; Qureshi and Awan, 1998).

Enhancing the accessibility of data, materials, information, and expertise is the main advantage of multimedia. By boosting the practical exposures, multimedia, as stated by Wang, contributes to lessen the shortcomings in the conventional instructional approaches. Using multimedia, students learn how to implement and apply their information. For pupils, particularly those with impairments, the use of multiple formats and dynamic graphical presentations is more successful than a single medium. Furthermore, contemporary multimedia material is readily saved on a variety of platforms, including flash drives, large capacity hard drives, and cloud-based systems This improves the contents' connectivity, preservation, and sustainability (Wang, 2009; Green, 1995).

Numerous multinational software businesses involved in multimedia applications have security auditors evaluate their websites and post the findings on their sites. Furthermore, these firms analyze their apps using the most popular antivirus systems in an effort to demonstrate their safety, and they provide you the results. Providing the required clarifications about the databases and/or software that these firms employ to ensure that the systems, programs, and applications they use do not conflict or overlap, and if they do, offering recommendations on them, is another crucial security concern. In this regard, not only does it improve security but it also increases speed, therefore it is very crucial for software firms to offer information without causing users' misunderstanding or pollution. Payment security is just as crucial to cybersecurity as, if not more so than, data security and privacy. Because money transfers, payments, collections, and purchases are the most realistic transactions—even on a virtual platform—on this platform. Even while consumers are able to make orders from shopping sites and are accustomed to bank websites and mobile applications, it is still helpful to look at the payment security precautions taken by websites that provide services like music, video, and video applications and programs. Software businesses do not hesitate to explicitly indicate that there is a refund option and the specifics of this, in order to reassure its users or customers that they are secure. It is helpful to consider these kinds of things as well. View prediction and progressive transmission are used by Vázquez and Sbert (2004) to minimize the bandwidth used by navigation systems. Multimedia recommender systems, including those for movies and videos, are highly sought after. In particular, collaborative filtering systems that tailor results based on filtered content aspects like actors, directors, and genres are in high demand. People construct a movie recommender agent that expands its predictions into the content space via collaborative filtering. The accuracy of predictions made exclusively on the basis of content is increased by this content-based filtering. Such recommender systems will make it simple to approach recommendations for just launched, unrated titles. A recommendation system based on the Multiplicative Utilitarian Strategy and the Slope One algorithm is provided for user groups that visit movie theatres. The framework proposed by Briguez et al. uses reasons for and against suggestions to decide whether or not to provide a proposal to a user. Defeasible Logic Programming (DeLP) is used as the formalism to represent facts and regulations about the recommendation domain (Fernandez et al., 2014; Briguez et al., 2014; Salter and Antonopoulos, 2006; Vázquez and Sbert, 2004).

A number of methods were put forth in the research on digital picture forensics to investigate various interfering activities, including resampling, lighting irregularities, irregular noise structures, changes in correlation brought about by colour filter array interpolating, and predicting the quantification charts of JPEG compression images. For the purpose of detecting contrast modifications, gamma correction, and other nonlinear points procedures on pictures, more complex statistic have been suggested. Photorealistic pictures have been identified and image manipulation has been detected using wavelet-based characteristics. To differentiate between computer graphics and photographic pictures, characteristics driven by physics have been included (Johnson and Farid, 2005; Ng et al., 2005; Popescu and Farid, 2004; Popescu and Hany, 2004; Zhigang Fan and de Queiroz,2003; Farid and Lyu, 2003; Farid, 2001).

II. Materials and Method

Human beings develop information for their senses by using elements such as sound, writing, shape, picture, photograph and film. The multimedia environment in which this information is edited together in a way to strengthen the perception and understanding process is defined as "multimedia". In a multimedia application, someone use all senses except the sense of touch. In the simplest sense, multimedia is a user interface supported by the use of visual and auditory tools such as text, sound, image, graphics, video and animation in a computer-based application. Multimedia applications, which can be defined as the use of different types of data in a computer environment to explain an idea, a subject or an event, are rapidly expanding their use today. The widespread use of portable, inexpensive media (CDs) has led to the use of multimedia applications in many different fields such as engineering, medicine, education and industry. *Media elements:* Audio, Video, Documents (including HTML documents), Images, Graphics, Graphic or Scene Models, Programs (executable code). *Multimedia security-Tools set*: Encryption (encryption of data), Authentication (proving authenticity), Hashing (account-based addressing), Time-stamping, Watermarking (Media Elements, 2024; Jigang and Shixing, 2003).

A. Hashing

The technique of generating a fixed size output from various sized inputs is known as hashing. Extracting summary information from a set of data by means of a mathematical function. This summary data has the following characteristics: (Make our data a text file of size 1 MB). The data obtained with hashing is very small compared to the real data. The hash is obtained from the data, not vice versa (unless hacking is used). Using a hashing operation, the data architecture approach of hashing involves breaking up vast amounts of data into smaller tables. It goes by the name of the content digest algorithm as well. It is a method for distinguishing one particular thing from a group of related products in a unique way. A change of even 1 byte in the actual data will cause the hash value to change completely. Areas of use: Hashing is especially used in security software. Hashing is used to prove that a data has not been altered (authentic). The most known hashing algorithms are: DES, MD4 (very weak), MD5 (long the industry standard) and SHA 512 (the strongest). It can be used to block a piece of software. If you want to block winamp.exe on a system, you cannot do it with the name of the file. Because winamp.exe can be renamed (e.g. word.exe) and the same music can be played. Instead, if you get the hash of winamp.exe and put it in the forbidden hash, you will get a definitive result because no exe can change its size and will immediately give itself away by checking the hash. Used in Network authorization systems such as NT-LM. Since it would be insane to send exact passwords over the network, a hash of the password (which is encrypted) is sent (Hashing in Data Structure: Function, Techniques, 2024; Veri Yapısında Karma, 2024; Hashing Nedir?, 2024).

Digital forensics is an active and constantly evolving area of research that performs numerous studies for the security of digital data content, including audio, picture, and video, integrity, and data verification, in order to identify forgeries on digital multimedia data. At the moment, courts employ digital forensics in a variety of instances. Upon analysis of the digital forensics' literature, it is evident that the picture and video domains saw the commencement of research earlier than the audio domain. However, research on audio forgery detection is still in its early stages. With the increasing usage of computers and the internet in the early 2000s, the field of digital forensics began to take shape. It was originally known as computer forensics since the evidence gathered in those early years was computer-based. However, a variety of technical items have evolved as a result of current technological advancements. These technical items provide digital evidence as well as evidence in the form of the gadget itself. With the advent of digitization in all fields in recent years, the idea of computer forensics has been renamed as digital forensics and has begun to appear in publications under this moniker. From the identification of digital multimedia data as evidence at the crime scene to its presentation as evidence in court, digital forensics is a multi-phase procedure. Changes made to digital multimedia data have been called by a number of titles in the literature, including manipulation, tampering, and forging. All these definitions speak about modifications to the data. It has been noted in the literature that picture, video, and audio data are the primary targets for counterfeit detections on digital multimedia data. This demonstrates how crucial it is to detect forgeries in picture, video, and audio data. Compared to other forgery detections, copy-and-paste and merge forgery detections

on images, videos, and audio are comparatively more challenging. Compared to other forms of forgeries, the integrity of meaning in the data can be altered by these forgeries, hence detecting them is more important (Qazi et al., 2022; Akdeniz and Becerikli, 2021; Bourouis et al., 2020; Khan et al., 2017; Raghavan, 2012; Yerushalmy and Hel-Or, 2010).

Huang et al. divided the signal in 2020 in order to identify spoken content in audio files. Zhang and friends (2022) presented ASLNet, an encoder-decoder architecture-based audio compositing forgery detection technique, in 2022. Shelke and Kasana (2021) published a thorough study on passive methods for video forgery detection in 2021. This study's primary goal is to examine and evaluate the methods currently in use for passive video forgery detection. Li et al. (2023) detected video insertion fraud using pattern noise from camera sensors. In their investigation, they eliminated the frame's foreground items before employing frames devoid of foreground objects to train the reference sensor's pattern noise (Li et al., 2023; Zhang et al., 2022; Shelke and Kasana, 2021; Huang et al., 2020).

B. Multimedia Security Applications

Applications as well as information security have grown quickly, and networks for communication have given rise to several significant difficulties. The use of multimedia information—text, images, and video—has been rising recently as a result of less expensive methods for sending this data over international borders via various unprotected networks. Nevertheless, initiatives at hostile assaults and information stealing across communication systems have made ownership detection and avoidance of copyright violations difficult problems. These attacks may be carried out with the intention of changing or removing the document watermark in order to falsely assert ownership or to stop the information from reaching its intended receivers. As a result, solving these issues has proven to be a fascinating task for safe communication via public networks. The merging of content (knowledge) and applications (being in charge over how the information is presented); the ability to present data using a variety of media types (text, graphics, images, sound, and video); and the capability to present information concurrently through all of these methods are the three characteristics that define applications for multimedia. As a consequence, two or more media types—such as text, images, hearing, video, voice, or animation—are integrated into a computer-based program. This allows information to be presented simultaneously in a variety of forms, with a focus on responsiveness. Some of Them Are Like This: Stealth, Forgery Detection -->Watermarking, Copyright Protection -->Watermarking, Proof of Purchase--> Proof of Purchase (Undeniable), Proof of Delivery (Undeniable), Intruder Detection (Li et al., 2023; Zhang et al., 2022; Shelke and Kasana, 2021; Huang et al., 2020; Jung et al., 2019; Sencar et al., 2010; Pozzebo, 2003).

C. Watermarking

One of the two steganography tools is watermarking. All types of assets, including documents, music, video, and photos, may be copied, utilized, and disseminated with ease in a digital environment. Owing to the nature of digital media, an identically quality copy of the original file is produced during the copying process. Thus, in such a digital world, how can an author or photographer assert copyright when other individuals potentially own identical copies of his/her work? Including more information in the file and distributing it separately is one way to solve the problem. Knowing what a watermark is and how to utilize digital watermarking technology to safeguard the security of the digital files is essential in the field of managing digital assets. Businesses risk major consequences, such as asset abuse, brand degradation, and fines from the law, when they fail to secure their digital assets. It's also astonishing that some businesses aren't using the watermark protection function to safeguard their assets given the amount of money and effort required to produce original material and the potential consequences of abuse. The technique of adding a logo or text watermark to a text or picture file is known as watermarking, also and it's crucial for advertising and copyright safeguarding of digital compositions. Although most watermarking is done digitally these days, the word "watermarking" has been around for centuries. Material was watermarked while it was still wet, which is why the word is still in use today. Historically, the mark of watermark was just apparent when the document was propped towards illumination or when it remained saturated. Embedding a digital code or image which may be obvious or hidden into multimedia information is known as digital watermarking. Because digital watermarking includes source tracking code, it may be used to

track copyright infringement. It is essentially a security technique designed to identify the legitimacy and ownership of digital material and to prevent and deter piracy. This embedded data, also referred to as a watermark, gives details about the file's ownership, copyright, or permission. Put another way, watermarking is the act of adding information—a watermark—on a file (text, audio, picture, or video) in order to protect its copyright (Digital Watermarking and its Types, 2024; What does watermark mean?, 2024; What is a Watermark and Why is Digital Watermarking Software Important?, 2024; What Is Digital Watermarking?, 2024).

D. Watermark that is invisible

The markings that are watermarked are visible to the naked eye. A logo in the corner of the screen on television stations that indicates which channel or agency captured the image is one example, as are pictures on coins that glow when held up to the light). Eliminating this watermark is the only method to combat it. The fact that the passport holder's serial number is included into the picture is an example of an invisible watermark. When a person copies their own pictures onto a passport they have got, certain scanners will reveal that the serial number is either missing or does not match. Compared to visible watermarks, invisible watermarks offer a few benefits. The positions of watermarks are not always clear, and their presence or absence may not be apparent. This offers some defence against assaults using cropping techniques. However, a file is stronger and more secure against assaults the less information it contains encoded in it. To lessen redundancy in the file, this is required. Goals: * Ensuring the accuracy of the image * Tracking down counterfeit versions of the image * Preventing unsanctioned releases (Watermark Nedir? Ne işe Yarar? Nasıl Kullanılır? 2024; What's a Watermark? When and How You Should Use One, 2024; Digital Watermarking and its Types, 2024).

III. RESULTS

Where are Watermarks used - Stenography: Watermarking constitutes one of the steganography techniques. It is simple to copy, use, and share any type of content in digital media, including documents, audio, video, and photos. The digital nature of the environment means that this copying procedure produces an identically sized replica of the original file. Steganography - (covered writing) techniques used to hide information within other information to conceal the very existence of the message, used much longer than cryptography, Different than cryptography in that an illegal user may intercept the message. Concerning the field of cybersecurity, this approach may be used by some threat actors to insert harmful material into files that appear legitimate. Furthermore, the approach has been employed in a number of cyberattacks in recent years, so this concern is not only theoretical. Content is additionally extracted from the computers of the victims via steganography. For instance, after breaking into a corporate network, the attacker wants to transmit data home. Malware that uses steganography succeeds in this endeavour. Often recognized as the initial instance of steganography, which involves hiding a message inside a different letter, a banished monarch by the initials of the time of Hist intended to instigate a rebellion against a competitor. He decided to tattoo an inscription on a servant's forehead after shaving it clean. The concealed message was simply delivered over enemy territory after the hair came back. Watermarks are used in digital cameras, in audio files, in DVD movies, in publish videos, in key distribution systems, in metadata "binding" mechanisms, in preventing counterfeit bank note profitability, in digital camera (Steganography in Cybersecurity: A Growing Attack Vector, 2024; Create and Prevent Steganography in Five Minutes, 2024; Furht and Kirovski, 2005).

Examine watermarking methods: Coefficient modulation; band watermarking; spatial watermarking; weak watermarking; Components of watermarking methods; The picture contains the watermarking algorithm; each owner has a unique watermark; Algorithm for verification.

Attacks: Watermark attacks include more than just taking the watermark off. Disabling the watermark's readability can also be adequate. Image editing techniques like cropping the image somewhat, blurring it, lowering its brightness, and rotating it a few degrees can all be used to accomplish this. Tools for applying and removing watermarks may be found online for free.

Fundamental ideas: Vigour against assaults – once the picture has undergone linear and non-linear procedures, the watermark is not visible inside the image under normal viewing conditions. Brittle watermarks: Copy is utilized for authentication rather than detection; image alteration is easily found and identified.

Attackers: Consolidation: Geometric assaults - cropping, resampling, rotation - Filtering - Printing and rescanning - Collusion - Temporal and Spatial - Analogue conversion (Steganography in Cybersecurity: A Growing Attack Vector, 2024; Create and Prevent Steganography in Five Minutes, 2024; Furht and Kirovski, 2005).

IV. CONCLUSION

Systems for multimedia security are gradually developing. In networked multimedia systems, digital watermarking may be highly essential. Time stamps are also crucial. New approaches allow for updates and are compatible with compressions. Research on watermarking is still in its infancy for many related issues. These issues are listed as below;

(i) where will it come in handy?
(ii) Is it intended just for secondary security purposes?
(iii) Will there be noteworthy developments in theory?
(iv) Will watermarking improve the visual appeal of multimedia technology?

With the potential to liberate millions of individuals from the marginalization that results from having no voice in international affairs, the digital communications revolution is also transforming society. People now own the power, and they anticipate being heard as a correct. The media, telecommunications, and technological sectors globally are going through a very transformative time. A culmination of intricately linked advancements, such as the World Wide Web's and the internet's exponential expansion, digitization, drastically falling processing power costs, liberalization, and privatization of markets, has

started what is known as the digital revolution. Academics, teachers, legislators, and parents have been discussing for some time now how media and digital technology affect literacy, attention span, social tolerance, and aggressive tendencies, among other things. We are facing a communications tsunami, and many of us are unsure of how to respond. We observe the tide receding rapidly. However, patiently expecting it to roar back in while remaining on the beach is not an option. Digital interactions are exactly what they appear such as: communications carried out using and powered through technology that is digital. Multimedia designers and executives employ electronic means of communication to generate a wide range of recreational activities, design for graphics, and creative works. In a world defined by multimedia more and more, where the Internet is a vital source of knowledge and pleasure, security is a big worry. The technology used by network systems to safeguard and grant access to vital and urgently needed copyrighted content and/or private data is called digital rights management. This provides aspirational college protégés and astute technology professionals with the most recent techniques, tactics, and technologies required to effectively fight those who prey on vulnerabilities and security flaws. This approach offers a thorough analysis of current and upcoming field technologies, including as encryption, authentication, copy control, tagging, tracing, conditional access, and media identification. It is chock-full of practical application situations and methods. The digital communications transformation is changing society, with the potential to free millions of people from the marginalized that comes from not having a voice in world affairs. People increasingly own the authority, and they expect their voices to be acknowledged as valid concerns. On a global scale the media, telecommuting, and technology industries are undergoing a period of profound transformation. The rapid development of the internet and the World Wide Web, digitalization, sharply declining processing expenses, liberalization of markets, and privatisation are only a few of the interconnected innovations that have contributed to the digital revolution. For a while now, educators, lawmakers, parents, and academics have been debating the effects of media and electronic devices on a variety of issues, including aggressive inclinations, concentration spans, social tolerance, and literacy. The majority of individuals are clueless about how to react to the communications tsunami that we are currently confronting. Everyone watches the tide quickly recede. But staying on the beach and waiting for it to thunder back in is not a possibility.

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Empirical Evaluation of Factor Models of Asset Returns

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Abstract – The purpose of this study is to evaluate the accuracy of the CAPM across two distinct periods: within the sample and beyond it. Additionally, four specific macroeconomic factors—specifically, the default premium, the term premium, the return of the market portfolio, and the real 1-month T-Bill return—were incorporated to create an economic model. This model aims to compare its explanatory power with that of the CAPM during both the within-sample and out-of-sample periods. To analyze the data and assess the significance of betas and pricing errors for each period, we utilized the two-step Fama-Macbeth methodology for both models. Unlike the CAPM, which struggles to elucidate industry returns, our economic model appears to provide a more accurate explanation of portfolio returns across industries.

Keywords – Macroeconomic Risk Factors, Factor Models, Capital Asset Pricing Model, Market Efficiency, Market Risk

I. INTRODUCTION

A common criticism of the simple Capital Asset Pricing Model (CAPM) is that a single market risk premium factor fails to adequately explain the returns of specific stocks or portfolios. Various risk-related characteristics might explain stock returns, but these are often unknown due to numerous limitations in economic and financial research, affecting methodology and data accuracy. Human behavior also plays a significant role in influencing these variables.

The Fama-MacBeth two-step procedure builds on the original 1973 methodology, with significant econometric improvements by Shanken (1985) and subsequent enhancements by Kim (1995) and others. These contributions address issues such as precision in risk estimates and biases in beta calculations. In our study, we used Harvey's approach (1991) to construct risk factors and apply the Fama-MacBeth procedure to assess the impact of economic variables on asset returns.

We selected four macroeconomic risk factors: the default premium, the term premium, the market portfolio return, and the real 1-month T-Bill return. Betas were calculated using time-series regression, while cross-sectional regression decomposed monthly excess returns into risk-related and residual components.

II. MATERIALS AND METHOD

Our primary objective is to validate our model's ability to explain portfolio returns or reject the selected risk factors. We aim to confirm Ferson and Harvey's (1991) findings that the stock market risk premium is crucial in explaining stock portfolio variations. We first apply the Fama-MacBeth regression to the in-sample period to test beta significance and verify the market risk premium's positivity and absence of pricing error. The extended model incorporates four macroeconomic factors to enhance CAPM and test its validity. This process is repeated for the out-of-sample period to assess model performance and variable stability.

Monthly portfolio data of U.S. stocks, categorized by industries, is used for the two-step Fama-MacBeth regression. The extended model includes the four macroeconomic factors in the second-step

regression. To evaluate whether these factors explain cross-sectional portfolio returns and their premium differences, we use a two-stage Fama-MacBeth regression. A rolling window regression is also employed to assess model stability over time, as suggested by Zivot and Wang (2006). For the CAPM in-sample analysis, the initial step involves running a time-series regression to estimate betas using the following form:

$$r_{kt} - R_f = \alpha_k + \beta_k(r_t - R_f) + \varepsilon_{kt}, \qquad t = 1, \dots, T$$

We use the rolling window regression to generate parameter estimates over a fixed size of 60 through the entire sample. To do so, the data from 49-industry portfolio is initially split into an in-sample period, starting from the beginning of the sample, December 1971, to August 2008 (441 monthly-time period). In the first part, we use $\overline{r_{kt} - R_f}$ as estimates of the mean excess returns to run a time-series regression on the market excess return to test the significance of the estimate beta and calculate the pricing error. The subsequent step is to construct a t-test by stating the null hypothesis and the alternative one. The t-statistics is constructed as $t = \frac{\beta - \beta_{H_0}}{s.e._\beta}$ to compare with critical values at 1%, 5% and 10% with (n-k-1) degrees of freedom. The way we compare is to subtract the critical value from the statistical value. If the outcome value is positive, there is evidence to reject the null hypothesis. Then, a cross-sectional regression is performed to test the significance of the estimated coefficients. The form we use is as follows:

$$E(r_k - R_f) = \gamma_0 + \gamma_1\beta_k + u_k, \qquad k = 1, \dots, N$$

Under CAPM, the estimated coefficients should be: $\hat{\gamma}_0 = 0$, $\hat{\gamma}_1 = E(R_m - R_f) > 0$. The way we construct t-statistic to test the significance of market risk premium is different. The equation we use is as follows:

$$t = \frac{\gamma_1 - E(R_m - R_f)}{\text{s. e. }(\gamma_1)}$$

For the extended model, we construct it by adding more macroeconomic risk factors, i.e., default premium, term premium and real 1-month T-Bill return.

$$R_{n,t} = \alpha_n + \beta_{n,PREM} * PREM_t + \beta_{n,T.PREM} * T.PREM_t + \beta_{n,REALTB} * REALTB_t + \beta_{n,ERMP} * M.PREM_t + \varepsilon_{n,t}$$

The following step is to run time-series regression to get four factor betas for each industry in each time period. These betas are then used to run a cross-sectional regression based on the rolling basis to estimate the factor risk premiums and get the intercept. Similarly, we construct t-test and test the significance of the betas and the pricing error. For the out-of-sample, apply the same methodology to the in-sample but use different time period.

The CAPM implies that expected return on a security *i, E(Ri)*, consists of two components: the risk-free return and the reward for risk (security i's beta (β_i) multiplied by the market risk premium $(E(R_M) - R_f)$. An important implication of the CAPM is that the relationship is linear: the asset's risk premium is proportional to the asset's beta and this proportion factor is market risk premium.

We use Fama-MacBeth Methodology to test the validity of the CAPM model. After running the cross sectional regressions we found the intercepts in range of $\gamma_0 = \langle -1.39; 2.03 \rangle$, and coefficient of market beta is $\gamma_1 = \langle -1.83; 2.57 \rangle$.This is the summary of results across different time windows and portfolios.

If the CAPM holds, the following three conditions should be satisfied, i.e., expected returns are positively correlated with the time-series betas, and the cross-section beta values are sufficient to capture all the variation in expected returns, and the market risk premium is positive. Therefore, the three sets of null and alternative hypotheses must be described as following: $\gamma_1 = \langle -1.83; 2.57 \rangle$

Step1: Ho: time-series betas is equal to zero
H1: time-series betas is significantly different to zero

Step2: Ho: there is no pricing error.
H1: there is pricing error.
Step3: Ho: the expected market risk premium is not greater than zero.
H1: the expected market risk premium is greater than zero.

Different from the simple CAPM, the extended model is an economic factor model of which the factors are realizations of market time-series and thus are observed. The factor loadings i.e. betas, (measuring the sensitivity of the portfolio return to the change in the risk factors), are required to be estimated. It is also important to investigate whether these risk factors play a role in explaining the portfolio return.

The t-test is constructed to test the following hypotheses:

Ho: the risk factor has no effect on the portfolio return.
H1: the risk factor positively affects the portfolio return.

III. RESULTS

The table 1 shows the beta values in the in-sample data period. According to the table, it is obvious that almost all beta values are strongly significant and positive except for Soda & Households (only significant at 5% and 10%) or Guns & Mines (only significant at 10%).

$$t = \frac{\beta_0 - \beta_{Ho}}{s.e._{\beta_0}} \sim t_{N-k} = \frac{0.13391}{0.525315} = 0.254914$$

Based on the t statistic we fail to reject the null hypothesis at 10 percent significance level.

Now, we run the second step of Fama-MacBeth regression in order to obtain the intercept (gamma zero) coefficient for the test of pricing error.

Then, we calculate the following t-statistic for γ_0 and compare it to the 5 percent critical values of t-distribution.

$$t = \frac{\gamma_0 - \gamma_{Ho}}{s.e._{\gamma_0}} \sim t_{N-k} = \frac{0.5253152}{0.63570} = 0.0058$$

We fail to reject the null based on the t-test. This means that the intercept of the cross-sectional regression model is not statistically different from zero and thus CAPM correctly predicts the excess returns for our 49 portfolios (on average).

Finally, we test the hypothesis about the expected market premium.

$$\text{Ho: } \gamma_1 - (E(R_m) - R_f) \leq 0$$

$$\text{H1: } \gamma_1 - (E(R_m) - R_f) > 0$$

The t-statistic is -0.005. Based on the test we fail to reject the null hypothesis of non-positive market risk premium. This suggests that there is non-positive risk premium, which is inconsistent with CAPM. To conclude, we reject the bivariate CAPM based on our 3 hypothesis tests due to failed condition of positive $(E(R_m) - R_f)$, as there must be positive reward for risk.

Similar to the results in the in-sample data, according to table 2, the out-of-sample beta values are strongly significant and positive except for Gold (only significant at 5%) or Beer & Textiles (insignificant at any level). Hence, expected returns are positively correlated with the time-series betas.

In the second test, the t-statistic for γ_0 is calculated as 2.34. Therefore, we fail to reject the null hypothesis at 1% significance level, but reject the null at 5% and 10% significance level. It means the second test of the CAPM is not always successful. Only at the 1% significance level, betas can capture all

the variation in expected returns on average. However, for other two conditions, there is a pricing error problem and there must be some other important economic risk factors which can capture the variation in expected return. Also, the t-statistic for γ_1 is calculated as 0.578 leading to the failure to reject the null at any significance level, which indicates there is no evidence of positive market risk premium. Obviously, CAPM does not hold mainly due to non-positive market risk premium during the out-of-sample period. Moreover, the estimated pricing error is significant at 5% and 10% significance level.

The table 3 displays average beta values estimated from the rolling time-series regression for 49 portfolios and their corresponding significance at 1%, 5% and 10% level by using the t-test.

The number in brackets, next to portfolio's name refers to the number of portfolio in the list of industries. b_default prem, b_term prem, b_market portfolio and b_real 1-month TB represent the coefficients of the four macroeconomic risk factors, namely, the default premium, the term premium, the return on the market portfolio and the real 1-month T-Bill return. Therefore, for the entire column, the data shows the impact of the risk factor on forty-nine industries while the entire row indicates the impacts of the four macroeconomic risk factors on one industry.

It can be shown that only default premiums are significant, even at 1% significance level for the overwhelming majority of industries, i.e., there is strong evidence that the industries' return is affected by the default premium. Just for the Gold (27), the default premium has no influence based on these three significance levels. In addition, Guns (26) is only significant at 10% level. As with other three risk factors, the result implies that they do not affect the portfolio returns. The default risk is the only driver for the portfolio return before the financial crisis. However, this analysis is valid on the assumption that the extended model is the correct model for explaining the cross-section portfolio returns. Thus, caution should be given to test the validity of the model. The intercept, which captures the pricing error is included in the regression as it appears in the model. If the model is correct, the expected value of the intercept is supposed to be zero. The t-statistic is calculated as:

$$t = \frac{\beta_0 - \beta_{Ho}}{s.e._{\beta_0}} \sim t_{N-k} = \frac{-0.01378}{0.092888} = -0.1484$$

Compared with two-tailed absolute critical value t(1%) =|2.704|, t(5%) =|2.021| and t(10%) =|1.684| with n-k-1= 49-4-1= 44 degree of freedom, the null hypothesis that the pricing error is zero is not rejected. There is strong evidence that there is no pricing error. Hence, a conclusion that the economic model has a good capacity in explaining the cross-section portfolio returns on average can be drawn.

In comparison to the CAPM whose the market risk is insignificant for almost all industries at 5% significance level, the industries' return in the extended model is only affected by the default risk rather than other three risk factors. It appears that the extended model fits the in-sample data more. Similar to the in-sample betas, the table 4 shows average betas calculated using the same method but from different periods and their corresponding significance. As it can be seen from the table, contrary to the in-sample, the beta of default risk is insignificant even at 1% significance level for all the portfolios. The beta of term risk is significant at 5% significance level to a few portfolios, such as Books (8), Health Care (8), Medical Equipment (11), and Whole Sales (42) while all the betas of the market portfolio excluding the Soda (3), Textile (16) and Gold (27) are significant at even 1% level. Betas for Soda (3) and Gold (27) are significant at 5% level. Nevertheless, Textile (16) is not affected by any of these four factors. Additionally, betas for real 1-month return are significant at 5% level just for Soda (3), Steel (19) and Personal Services (33).

According to the result, the market risk seems to highly affect all of the forty-nine industries except Textile (16). The default risks which predominately influence all the industries before the crisis have no impact on the industries' return during the financial crisis, while the other two risk factors have moderate impacts on specific industries. The reason why the default risk is insignificant could be that this risk is incorporated into the market risk.

To identify whether the model suits the out-of-sample data, it is essential to test the significance of pricing error by using following t-test.

$$t = \frac{\gamma_0 - \gamma_{Ho}}{s.e._{\gamma_0}} \sim t_{N-k} = \frac{0.719847}{0.567092} = 1.269366$$

Compared with the two-tailed critical value t(1%) =2.704, t(5%) =2.021 and t(10%) =1.684, we reject the null if the absolute statistical value is larger than the critical value. Failure to reject the null hypothesis that pricing error is zero indicates that there is no evidence against the model. This model can be applied to explain the portfolio return on average.

Table 1. average beta values for 49 portfolios in the CAPM (in-sample)

Portfolio#	Beta(Mkt)	Portfolio#	Beta(Mkt)
1	1.182451518***	26	0.828354688***
2	0.434301994***	27	0.324987506**
3	0.697036947***	28	1.683438647***
4	0.501161918***	29	1.714641529***
5	0.710798135***	30	0.963615865***
6	0.960442224***	31	0.523308035***
7	1.521205529***	32	0.914714382***
8	1.217589576***	33	1.196810212***
9	0.625289553***	34	1.015026424***
10	1.245814824***	35	1.133723294***
11	0.907640435***	36	0.9634869***
12	0.888878282***	37	1.187293118***
13	0.584346841***	38	1.083254471***
14	1.350714118***	39	1.101305276***
15	1.228082859***	40	0.985036253***
16	0.45305982	41	1.130355588***
17	1.494227882***	42	0.925350359***
18	1.290946941***	43	0.8255384***
19	1.683424706***	44	0.712770865***
20	1.295332824***	45	1.265565***
21	1.480077529***	46	1.046038376***
22	1.365448647***	47	1.867584294***
23	1.633413412***	48	1.275143176***
24	1.162144235***	49	1.364414***
25	1.912102235***		

Note: '***' denotes for significance at 1% level.'**' denotes for significance at 5% level.'*' denotes for significance at 10% level (with n-k-1=49-4-1=43 degree of freedom)

Table 2. Average beta values for 49 portfolios in the CAPM (out-of-sample)

Portfolio#	Beta(Mkt)	Portfolio#	Beta(Mkt)
1	1.182451518***	26	0.828354688***
2	0.434301994***	27	0.324987506**
3	0.697036947***	28	1.683438647***
4	0.501161918***	29	1.714641529***
5	0.710798135***	30	0.963615865***
6	0.960442224***	31	0.523308035***
7	1.521205529***	32	0.914714382***
8	1.217589576***	33	1.196810212***
9	0.625289553***	34	1.015026424***
10	1.245814824***	35	1.133723294***
11	0.907640435***	36	0.9634869***
12	0.888878282***	37	1.187293118***
13	0.584346841***	38	1.083254471***
14	1.350714118***	39	1.101305276***
15	1.228082859***	40	0.985036253***
16	0.45305982	41	1.130355588***
17	1.494227882***	42	0.925350359***
18	1.290946941***	43	0.8255384***
19	1.683424706***	44	0.712770865***
20	1.295332824***	45	1.265565***
21	1.480077529***	46	1.046038376***
22	1.365448647***	47	1.867584294***
23	1.633413412***	48	1.275143176***
24	1.162144235***	49	1.364414***
25	1.912102235***		

Note: '***' denotes for significance at 1% level.'**' denotes for significance at 5% level.'*' denotes for significance at 10% level (with n-k-1=49-4-1=43 degree of freedom)

Table 3. Average beta values for 49 portfolios in the extended model

Portfolio#	Beta(def)	Beta(term)	Beta(mkt)	Beta(int)
1	0.834720043***	-0.461164304	0.089107582	2.691959151
2	0.703594866***	-0.5167279	0.026294234	2.506275116
3	0.843975601***	-0.30545643	0.050439197	1.261800621
4	0.809765518***	-0.701200853	0.090936185	3.077584756
5	0.727680924***	-0.282716361	-0.598591977	3.850508448
6	1.115889763***	0.604357344	-0.227905253	-2.666697577
7	1.216953022***	0.112921449	0.173578207	-0.674295811
8	0.956538184***	0.037247655	0.137600489	-0.565293124
9	0.821574938***	0.010818529	0.079353749	-0.286160493
10	1.074225823***	0.573998354	-0.110528528	-1.753008152
11	1.080703266**	-0.117601223	0.020849731	1.766015843
12	0.95064754***	-0.263367803	-0.250941466	1.60686959
13	0.845716757***	-0.250500153	-0.447640991	2.405911479
14	1.00082608***	0.182155024	-0.0250701	-0.471014319
15	0.998468896***	0.559530585	0.141175515	-2.099184827
16	0.948573404***	0.076957115	0.311508094	-1.146997287
17	1.07142887***	0.321382727	-0.001028953	-1.0077377
18	1.259692475***	1.475995307	-0.869896443	-3.299384534
19	1.253511477***	0.456656344	0.182541119	-1.747180043
20	1.002711953***	0.042070814	0.269366567	-0.474546118
21	1.185105195***	0.739609717	0.162396147	-2.958688948
22	1.174713349***	0.184421211	0.137770648	-0.033013364
23	0.993823203***	0.771386952	0.045290263	-2.131515379
24	1.07434664***	-0.217668382	0.325993033	1.267658519
25	1.011799952***	-0.478079075	0.289332855	1.032328727
26	0.743422827*	-0.496176346	0.283430031	3.280811833
27	0.626806038	3.772847299	-0.814546929	-11.59606305
28	1.007517724***	1.20211413	-0.225288638	-3.155620573
29	1.11221546***	1.486659267	-0.76761309	-3.067078632
30	0.754595278***	-0.068571044	0.102017328	1.532952279
31	0.494006924***	-0.627833906	-0.036397641	3.32516513
32	0.792680459***	-0.261475086	0.032891837	0.213289854
33	1.056849042***	0.049105409	0.057557333	-1.146521182
34	1.138066919***	0.113744522	0.089520783	-0.268398595
35	1.271938436***	0.529798027	-0.081942194	-2.181495498
36	1.630827175***	0.897028586	-0.17567898	-2.783425379
37	1.47462449***	0.387692003	0.402160073	-2.750029051
38	1.375265497***	0.450924014	0.122435779	-1.811107443
39	0.941154358***	0.417671645	0.059932007	-1.100195629
40	0.882728853***	-0.362868628	0.52153634	-0.172763395
41	1.034072916***	0.475882929	-0.171696918	-1.541130094
42	1.006507699***	-0.004308819	0.036225552	0.425972849
43	1.034755333***	0.251638753	0.015614714	-1.117966725
44	1.033833212***	0.038156316	0.074443823	-0.354699743
45	1.062869774***	-0.724450112	0.060853978	2.016494154
46	0.900385249***	-0.816192302	0.104583473	3.094486515
47	0.964835894***	0.320924712	0.136470317	-1.931457943
48	1.215831768***	-0.02268733	-0.066482707	-0.281777341
49	1.132974906***	-0.592408232	0.049147684	1.966573171

Note: '***' denotes for significance at 1% level.'**' denotes for significance at 5% level.'*' denotes for significance at 10% level (with n-k-1=49-4-1=43 degree of freedom)

IV. DISCUSSION

In this section, we analyze and compare the results of the two models. For the out-of-sample period, market risk is significant only in the extended model, whereas the CAPM fails to explain industry returns. The extended model demonstrates some explanatory power for industry returns and shows no pricing errors at the 5% significance level. Conversely, the CAPM exhibits pricing errors at both the 5% and 10% levels and lacks evidence of a positive market risk premium in both periods.

During financial crises, systematic risk impacts nearly all industries. The extended model performs better as it has no pricing errors and most betas are significant and positive. The risk factors in the extended model shift from default risk to market risk between in-sample and out-of-sample periods, indicating the model's flexibility and varying explanatory power over time. This reflects the time-varying beta problem, where the sensitivity of each risk factor to industry returns changes based on market conditions.

The CAPM consistently fails to explain industry returns in both periods. A major limitation of the CAPM is the potential correlation between the risk factor and the residual, leading to biased beta estimates. This occurs because market risk does not capture all variations in stocks under different economic conditions. In contrast, the economic factor model allows risk factors to vary over time, adapting to different market conditions since the risk factors are derived from market time-series data.

V. CONCLUSION

In summary, we used the Fama-MacBeth two-step methodology to test the CAPM and compare it with an extended economic model. Our findings indicate that the economic model better captures the risks affecting industry returns in both sample periods. However, this study has limitations, such as the correlation between risk factors and residuals in the CAPM and the static risk factors in the economic model under changing conditions. Future research should address these issues. For the CAPM, testing the correlation between risk factors and residuals is crucial to avoid biased estimates, as our rejection of the CAPM might stem from factor construction. For the economic model, it's important to adapt risk factors to changing economic conditions, especially during extreme events like financial crises.

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Cytotoxic Effects of PLGA-mir128-1-5p Nanocapsule on Lung Cancer and Investigation of Gene Activations on the Apoptotic Pathway

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Abstract – Lung cancer is known globally as the cancer type with the highest incidence and mortality rates, regardless of gender. Consequently, current treatment strategies continue to be developed. Drug candidates developed using nanotechnology can be designed with encapsulation structures for use in controlled release. Polymeric nanoparticles, due to their colloidal nature, can traverse biological structures such as cellular membranes, tissues, and biological barriers, allowing for cellular uptake and release. miRNAs play a crucial role in the diagnosis, detection, and treatment of certain pathological conditions, including cancer, as well as in the regulation of gene expression. In this study, nanocapsules were synthesized using the emulsion-solvent evaporation method with the biocompatible PLGA polymer, and miRNAs were encapsulated within these nanocapsules (PLGA-mir128-1-5p) to develop a novel treatment strategy against lung cancer. The size distributions of these nanocapsules were determined through SEM analysis. The cytotoxic effects of the nanocapsules on A549 cells were assessed using the Alamar Blue assay. The expression of genes involved in the apoptotic pathway (BAG-1, BNIP3L, HRK) and cell migration (TPPP, PALM, SBK-1) were analyzed using qRT-PCR. The nanocapsules had an initial size of 216 nm, which increased to 236 nm after miRNA encapsulation. The IC_{50} value of the nanocapsules on lung cancer cells was found to be 266.4 µg/mL, indicating that the nanocapsules did not exhibit direct cytotoxic effects on lung cancer cells. qRT-PCR analysis showed that the expression of the apoptotic genes BAG-1, BNIP3L, and HRK increased by 1.90-fold, 1.80-fold, and 2.25-fold, respectively. Conversely, the expression of the genes TPPP, PALM, and SBK-1 involved in cell migration decreased by 0.87-fold, 1.90-fold, and 1.27-fold, respectively. In conclusion, the results demonstrated that miRNA transfection efficiency was enhanced through nanocapsulation with the PLGA polymer. This study suggests that PLGA nanocapsules encapsulating miRNAs could serve as a promising strategy for lung cancer treatment.

Keywords – Nanocapsule, PLGA, miRNA, Lung cancer, Cytotoxicity, Gene expression.

I. INTRODUCTION

Lung cancer, which is frequently diagnosed worldwide, is ahead of cancer and cancer deaths [1]. Although radiotherapy, chemotherapy and surgical treatment methods are the most common treatment methods used in the treatment of lung cancer patients, the treatment of lung cancer still faces strong challenges. For this reason, it is necessary to develop up-to-date and effective treatment strategies [2]. The merging of the fields of nanotechnology and oncology has led to significant advances in targeted drug development [3]. Through the advancing clinical applications of cancer nanotechnology, it has demonstrated the potential of nanoparticles to revolutionize cancer diagnosis, imaging, and therapeutic drug carriers, especially lung cancer [4]. Nanoparticles, which stand out with their high surface area, adjustable properties (thermal, magnetic, optical, electrical), various shape and size options, have the ability to overcome biological and chemical barriers. Thanks to these features, it allows the development

of less invasive and biocompatible treatment methods, thus increasing therapeutic and diagnostic efficacy with the aim of improving the quality of life of patients [5]. Polymeric nanoparticles can provide more effective entry and exit on biological structures such as tissues, biological barriers and cellular membranes thanks to their colloidal structure. Thanks to their small size, they have the ability to penetrate into capillary structures and tumor tissues. In addition, their small volume allows them to avoid circulating phagocytes, so they can stay in the circulatory system for a long time and reach the target site [6]. In eukaryotic cells, there are functional RNA molecules that do not code and do not participate in protein synthesis but play an important role in cellular processes. These non-coding RNAs are divided into different subgroups as microRNA (miRNA), small interference RNA (siRNA), piwi-interacting RNA (piRNA), small nuclear RNA (snRNA), small nucleolar RNA (snoRNA) and long non-coding RNAs lncRNAs [7, 8]. miRNAs are single-stranded RNA molecules that are approximately 21 nucleotides long. The miRNAs encoded in the nuclear genome function by base pairing with complementary mRNA molecules. In this way, targeted mRNAs reduce or manipulate translational efficiency [9]. miRNAs can act as oncogenic or tumor suppressors, depending on the gene-level characteristics of the mRNAs they target. If miRNA expression is increased, there is a high probability that the expression of tumor suppressor genes will decrease, which may facilitate tumor formation. In addition, miRNAs are more advantageous than chemotherapeutic drugs used in cancer treatments due to their easy synthesis and high efficiency [10]. In this study, it was aimed to determine the effects of hsa-mir-128-5p on lung cancer cells at the gene level and to develop a new treatment. For this, nanocapsule synthesis was carried out by double emulsion emulsion evaporation method using PLGA polymer with high biocompatibility. It was then encapsulated into hsa-mir-128-5pPLGA nanocapsules. The size distribution of nanoparticles was examined by SEM analysis. Cytotoxicity studies have determined the effects of miRNAs on lung cancer cells. In addition, the level of genes involved in the cell migration and apoptosis pathway of hsa-mir-128-5p miRNA in lung cancer cells was examined.

II. Materials and Method

A. Materials

miScript miRNA Mimic (3172663) Qiagen was obtained from Germany, HRK, BAG-1, BNIP3L, TPPP, PALM and SBK-1 Primers were obtained from Oligomer, Turkiye. The A549 lung cancer cell line (CRM-CCL-185™) was obtained from the American Culture Collection (USA). DMEM F12 growth medium (01-170-1A), Fetal Bovine Serum (FBS; 04-127-1A), PenStrep (03-031-1B), L-glutamine (03-020-1B) were obtained from Biological Industries, Israel. Alamar Blue reagent Invitrogen was obtained from Thermo Fisher Scientific, QIAzol® (79306) was obtained from QIAGEN, Hilden, Germany.

B. Methods

Synthesis and Encapsulation of PLGA Nanoparticles by miRNA

The nanoparticles were synthesized according to the double emulsion evaporation method. In this context, PDLG 5004: Dichloromethanenemulsion was created in a ratio of 1:10. Encapsulation of miRNA was performed by adding 150µL of microRNA mimic/nuclease-free water/FAM oligo and sonication. It was allowed to incubate at room temperature at 600 x rpm for 3 hours to evaporate the dichloromethane. The suspension containing the nanoparticles was centrifuged 3 times for 10 min at 18.000 x rpm, and the pellets were resuspended with 5 mL of nuclease-free water and dried in a lyophilizer at −110°C [11].

Scanning Electron Microscopy Analysis

Since the lyophilized nanoparticles have a non-conductive structure, they are coated with gold plating before imaging. Surface morphology and size distribution were observed at different magnifications with scanning electron microscopy (Zeiss).

Determination of the Cytotoxic Effect of PLGA/PLGA-miRNA Nanoparticles on Lung Cancer Cells

Human lung cancer cell line A549 was grown in an incubator containing 37ºC, 5% CO_2, in DMEM growth media. 10% Fetal Bovine Serum (FBS), 2mM L-glutamine, and 2% Penicillin-Streptomycin were

added to the growth medium. The cells were planted in slabs with 96 wells, $1x10^4$ cells in each well. At the end of approximately 24 hours of incubation, cells that reached sufficient density were treated with PLGA-miRNA prepared in 1mg/mL in the dose range ranging from 0 to 250 μM. The cytotoxic properties of PLGA-miRNA on A549 cells were determined using Alamar blue at the end of 72-48-24 h incubation. A sigmoidal graph was drawn from the obtained cell mortality rate and the PLGA-miRNA concentration (IC_{50}), which inhibits 50% cell growth, was calculated [12, 13].

The Effect of PLGA/PLGA-miRNA Nanoparticles on Gene Expression in Apoptosis and Cell Migration Pathways of Lung Cancer Cells

Total RNA Isolation

A549 cells were planted in 12-well plates at a rate of $60x10^4$ cells per well and incubated in a 5% CO_2 environment at 37°C for 24 h. Cells were treated with IC_{50} values of PLGA-miRNAs and incubated for 48 h. The total RNA obtained from these cells was isolated using the Trizol method. The amount and purity measurement of the obtained RNAs were measured using Nanodrop (ThermoScientific) as an A260/A280 ratio for purity and an A260/A230 ratio for RNA amount.

cDNA synthesis

The synthesis of cDNA from the obtained RNAs was carried out with the iScript™ cDNA Synthesis Kit. cDNA was synthesized from RNA samples using Thermal Cycle at 25°C for 5 min, 46°C for 20 min, 95°C for 1 min and 4°C for 4°C.

qRT-PCR Study

Quantitative real-time PCR (qRT-PCR) was performed using the CFX-connect Real-Time PCR system (Bio-Rad, USA). The qRT-PCR process was performed after a total of 40 cycles, 10 minutes of denaturation at 95ºC, 20 seconds of amplification at 95ºC, 30 seconds at 60ºC, and 30 seconds at 72ºC, with a final extension of 30 seconds at 49ºC [14].

III. RESULTS

The synthesized nanoparticles were imaged with a scanning electron microscope and their sizing was made. Looking at the images, the smallest nanocapsule that could be labeled was 219.2 nm, while the average nanocapsule size was 418 nm (**Figure 1**).

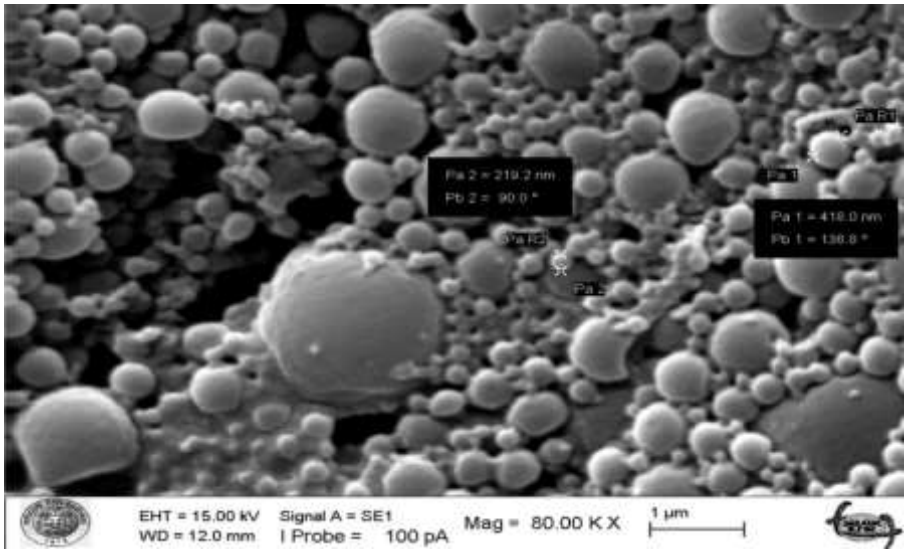

Figure 1. Scanning Electron Microscope Image of PLGA Nanoparticles

It was determined that there was no significant change when the PLGA nanocapsule synthesized on A549 lung cancer cells was treated for 24, 48, and 72 hours. It was found that there was no decrease in

percentage cell viability versus logarithmic concentration (**Figure 2a**). Lung cancer cells of miRNA were treated directly without any encapsulation. As a result of the cytotoxicity study, the IC_{50} value of the directly treated hsa-mir-128-1-5P was found to be 266.4 mg/mL (**Figure 2b**). PLGA/miRNA complex data have shown that nanoparticles do not have direct cytotoxicity. In this context, it is seen that there is a decrease in the cytotoxicity of miRNAs after they are encapsulated in PLGA NP (**Figure 2c**). According to the qRT-PCR results, it was concluded that the efficacy of miRNAs encapsulated in PLGA nanoparticles for the BAG1 gene was more effective than the control group. For the BNIP3L gene, it was found to be significantly higher in miRNA-treated cells than in the control group. An increase approaching 2-fold was observed when treated with PLGA/mir-128-1-5P. For the HRK gene, a significant increase in miRNA-treated cells was detected compared to the control group. An increase approaching 2.5-fold was observed when treated with PLGA/mir-128-1-5P. For the TPPP gene, a significant decrease in miRNA-treated cells was found compared to the control group. A reduction approaching 0.5-fold was observed when treated with PLGA/mir-128-1-5P. For the PALM gene, a significant decrease in miRNA-treated cells was detected compared to the control group. A reduction approaching 0.5-fold was observed when treated with PLGA/mir-128-1-5P. For the SBK1 gene, a significant decrease was found in miRNA-treated cells compared to the control group. A reduction approaching 1-fold was observed when treated with PLGA/mir-128-1-5P (**Figure 2d**).

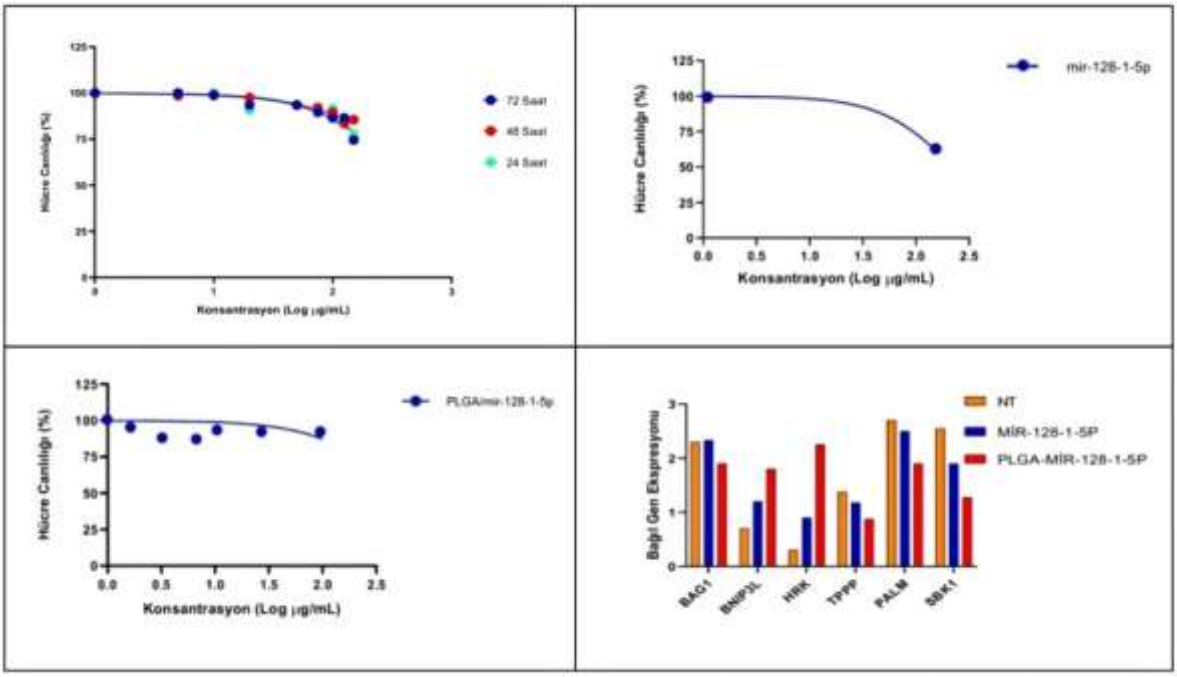

Figure 2. Cytotoxicity and qRT-PCR results of hsa-mir-128-5p PLGA nanocapsules on A549 cells a) Cytotoxicity results of PLGA nanoparticles; b) HSA-MIR-128-5P cytotoxicity results; c) This gene expression is known to induce apoptosis even in the presence of the dimeric mitochondrial protein BCL-2 encoded as a result of cytotoxicity results; d) qRT-PCR results.

IV. DISCUSSION

In this study, a nanocapsule was synthesized using PLGA polymer, and miRNA encapsulation was performed. Then, it was aimed to develop a new treatment strategy by examining its effects on human lung cancer cells (A549). It has been determined that the genes that play a role in apoptosis (cell death) and cell migration in human lung cancer cells are HRK, BAG-1, BNIP3L, TPPP, PALM, and SBK-1. HRK, BAG-1, and BNIP3L genes are involved in apoptosis pathways. HRK has a BH3 structure that triggers cell death by interacting with BCL-2 and BCLXL genes, and the increase in HRK gene expression has led to the idea that lung cancer cells are killed by apoptosis. BAG-1 enhances the anti-apoptotic effect of BCL-2 through growth receptors. The decrease in BAG-1 expression is thought to lead

to apoptosis. Even in the presence of BNIP3L, BCL-2 is known to cause apoptosis. Furthermore, BNIP3L is thought to be sufficient to induce apoptosis and necrosis-like cell death by increased gene expression. A decrease in the expression of TPPP, PALM, and SBK-1 genes, which are involved in cell migration, has also been observed [15-17].

V. CONCLUSION

The biocompatibility and degradation of PLGA nanoparticles provide an important advantage for drug delivery systems. In addition, the easy synthesis and high efficiency of miRNAs make them a more advantageous option in cancer treatments compared to chemotherapeutic drugs. It was determined that the synthesized PLGA/mir-128-1-5P nanoparticle did not have a cytotoxic effect on A549 cells and increased miRNA transfection efficiency. Therefore, it shows that miRNA capsules synthesized using the nanoencapsulation method with PLGA polymer have a promising strategy in the treatment of lung cancer.

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Investigation of Antioxidant Properties of Propolis Extracts Prepared in Different Solvents

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Abstract – Propolis is a natural product bees produce from plant resins, containing bioactive compounds such as phenolic acids, flavonoids, and terpenoids. These components support propolis' antioxidant, antimicrobial, anti-inflammatory, and antitumor properties. In this study, propolis extracts were obtained using ethanol, methanol, and water solvents, and their phenolic and flavonoid contents were analyzed using copper ion reducing antioxidant capacity (CUPRAC) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) methods. The concentrations of phenolic compounds were found to be 129.13 µg/mL ± 0.06 for ethanol extract, 75.76 µg/mL ± 0.08 for methanol extract, and 50.34 µg/mL ± 0.04 for water extract. Similarly, flavonoid concentrations were determined as 73.62 µg/mL ± 0.06 for ethanol, 98.78 µg/mL ± 0.03 for methanol, and 29.24 µg/mL ± 0.006 for water extract. According to CUPRAC analysis, the absorbance values at 100 µg/ml concentration were highest in the methanol extract (29.41 ± 0.05), while the DPPH assay showed the highest inhibition effect in the ethanol extract (91.21 ± 0.003%). This study demonstrates that propolis extracts, particularly those obtained with ethanol and methanol, exhibit higher phenolic and flavonoid contents and superior antioxidant activities compared to water extract.

Keywords – Propolis, Antioxidant activity, Phenolic substance amount, flavonoid substance amount, CUPRAC.

I. INTRODUCTION

Propolis is a resinous natural product produced by bees by processing from many different plant sources and beeswax [1, 2]. The chemical composition of this natural compound generally includes vegetable balm and resin, aromatic and essential oils, wax, pollen, and other substances [3]. Due to its resinous structure, it is used by bees in the assembly and repair of the hive, to protect the hive against external factors (temperature, humidity, heat, and invaders) and as a hygiene material for the hive [4-6]. It has been determined that it contains more than 500 bioactive compounds such as flavonoids, terpenes, polyphenols, coumarins, phenolic compounds, terpenoids, amino acids, and aromatic acids [7]. Thanks to these compounds, they have various biological properties, including antioxidant activity, antimicrobial, anti-inflammatory, anticancer, and antifungal effects [8]. Studies have shown that propolis has strong antioxidant effects thanks to its rich polyphenol content and helps in the treatment of diseases such as diabetes, cardiovascular diseases, cancer, inflammation, and rheumatoid arthritis [8-11]. Although there are various extraction methods to process crude propolis, 96% ethanol is the most commonly used solvent as the best solvent [12, 13]. In addition, it is used in different solvents such as water, methanol, ethyl acetate, acetone, methylene chloride, dichloromethane, hexane, dichloromethane, and methylene chloride [10]. In this study, the antioxidant activities of propolis extracts formed using methanol, water, and ethanol solvents were investigated by using phenolic substance quantification, flavonoid substance quantification, antioxidant activity (DPPH), and copper ion reducing antioxidant capacity (CUPRAC) determination methods.

II. Materials and Method

A. *Preparation of Propolis Extracts*

The preparation of propolis extracts was carried out using different solvents. Ethanol (Et-OH), methanol (Met-OH), and water solvents were used to extract propolis components. Propolis was collected from natural sources and purified by cleaning. After being purified from dust and impurities, the propolis was frozen, and then powdered and mixed well to be homogeneous. The collected propolis samples were weighed at 5 g and extracted separately with ethanol, methanol, and water. The solutions obtained after extraction were filtered using vacuum filtration. The filtrates were then lyophilized and dried under vacuum at -55°C. The dried extracts were weighed and stored in glass tubes at +4°C until further studies.

B. *Determination of Antioxidant Activity and Total Phenolic Substance Amount of Propolis Extracts Obtained:*

Total phenolic substance analysis

The analysis of the total amount of phenolic substances in the sample extracts was carried out by spectrophotometric measurement of the blue color formed as a result of the oxidation of the compounds in the solution by phenolic compounds using Folin-Ciocalteu's solution.

Analysis of the total amount of flavonoids

The analysis of the total amount of flavonoid substances in the sample extracts was carried out by spectrophotometric measurement of the yellow color formed by the oxidation of the compounds in the solution by the flavonoid compounds using aluminum chloride solution.

DPPH free radical removal activity method

Using DPPH free radical, the free radical removal activity of sample extracts was determined [14]. 0.4 mM DPPH solution was added to the samples at different concentrations. Under normal conditions, after incubation in the dark, absorbances were measured at 517 nm using a 96-well microplate reader.

Cu(II) reduction activity (CUPRAC) method

The reducing power of sample extracts was determined using copper(II) ion reducing antioxidant capacity [15]. 10 mM Cu (II), ammonium acetate (NH4OAc) buffer, and 7.5 mM neoocripin solutions were added to the samples at different concentrations and left for incubation. Then, their absorbance was measured at 450 nm using a 96-well microplate.

III. Results

Total phenolic substance analysis and total flavonoid substance analysis of different propolis solvents (ethanol, methanol, and water) were performed. Concentration graphs are drawn against absorbance values. The determination of the Total Phenolic Substance is given in **Figure 1a** of the Gallic Acid standard. The Total Flavonoid Substance is determined in **Figure 1b** of the Quercetin standard. The results of Total Phenolic Substance Determination and Total Flavonide Substance Determination are given in **Table 1**.

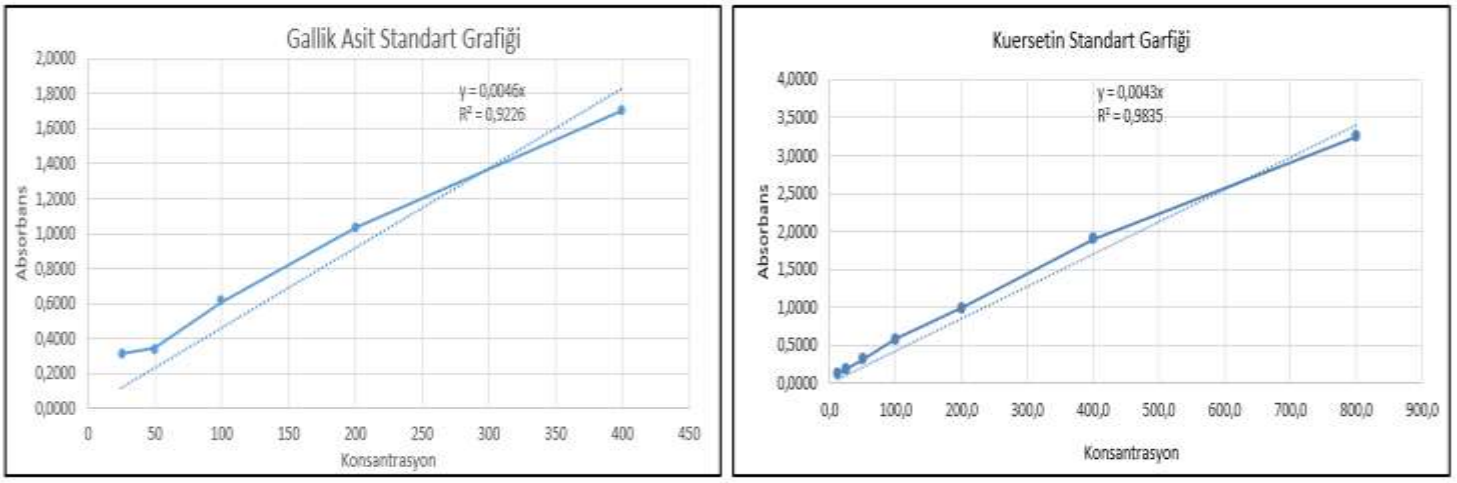

Figure 1. Determination of Total Phenolic Substance a) Gallic Acid standard graph b) Quercetin standard graph

Table1. Total Phenolic Substance Determination and Total Flavonide Substance Determination.

	Total phenolic and flavonoid contents of extracts	
Extraction	**Total phenolic concentration (mg GAEa/g extract)**	**Total flavonoid concentration (mg QEb/g extract)**
Propolis Ethanol Extract	129,13 µg/mL ± 0,06	73,62 µg/mL ± 0,06
Propolis Methanol Extract	75,76 µg/mL ± 0,08	98,78 µg/mL ± 0,03
Propolis dH_2O Extract	50,34 µg/mL ± 0,04	29,24 µg/mL ± 0,006

The results were evaluated against the quercetin standard and the concentration graph was drawn against the % inhibition values. IC_{50} values were determined. The image of the standard graph of DPPH Quercetin is given in **Figure 2**. DPPH Determination Analysis result table of propolis extracts is given in **Table 2**.

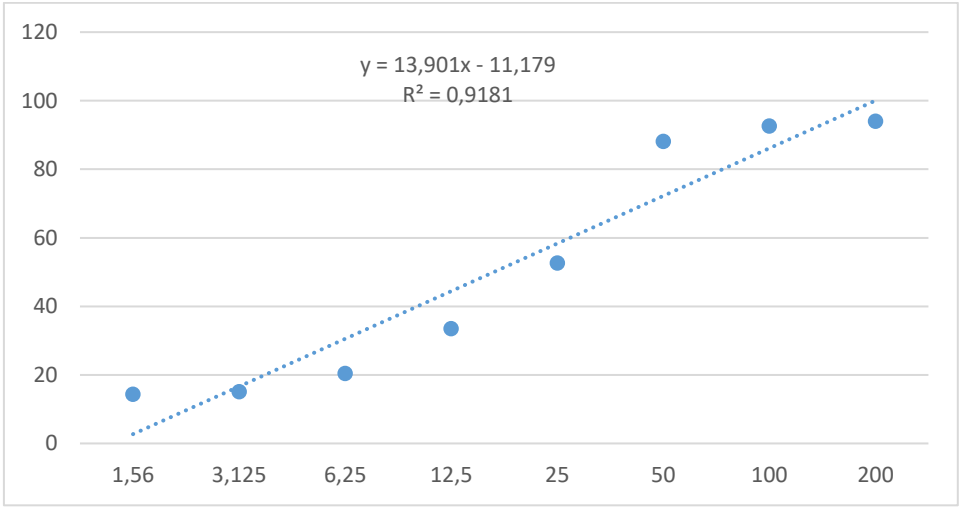

Figure 2. Standard graph of DPPH Quercetin

Table 2. DPPH Determination Analysis results in table of propolis extracts

DPPH Activity (% Inhibition)									
	100µg/mL	**200µg/mL**	**500 µg/mL**	**1000 µg/mL**					**IC_{50} µg/mL**
Propolis Ethanol	91,21 ± 0,003	13,23 ± 0,014	15,19 ± 0,021	6,03 ± 0,012					1,767± 0,07
	100µg/mL	**200µg/mL**	**500 µg/mL**	**1000 µg/mL**					**IC_{50} µg/mL**
Propolis Methanol	82,85 ± 0,16	53,85 ± 0,93	51,61 ± 0,31	6,16 ± 0,05					2,44 ± 0,82
	100µg/mL	**200µg/mL**	**500 µg/mL**	**1000 µg/mL**					**IC_{50} µg/mL**
Propolis dH_2O	69,28 ± 0,10	53,86 ± 0,92	51,61 ± 0,31	6,16 ± 0,05					1,48 ± 0,82
	1,56 µg/mL	**3,125 µg/mL**	**6,25 µg/mL**	**12,5 µg/mL**	**25 µg/mL**	**50 µg/mL**	**100 µg/mL**	**200 µg/mL**	**IC_{50} µg/mL**
Quercetin	14,40 ±0,05	15,10 ± 0,06	20,42 ± 0,09	33,50± 0,002	52,68±0,05	88,16 ± 0,07	92,65 ± 0,01	94,05 ±0,007	4,40 ± 0,03

Using the CUPRAC (Copper II) Ion Reduction Capacity method, the absorbance values of Propolis extracts (ethanol, methanol, and water) were measured at 450 nm. A concentration plot was drawn against absorbance values. The visual of the Gallic Acid standard chart of the CUPRAC Determination is given in Figure 3. The result table of CUPRAC Determination Analysis Propolis extracts was given in Table 3.

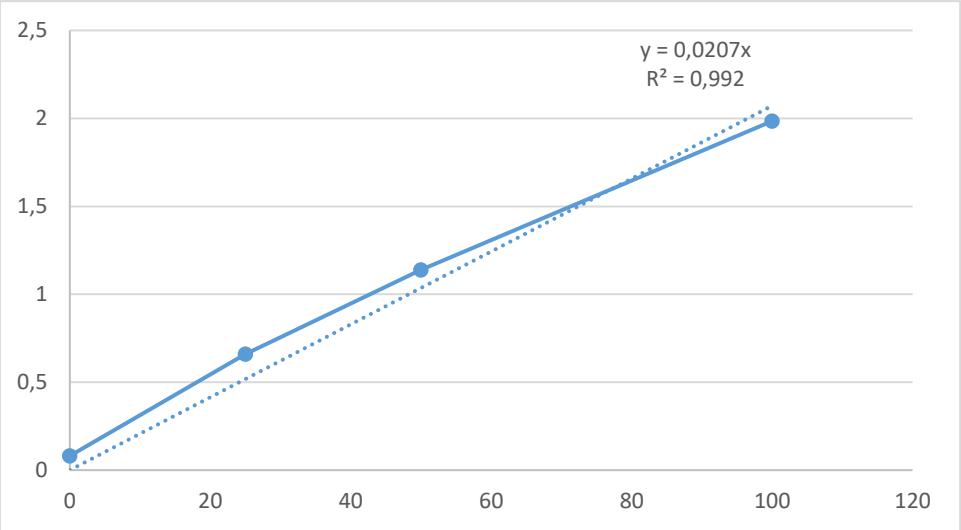

Figure 3. CUPRAC Analysis standard chart

Table 3. CUPRAC Determination Analysis Result table of propolis extracts

CUPRAC Activity (Absorbance)					
	100 µg/mL	**200 µg/mL**	**400 µg/mL**	**800 µg/mL**	**$A_{0,50}$ µg/mL**
Propolis Ethanol	24,50 ± 0,19	17,75 ± 0,04	9,47 ± 0,006	6,41 ± 0,03	1743,68 ± 0,28
	100 µg/mL	**200 µg/mL**	**400 µg/mL**	**800 µg/mL**	**$A_{0,50}$ µg/mL**
Propolis Methanol	29,41 ± 0,05	16,52 ± 0,03	9,47 ± 0,03	7,65 ± 0,06	1451,99 ± 0,28
	100 µg/mL	**200 µg/mL**	**400 µg/mL**	**800 µg/mL**	**$A_{0,50}$ µg/mL**
Propolis dH_2O	21,30 ± 0,18	8,50 ± 0,05	5,55 ± 0,01	3,25 ± 0,01	1945,55 ± 0,28
	0 µg/mL	**25 µg/mL**	**50 µg/mL**	**100 µg/mL**	**$A_{0,50}$ µg/mL**
Gallic acid	0,08 ± 0,01	0,66 ± 0,04	1,14 ± 0,02	1,98 ± 0,08	366,3 ± 0,71

IV. DISCUSSION

Propolis is known to have a strong antioxidant effect thanks to the compounds such as phenolic compounds, flavonoids, and terpenoids found when it contains it. In this study, water, methanol, and ethanol extracts of propolis were compared in terms of total flavonoid substances and total phenolic substances, and the results obtained show that ethanol and methanol extracts of propolis are higher in terms of phenolic and flavonoid substance amounts compared to water extract. In studies conducted in the literature, it has been observed that the phenolic content of ethanol extract is higher [7, 12]. In addition, according to the results of DPPH and CUPRAC, it was observed that the antioxidant effect of propolis ethanol extract was higher than methanol and water extracts.

V. CONCLUSION

Propolis is seen as an assistant natural product in the treatment of many chronic diseases thanks to its bioactive compounds such as flavonoids, polyphenols, phenolic acids, terpenes, and terpenoids. In this study, water, ethanol, and methanol extracts of propolis were prepared. These extracts were compared by performing phenolic substance, flavonoid substance, DPPH, and CUPRAC analyses. As a result of the analysis, it was observed that the antioxidant activity of the extracts of propolis extracted with ethanol was higher. It can be preferred in studies on the antimicrobial, anticancer, and antifungal effects of ethanol extract of propolis.

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Cytotoxic Effects of Pulsed Magnetic Field Exposure on Human Glioblastoma Cell Line Treated with Resveratrol and Themozoloid

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Abstract- Astrocytic tumors such as glioblastoma multiforme (GBM), one of the most common malignant astrocytic primary brain tumors in adults. Pulsed magnetic field therapy is an alternative non-invasive method in the treatment of many different cancers. Temozolomide (TMZ), an oral alkylating agent, is frequently used in the treatment of GBM. Resveratrol (RES) is a naturally occurring polyphenolic compound that has strong antioxidant properties. Studies investigating the cytotoxic effects of RES, and TMZ, together with pulsed magnetic field exposure on glioblastoma cells are limited. Therefore, the main goal of the present study was to examine the possible cytotoxic effects of 75 Hz frequency, 1 mT intensity of pulsed magnetic field exposure on RES- and TMZ-treated U87-MG cells. Cells were examined in 4 experimental groups: Group I: Cells treated with TMZ; Group II: Cells exposed to pulsed magnetic field for short (15 min) and long (6 h) periods after treatment with TMZ; Group III: Cells treated with RES; Group IV: Cells exposed to pulsed magnetic field for short (15 min) and long (6 h) periods after treatment with RES. The cytotoxic effects of RES and TMZ compounds on cells were examined using Alamar Blue reagent. The calculated IC_{50} values were as follows: Group I: 63.27 µg/mL; Group II: 80.55 µg/mL for short- and 31.83 µg/mL for long-term, respectively; Group III: 33.64 µg/mL; Group IV: 28.58 µg/mL for short- and 10.53 µg/mL for long-term, respectively. Obtained data showed that short- and long-term pulsed magnetic field exposure increases the cytotoxic activity of RES by 1.2-fold and 3.2-fold ($p<0.001$), respectively. However, while short-term exposure reduced the cytotoxic activity of TMZ, long-term exposure increased it 1.98-fold ($p<0.001$). In conclusion, pulsed magnetic field exposure increases the effectiveness of flavonoid compounds with known antioxidant properties and has the capacity to increase the potential effects of these compounds in cancer treatment.

Keywords – Glioblastoma, Resveratrol, Themozoloid, Pulsed magnetic field

I. INTRODUCTION

Pulsed magnetic field refers to a category of extremely low-frequency electromagnetic fields (ELF-EMFs) that promote tissue regeneration without causing a rise in the temperature of the affected biological tissue [1]. Pulsed magnetic field applications offer a safe and non-invasive approach to treating injuries, inflammation, and pain. Scientists continue to be intrigued by the underlying mechanisms and interactions between exposure to ELF-EMFs and biological systems. The biological responses are influenced by various factors, such as the type of organisms, tissues, and cells being studied, as well as the intensity, frequency, and duration of exposure to pulsed magnetic fields [2]. ELF-PEMFs can be used as inexpensive and safe options for cancer treatment by triggering apoptosis and inhibiting the growth of tumor cells [3].

Cancer cells proliferate indiscriminately during carcinogenesis as a consequence of mutations in genetic factors that are involved in advanced genetic apoptosis and cell division [4]. This uncontrolled proliferation

leads to the accumulation of cancer cells in tissues, which in turn causes the formation of tumors. Glioblastoma multiforme (GBM) is the most aggressive form of brain cancer that arises from glial cells [5]. Temozolomide (TMZ), an oral alkylating agent, is frequently used in the treatment of GBM [6]. Resveratrol (RES) is a well-known polyphenol found in many plants, including grapes, mulberries, and peanuts, and it can be used as an alkylating agent in the treatment of GBM. RES has been demonstrated to prevent a variety of cancers, including brain cancer, leukemia, lymphoma, and colorectal cancer [8]. In brain cancer, RES affects the cell cycle and exerts proapoptotic activities by crossing the brain barrier via blood [7]. By inducing oxidative stress, RES induces autophagy [8]. It also influences cancer cells through a variety of signaling mechanisms including apoptosis, cell cycle mechanisms, modulation of signal transduction mechanisms [9][10]. RES is becoming a more prominent focus of research in the treatment of a variety of neurological disorders, such as Alzheimer's, Parkinson's, and other neurodegenerative diseases, as well as brain tumors [7][8]. In the literature, studies investigating the cytotoxic effects of RES, and TMZ, together with pulsed magnetic field exposure on glioblastoma cells are limited. Hence, the main objective of the present study was to examine the possible cytotoxic effects of 75 Hz frequency, 1 mT intensity of pulsed magnetic field exposure on RES- and TMZ-treated U87-MG cells.

II. Materials and Method

A. *Pulsed Magnetic Field Exposure*

The pulsed magnetic field equipment was a Pasco UI-5000, manufactured by Pasco Scientific in California, United States (Figure 1). For the purpose of generating a consistent magnetic field environment for cell exposure, the apparatus incorporates Helmholtz coils, which are composed of two pairs of 500-turn coils that are arranged in parallel positioning. These coils were connected to one another and a pulse generator was used to operate them. In order to generate a pulsed signal with a frequency of 75 Hz, a pulse duration of 1.3 milliseconds (duty cycle of 1/10), and an amplitude of 15 V, the software that was included in the package (Pasco Capstone, UI-5400) was utilized. Using a Hall effect-based magnetic field sensor (CI-6520A, Pasco Scientific, CA, USA) with an accuracy of 0.2%, the homogeneity inside the coil system, where cultures were placed, was ensured by measuring a peak field level of 1 ± 0.2 mT between two coils. The apparatus was assembled inside of a cell incubator, and the temperature of the surrounding environment was kept at 37 °C in order to reduce the impact of the temperature on the cells.

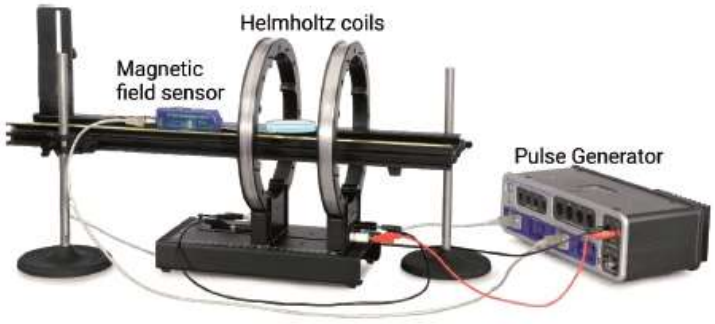

Figure 1 PEMF exposure set-up [2].

B. *Cell Culture*

Human glioblastoma U87-MG cell line and human astroglial healthy SVGp12 cell line were obtained from the American Type Culture Collection (ATCC, Missouri, USA) and stored at -80°C until use. Before the experiment, cell lines were cultured and supplemented with 12 ml of nutrient medium (10% EMEM (U87-MG)-10% DMEM (SVG-p12), 10% fetal bovine serum, 1% L-Glutamine, 1% penicillin-streptomycin). The cultures were incubated in a T75 flask in a sterile incubator containing 5% CO_2 at 37°C and 95% humidity. Cells were divided into the following experimental groups after being transferred to 96-well plates: Group I: Cells treated with TMZ; Group II: Cells exposed to pulsed magnetic field for short

(15 min) and long (6 h) periods after treatment with TMZ; Group III: Cells treated with RES; Group IV: Cells exposed to pulsed magnetic field for short (15 min) and long (6 h) periods after treatment with RES.

C. Cytotoxicity Assay

Cells cultured in T-75 flasks were removed using a used medium glass pasteur pipette. In order to eliminate contaminants and non-living cells from the surroundings, a solution of 10 mM phosphate-buffered saline (PBS) was used to wash the area. The unwanted substances were then extracted from the environment using a glass pasteur pipette. In order remove the cells, Trypsin-EDTA was introduced into the medium and allowed to incubate for a duration of 5 min in a 37°C incubator with 5% CO_2. Cell counting was performed using the Trypan Blue method, and 96 well plates were seeded with 104 cells per well. Cells that achieved a suitable cell density after around 24 hours of culture were exposed to TMZ and RES at concentrations varying from 0 to 200µg/ml. The cells were then exposed to PEMF for durations of 15 min and 6 hours for short- and long-periods, respectively. Cell viability was measured utilizing the Alamar Blue Cell Proliferation Assay. Colorimetric changes were detected. Cell viability percentages (%) were used to present the results.

III. RESULTS

The cytotoxic effects of pulsed magnetic field exposure on both human glioblastoma U87MG cell line and human astroglial healthy SVGp12 cell line treated with RES and TMZ have been investigated throughout the study. The concentration ranges at which cell viability of the human glioblastoma U87-MG cell line not exposed to PEMF decreased by 50% when treated with RES and TMZ are between 20-50 µg/mL and 50-100 µg/mL, respectively. According to IC50 values obtained from a short-term (15-min) exposure to PEMF after RES and TMZ treatment in the human glioblastoma U87-MG cell line, it was observed that cell viability reduced at concentrations of 20-50 µg/mL for RES and 50-100 µg/mL for TMZ. These values were between 10-20 µg/mL for RES and 20-50 µg/mL for TMZ in the U87-MG human glioblastoma cell line that exposed to long-term (6 h) PEMF. The concentration ranges at which cell viability of the human astroglial healthy SVGp12 cell line not exposed to PEMF decreased by 50% when treated with RES and TMZ are between 50-100 µg/mL and 10-20 µg/mL, respectively. According to IC50 values obtained from a 15-min exposure to PEMF after RES and TMZ treatment in the human astroglial healthy SVG-P12 cell line, it was observed that cell viability reduced at concentrations of 150-200 µg/mL for RES and 50-100 µg/mL for TMZ. These values were between 100-150 µg/mL for RES and 50-100 µg/mL for TMZ in the SVGp12 human astroglial healthy cell line that exposed to long-term (6 h) PEMF.

IC_{50} values were calculated in human glioblastoma U87MG and human astroglial SVGp12 cell lines treated with RES and TMZ but not exposed to PEMF, and exposed to PEMF for short- and long-term periods (Table 1). Accordingly, the IC_{50} values of RES and TMZ treatment in the human glioblastoma U87-MG cell line without PEMF exposure were calculated as 33.64 µg/mL and 63.27 µg/mL, respectively, while in the group with short-term (15 min) PEMF exposure, the IC_{50} values were 28.58 µg/mL and 80.55 µg/mL, respectively and in the group with long-term (6 h) PEMF exposure, these values were obtained as 10.53 µg/mL and 31.83 µg/mL, respectively. In the human astroglial SVG-P12 cell line without PEMF exposure, IC_{50} values of RES and TMZ treatment were calculated as 17.95 µg/mL and 97.70 µg/mL, respectively, while in the group with short-term (15 min) PEMF exposure, IC_{50} values were 150.4 µg/mL and 70.5 µg/mL, respectively. In the group with long-term (6 h) PEMF exposure, these values were obtained as 118.2 µg/mL and 55.13 µg/mL, respectively.

Table 1. IC_{50} (µg/mL) values of RES and TMZ treated human glioblastoma U87-MG and human astroglial SVG-P12 cell lines without PEMF exposure, and with short-term (15 min), and long-term (6 h) PEMF exposure

IC_{50} (µg/mL)	**Without PEMF Exposure**		**15 min PEMF Exposure**		**6 h PEMF Exposure**	
	U87-MG	**SVGp12**	**U87-MG**	**SVGp12**	**U87-MG**	**SVGp12**
RES	33.64 µg/mL	97.70 µg/mL	32.43 µg/mL	119.0 µg/mL	10.53 µg/mL	98.31 µg/mL
TMZ	63.27 µg/mL	17.95 µg/mL	64.21 µg/mL	70.15 µg/mL	31.83 µg/mL	47.90 µg/mL

IV. DISCUSSION

Resveratrol (RES) is a naturally occurring polyphenolic compound found in grapes that has strong antioxidant properties and is used in the treatment of various types of cancer such as colorectal and skin cancers [10]. According to the cytotoxicity results obtained from our study, it was determined that cell viability in the U87-MG cell line treated with RES and TMZ without PEMF exposure decreased more in the RES-treated group compared to the TMZ-treated group. A significant decrease in cell viability and a greater cytotoxic effect were found in the human glioblastoma U87-MG cell line when exposed to pulsed magnetic field for long periods (6 h) after treatment with TMZ and RES, compared to the group treated with TMZ and RES alone without exposure to PEMF. But this reduction was most prominent in the human glioblastoma U87-MG cell line that exposed to pulsed magnetic field for long periods (6 h) after treatment with RES. Overall data showed that short- and long-term pulsed magnetic field exposure increases the cytotoxic activity of RES by 1.2-fold and 3.2-fold ($p<0.001$), respectively. However, while short-term exposure reduced the cytotoxic activity of TMZ, long-term exposure increased it 1.98-fold ($p<0.001$). Our observations are consistent with previous research that has shown a decline in the effect of PEMF exposure on the survival of cancer cells in several cell lines [14][15]. For instance, a study performed by Kaszuba-Zwoińska Jolanta in 2018 found that subjecting H4 glioma cells to a 4-hour exposure of 7Hz, 30 mT low-frequency pulsed electromagnetic fields resulted in a decrease in cell viability and triggered apoptosis [16]. In addition, the application of PEMF to brain cancer cell lines, either alone or in combination with chemotherapeutic drugs, reduces cell viability and induces apoptosis by suppressing cancer cell proliferation [14]. Akbarnejad et al. (2017) examined the effects of various frequencies (10 Hz, 50 Hz, 100 Hz) and amplitudes (10 G, 100 G) of ELF-PEMFs on the structure of cells, their ability to survive, and the levels of proteins related to programmed cell death (Caspase-3) and cell division (Cyclin-D1 and TP53) in glioblastoma cells (U87). The findings demonstrated that ELF-PEMFs had the ability to either stimulate cell growth or trigger cell death, based upon the magnitude, frequency, and length of exposure. When cells were subjected to 50 Hz and 100 G ELF-PEMFs for a duration of 24 hours, there was a significant decrease in cell viability, together with increased levels of Cyclin-D1, caspase-3, and TP53 proteins.

V. CONCLUSION

In the literature, studies investigating the cytotoxic effects of RES, and TMZ, together with pulsed magnetic field exposure on glioblastoma cells are limited. Hence, we contend that the findings of our investigation will shed light on the literature. Ultimately, the exposure to pulsed magnetic fields enhances the efficacy of flavonoid compounds that are already recognized for their antioxidant qualities. Furthermore, it has the ability to amplify the potential impact of these compounds in the treatment of cancer.

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Farklı Sıra Arası Mesafelerin Bazı Aspir (*Carthamus tinctorius* L.) Çeşitlerinde Verim ve Verim Unsurları Üzerine Etkisi*

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Özet – Aspir (*Carthamus tinctorius* L.), Compositeae familyasından tek yıllık ve otsu yapıda değerli bir yağ bitkisidir. Bazı aspir çeşitlerinde farklı sıra arası uygulamalarının verim ve verim unsurlarına etkisini belirlemek amacıyla yürütülen bu araştırma; 2020 yılı aspir vejetasyon döneminde, Ankara kuru koşullarında gerçekleştirilmiştir. Çalışma, "Tesadüf Bloklarında Bölünmüş Parseller" deneme desenine göre üç tekerrürlü olarak kurulmuştur. Materyal olarak, sekiz aspir çeşidi (Hasankendi, Koç, Safir, Dinçer, Zirkon, Göktürk, Linas, Balcı) kullanılan çalışmada üç farklı sıra arası mesafe (15, 30, 45 cm) ele alınmıştır. Sıra araları ana parsellere, çeşitler alt parsellere tesadüfi olarak dağıtılmışlardır. Çalışmada; bitki boyu (cm), sap çapı (mm), ilk dal yüksekliği (cm), bitki başına dal sayısı (adet), bitki başına tabla sayısı (adet), tabla çapı (mm), tablada tohum sayısı (adet), bin tohum ağırlığı (g) ve tohum verimi (kg/da) gibi verim ve verim unsurları ele alınmıştır.

Araştırmada; bitki boyu 51.5-75.8 cm (Balcıx15cm-Linasx45cm), sap çapı 6.0-11.1 mm (Zirkonx15cm-Hasankendix15cm), ilk dal yüksekliği 24.5-38.0 cm (Göktürkx15cm-Dinçerx45cm), bitki başına dal sayısı 5.3-8.7 adet (Dinçerx45cm-Balcıx45cm), bitki başına tabla sayısı 12.5-23.1 adet (Dinçerx15cm-Göktürkx45cm), tabla çapı 22.5-27.5 mm (Balcıx15cm-Dinçerx45cm), tablada tohum sayısı 13.4-24.9 adet (Balcıx15cm-Zirkonx45cm), bin tohum ağırlığı 31.2-47.3 g (Koçx15cm- Dinçerx45cm) ve tohum verimi 88.5-188.7 kg/da (Balcıx45cm-Dinçerx15cm) arasında değişmiştir.

Araştırma sonucunda aspir çeşitleri arasında Ankara kuru koşullarında en yüksek tohum verimine sahip çeşit Dinçer (165 kg/da) olmuş, bu çeşidi Koç (155.6 kg/da) ve Safir (141.9 kg/da) takip etmiştir. Sıra arası mesafelerin tohum verimine etkisinin önemli bulunduğu araştırmada, en uygun sıra arası mesafe 146.2 kg/da tohum verimi ile 15 cm olurken 30 cm sıra arası mesafeden elde edilen değer (144.3 kg/da) ile aralarındaki fark önemli bulunmamış ve aspir tarımı için her iki sıra arasının da uygun olacağı sonucuna ulaşılmıştır.

Anahtar Kelimeler: Aspir, bin tohum ağırlığı, Carthamus tinctorius L.*, çeşit, sıra arası, verim, verim unsurları*

I. GİRİŞ

İnsan beslenmesinde önemli bir yer işgal eden bitkisel yağların tüketiminin giderek artması bu yağların üretimine hammadde sağlayan yağ bitkilerinin önemini ortaya çıkarmaktadır. Yağlı tohumlu bitkiler tohumlarında içerdikleri yağ ile bitkisel yağ sanayine, yağ alındıktan sonra kalan küspeleri ile yem sanayine hammadde sağlamaktadırlar. Ayrıca son yıllarda fosil yakıtların çevreye olan olumsuz etkileri ve sınırlı kaynak olmaları yenilenebilir enerji kaynaklarının kullanımını gündeme getirmiştir. Bu kaynaklardan biri olan olan yağlı tohumlu bitkilerin, gıda sektörü dışında biyodizel ve endüstriyel alanlarda kullanımı bitkisel yağlara talebi tüm dünyada artırmıştır [1].

Ülkemiz farklı yağ bitkilerinin yetişmesine uygun ekolojiye sahip olmasına rağmen, uzun yıllardan beri bitkisel yağ açığımız giderek artmakta ve bu açık ithalat yolu ile karşılanmaktadır. Türkiye'nin bu açığı kapatması ve dışa bağımlılığını azaltması mevcut yağ bitkilerinin ekim alanlarının ve birim alandan alınan verimin artırılması ve alternatif yağ bitkilerinin devreye sokulması ile mümkün olabilecektir. Ülkemizde bitkisel yağ üretiminde en büyük pay ayçiçeğine ait olup, üretiminin yarısından fazlasını karşılamaktadır. Ayçiçeği yanında alternatif yağ bitkileri arasında ülkemizde önemli bir potansiyel olarak görülen bitkilerden birisi de aspirdir.

Aspir (*Carthamus tinctorius* L.) Compositeae familyasından tek yıllık ve otsu yapıda değerli bir yağ bitkisidir. Yağ bitkisi olarak sınıflandırılmasına rağmen kullanımı sadece bitkisel yağ üretimi ile sınırlı kalmayan aspir, geleneksel ve modern tıpta kendine yer bulan, ilaç yapımından, boya sanayisine, kozmetik ürün geliştirilmesinden, çeşitli gıda imalatına, ruminant ve kanatlı hayvan beslenmesinden biyodizel üretimine kadar farklı sektörlerde kullanılmakta olan önemli bir endüstri bitkisidir. Aspir bitkisinin gen merkezinin Anadolu olması özellikle kurağa, kıraç alanlara ve farklı ekolojilere yüksek adaptasyon göstermesi, nadas alanlarının tarıma kazandırılması için kullanılabilecek bitkilerden olması, yetiştiriciliğinin ülkemizdeki bitkisel üretimde ağırlıklı payı olan ve çiftçinin alışkın olduğu tahıl üretimiyle benzer olması, tahıl mekanizasyonuna uyum sağlaması, yazlık ve uygun ekolojilerde kışlık ekiminin yapılabilmesi, yeni çeşitler geliştirilmesine açık bir bitki olması avantajları son dönemde aspir bitkisini ülkemizdeki yağ açığının kapatılabilmesi için ayçiçeği ve kolzaya önemli bir alternatif yapmıştır [2].

Yetiştirilen ürünlerin verimliliği; ekilen çeşidin genetik potansiyeli, çevre koşulları ve uygulanan kültürel işlemlere bağlıdır. Çevre koşullarını kontrol etmek mümkün olmamakla birlikte, çeşit ve kültürel işlemleri kontrol etmek mümkündür. Bitki verimi ile verim unsurları arasındaki ilişkileri etkileyen en önemli kültürel uygulamaların başında bitki sıklığı, ekim zamanı, sulama, gübreleme, hastalık ve zararlılarla mücadele gelmektedir. Birim alandaki bitki sayısı, tarla bitkilerinde verim ve verim unsurlarını etkileyen en önemli yetiştirme faktörlerinden birisidir. Tarla tarımında genel kural olarak, birim alanda optimum bitki sıklığı ile bitki gelişimine en uygun ortam ve yeterli alanın sağlanmasına özen gösterilmelidir. Birim alandaki optimum bitki sayısı; çeşit, ekim zamanı, rakım, yağış ve toprak verimliliği gibi faktörlere göre değişir. Kısa boylu, vejetatif aksamı küçük, dal ve yaprak sayısı az ve bitki gelişmesi hızlı olduğu için verim seviyeleri nispeten daha düşük olan erkenci çeşitlerin daha yüksek bitki sıklıklarında yetiştirilmesi önerilmektedir [3].

Bu araştırma, Ankara ilinde farklı çeşit ve sıra arası mesafelerin aspir bitkisinde verim ve verim unsurları üzerine etkilerinin incelenmesi, tohum verimi açısından en uygun çeşit ve sıra arası mesafenin belirlemesi amacıyla yürütülmüştür.

II.MATERYAL VE YÖNTEM

Ankara İli Haymana İlçesi Tarla Bitkileri Merkez Araştırma Enstitüsü'nün İkizce Araştırma ve Uygulama Çiftliği deneme alanında 2020 yılı aspir vejetasyon döneminde (Nisan-Eylül), kurak şartlarda yürütülen bu araştırmada, deneme alanında ekim öncesi 0-20 cm ve 0-40 cm derinliklerden toprak örnekleri alınmış ve analizleri yapılmıştır. Analiz sonuçlarına göre, deneme toprağı killi tınlı bir tekstüre sahiptir. Organik madde bakımından zayıf olup, tuzsuz bir yapıdadır. Kireç bakımından fazla kireçli olmakla birlikte, hafif alkalin bir reaksiyon göstermektedir. Organik madde içeriği düşük olan deneme toprağı, elverişli fosfor bakımından yüksek, elverişli potasyum bakımından ise orta seviyede bulunmuştur. Deneme yerine ait iklim verilerine göre; aspir vejetasyon periyodunda (Nisan-Eylül) düşen toplam yağış miktarı uzun yıllar (1966-2019) için 146.2 mm iken 2020 yılında %13.6 artış ile 166.1 mm olarak gerçekleşmiştir. 2020 yılı sıcaklık ortalamaları ile (17.6 ^{0}C) uzun yıllar ortalamaları (17.5 ^{0}C) arasında önemli bir farklılık görülmez iken, nispi nem oranı araştırma yılında (%48.7) uzun yıllar ortalamasının (%54.3) %11.5'i kadar altında kalmıştır.

Tesadüf bloklarında bölünmüş parseller deneme desenine göre üç tekerrürlü olarak kurulan araştırmada, 8 aspir çeşidi (Dinçer, Balcı, Linas, Zirkon, Koç, Safir, Göktürk ve Hasankendi) ile 3 farklı sıra arası mesafe (15, 30, 45 cm) ele alınmış, sıra araları ana parselleri, çeşitler alt parselleri oluşturmuştur. Alt parsellerden her biri 3 m uzunluğunda, 6 sıradan ibaret olmuştur. Deneme alanı sonbaharda bir defa kulaklı pulluk ile ilkbaharda ise soklu pulluk ile sürülmüş ve ekime uygun hale getirilmiştir.

Ekim, 17.04.2020 tarihinde araştırmada ele alınan sıra aralıklarına göre markör ile 3-4 cm derinliğinde açılan sıralara el ile yapılmıştır. Ekimi takiben yağış gelmemesi sebebiyle çıkışı sağlamak amacıyla bir defaya mahsus sulama yapılmıştır. Sıra üzeri mesafe bitkilerin 15-20 cm boy aldıkları dönemde yapılan birinci çapa ile birlikte yaklaşık 10 cm olarak ayarlanmıştır. Alt parsellere 8 kg/da saf fosfor (P_2O_5) ve 6 kg/da azot (N) olacak şekilde tamamı ekimle birlikte DAP (Diamonyum Fosfat) ve Amonyum Nitrat (%33 N) formunda gübre uygulanmıştır. Hasat, 15.09.2020 tarihinde parsel kenarlarından birer sıra, başlarından 0.5 m kenar tesiri çıkarıldıktan sonra geriye kalan alandaki bitkilerde, taç yaprakların tamamen kuruduğu, danelerin beyazlaştığı ve yaprakların kahverengiye döndüğü dönemde parsel biçerdöveriyle yapılmıştır. Denemede ölçüm ve sayımlar her alt parselde kenar tesiri dışında kalan alandan tesadüfi seçilen 10 bitki üzerinde gerçekleştirilmiştir. Çalışmada; bitki boyu (cm), sap çapı (mm), ilk dal yüksekliği (cm), bitki başına dal sayısı (adet), bitki başına tabla sayısı (adet), tabla çapı (mm), tablada tohum sayısı (adet), bin tohum ağırlığı (g) ve tohum verimi (kg/da) ele alınmıştır. Araştırma sonucu elde edilen değerler ‘’MSTAT-C’’ istatistik programında varyans analizine tabi tutulmuş, ‘’F’’ testi yapılmak suretiyle farklılıkları tespit edilen işlemlerin ortalama değerleri ‘’Duncan’’ önem testine göre gruplandırılmıştır.

III. BULGULAR VE TARTIŞMA

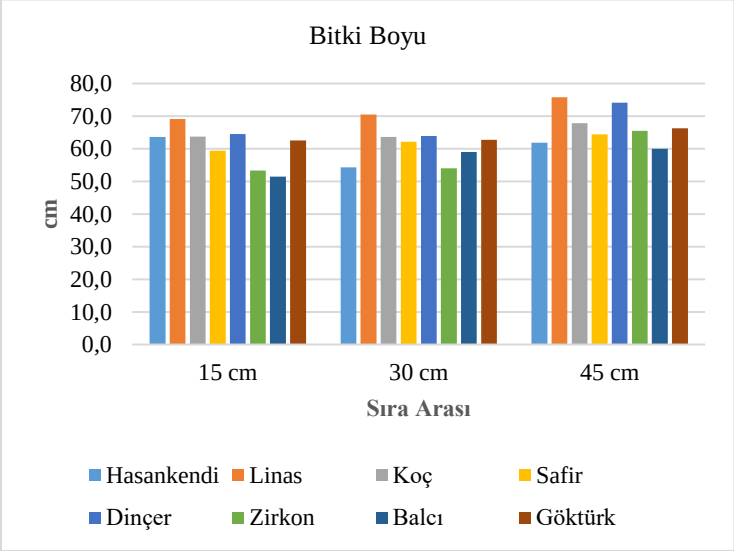
Araştırmada, ele alınan özelliklere ait ortalama değerler ve bu değerlere ait elde edilen sonuçlar aşağıda ayrı ayrı başlıklar halinde verilmiştir.

A.Bitki Boyu (cm)

Aspir çeşitlerinde farklı sıra arası mesafelerde bitki boyuna ait varyans analiz sonuçları Tablo 3.1, ortalama değerler ve ‘’Duncan’’ testi grupları Tablo 3.2’de verilmiştir. Bitki boyu bakımından, çeşitler arasındaki farklılıklar istatistiki olarak önemli, sıra arası ve sıra arası x çeşit interaksiyonu önemsiz bulunmuştur. Sıra arası mesafelerin bitki boyu üzerindeki etkisi önemsiz olmasına rağmen 15 cm’de en düşük (60.9 cm), 45 cm’de en yüksek bitki boyu (67.0 cm) elde edilmiştir. Çeşitler arasındaki bitki boyu farklılıklarının önemli bulunduğu araştırmada 71.8 cm ile Linas çeşidi ilk grubu (a) oluştururken, 56.9 cm ile Balcı son grubu (f) meydana getirmiştir (Tablo 3.2). Her ne kadar istatistiki anlamda önemsiz bulunsa da sıra arası x çeşit interaksiyonu incelendiğinde görülebileceği gibi, bitki boyu en uzun (75.8 cm) 45 cm sıra arasında ekilen Linas, en kısa (51.5 cm) 15 cm sıra arasında ekilen Balcı çeşidinde ölçülmüştür (Şekil 3.1).

Bu çalışma sonucuna benzer şekilde, Erzurum koşullarında Polat [17] tarafından yapılan çalışmada; 15, 30, 45 ve 60 cm’lik ekim mesafelerinde çeşitlerin ortalama bitki boyları sırasıyla, 68.22, 69.21, 70.30 ve 71.74 cm olarak belirlenmiş, sıra arası mesafe arttıkça bitki boyunun artış gösterdiği tespit edilmiştir.

Atam [4] aspir çeşitlerinde bitki boyunun 92.31-101.83 cm, Eslam ve ark. [5] 53.4-76.7 cm, Kılıç [6] kuru koşullarda iki yıl için 45.4-84.8 cm, Birben [7] 64.3-111.7 cm, Özaşık [8] 59.0-70.5 cm, Sefaoğlu [9] 64.87-69.63 cm, Gürsoy ve ark. [10] 101.8-126.1 cm, Kayan [11] 164.67-183.00 cm, Arslan ve Culpan [12] 58.93-77.70 cm ve Öner ve Şeker [13] 82.37-107.60 cm arasında değiştiğini bildirmişlerdir.



Şekil 3.1 Bitki boyuna ait sıra arası x çeşit interaksiyonu

Bu araştırma sonucu bulunan 51.5-75.8 cm bitki boyu değerleri bu konuda yapılan araştırmaların büyük bir kısmından düşük olmakla birlikte, çeşitlerin genetik yapılarının farklı olması, çevre koşullarının da etkisi ile uygulamaların bitki boyuna

Tablo 3.1 Farklı sıra arası mesafelerde aspir çeşitlerinde ele alınan özelliklere ait' "F'' değerleri

F Değerleri										
V.K.	**S.D.**	**Bitki Boyu**	**Sap Çapı**	**İlk Dal Yüksekliği**	**Bitki Başına Dal Sayısı**	**Bitki Başına Tabla Sayısı**	**Tabla Çapı**	**Tablada Tohum Sayısı**	**Bin Tohum Ağırlığı**	**Tohum Verimi**
Blok	2	1.4090	4.4093	8.5989	2.7909	6.3083	1.0445	1.4073	8.5288	0.0453
Sıra Arası	2	1.4489	10.0066*	9.1828*	0.3360	4.5579	0.3965	15.1946*	2.3192	69.2935**
Hata$_1$	4									
Çeşit	7	9.5407**	6.1677**	4.0135**	2.6497*	3.6253**	3.5565**	0.9105	4.5205**	14.1564**
Sıra arası X Çeşit	14	1.1088	1.0018	0.7015	1.2277	1.8991	0.8769	0.7977	0.8772	0.6246
Hata$_2$	42									
Ortalama	71									
CV %		7.79	10.20	13.90	17.44	17.13	6.30	18.59	10.51	12.86

* %5; ** %1 düzeyinde önemli

Tablo 3.2 Farklı sıra arası mesafelerde aspir çeşitlerinde ele alınan özelliklere ait ortalama değerler ve "Duncan'' testi grupları

	Sıra Arası (cm)			
Çeşitler	**15**	**30**	**45**	**Ortalama**
		Bitki Boyu (cm)		
Hasankendi	63.6	54.3	61.9	59.9def**
Linas	69.1	70.5	75.8	71.8a
Koç	63.7	63.6	67.8	65.0bc
Safir	59.4	62.2	64.4	62.0cde
Dinçer	64.5	63.9	74.1	67.5ab
Zirkon	53.3	54.0	65.5	57.6ef
Balcı	51.5	59.0	60.1	56.9f
Göktürk	62.5	62.7	66.3	63.8bcd
Ortalama	60.9	61.3	67.0	63.1
		Sap Çapı (mm)		
Hasankendi	8.0	9.3	11.1	9.5a**
Linas	8.6	8.9	10.1	9.2ab
Koç	7.8	8.1	9.9	8.6ab
Safir	7.4	8.7	9.3	8.5ab
Dinçer	9.1	9.1	9.8	9.3ab

Zirkon	6.0	7.1	8.4	7.2c
Balcı	7.9	8.6	8.5	8.3b
Göktürk	8.1	8.7	8.9	8.6ab
Ortalama	7.9b*	8.5b	9.5a	8.6
		İlk Dal Yüksekliği (cm)		
Hasankendi	25.3	28.9	26.9	27.0d**
Linas	31.6	35.6	35.9	34.4a
Koç	32.1	32.6	34.5	33.0ab
Safir	25.5	26.6	34.6	28.9bcd
Dinçer	32.3	32.6	38.0	34.3a
Zirkon	29.1	31.1	35.9	32.1abc
Balcı	25.6	26.9	35.7	29.4bcd
Göktürk	24.5	27.0	33.1	28.2cd
Ortalama	28.3b*	30.2b	34.3a	30.9
		Bitki Başına Dal Sayısı (adet)		
Hasankendi	7.9	6.5	8.1	7.5ab*
Linas	7.0	6.8	8.1	7.3ab
Koç	7.5	7.5	6.3	7.1ab
Safir	6.5	6.7	6.1	6.4bc
Dinçer	6.0	5.9	5.3	5.8c
Zirkon	5.8	7.0	6.7	6.5abc
Balcı	6.5	8.1	8.7	7.8a
Göktürk	6.8	6.2	7.9	7.0abc
Ortalama	6.7	6.8	7.1	6.9

Tablo 3.2-Devam

		Sıra Arası		
Çeşitler	**15**	**30**	**45**	**Ortalama**
		Tablada Tohum Sayısı (adet)		
Hasankendi	19.1	14.3	22.4	18.6a**
Linas	14.9	14.8	17.3	15.7ab
Koç	17.2	18.5	17.9	17.9a
Safir	14.5	15.7	14.5	14.9ab
Dinçer	12.5	13.8	14.5	13.6b
Zirkon	12.7	16.9	22.2	17.3ab
Balcı	14.1	18.2	20.9	17.8a
Göktürk	15.5	16.5	23.1	18.4a
Ortalama	15.1	16.1	19.1	16.8
		Tabla Çapı (mm)		
Hasankendi	26.6	25.3	25.1	25.7a**
Linas	24.1	24.7	24.5	24.4ab
Koç	24.0	24.7	24.5	24.4ab
Safir	24.5	26.7	25.2	25.5ab
Dinçer	26.5	25.1	27.5	26.4a
Zirkon	24.9	25.9	26.7	25.8a
Balcı	22.5	23.9	23.5	23.3b
Göktürk	24.3	25.6	23.9	24.6ab
Ortalama	24.7	25.6	25.1	25.0
		Tablada Tohum Sayısı (adet)		
Hasankendi	14.4	15.2	19.3	16.3
Linas	14.7	17.2	23.6	18.5
Koç	15.4	22.2	19.3	18.9
Safir	14.1	16.9	19.6	16.9
Dinçer	15.7	18.4	21.6	18.6
Zirkon	14.9	18.4	24.9	19.4
Balcı	13.4	19.2	19.4	17.3
Göktürk	15.1	18.6	20.1	17.9
Ortalama	14.7b*	18.3a	20.1a	18.0
		Bin Tohum Ağırlığı (g)		
Hasankendi	43.2	36.9	38.4	39.5ab**
Linas	38.5	39.5	41.3	39.8ab
Koç	31.2	35.3	36.0	34.2b

Safir	36.5	39.2	37.5	37.8b
Dinçer	42.7	42.0	47.3	44.0a
Zirkon	36.9	36.3	39.4	37.5b
Balcı	38.9	35.1	35.1	36.3b
Göktürk	37.8	38.5	39.7	38.6ab
Ortalama	38.2	37.9	39.3	38.5
		Tohum Verimi (kg/da)		
Hasankendi	144.8	153.9	102.7	133.8 bcd**
Linas	119.4	104.7	89.4	104.5 e
Koç	168.7	170.8	127.4	155.6 ab
Safir	156.8	161.8	107.2	141.9 bc
Dinçer	188.7	176.5	129.7	165.0 a
Zirkon	130.7	121.5	92.7	115.0 de
Balcı	127.9	123.6	88.5	113.3 de
Göktürk	132.8	141.3	105.9	126.7 cde
Ortalama	146.2 a**	144.3 a	105.4 b	132.0

** Aynı harflerle gösterilen ortalamalar arasındaki farklılıklar %1;* %5 seviyesine göre önemli değildir.

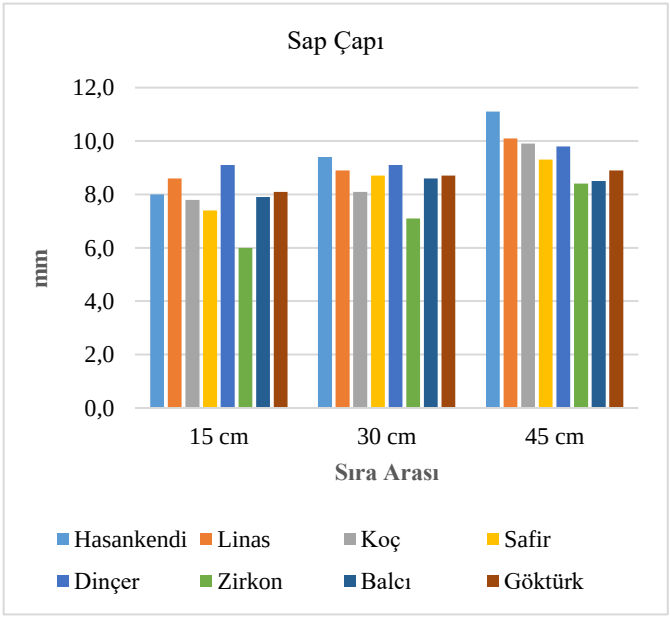
etkilerinin farklı olabileceği araştırıcılar tarafından ifade edilmektedir (Öztürk ve ark., 2009) [14]. Bu nedenle; çeşit farkı, iklim ve toprak koşulları ile sıra arası ve sıra üzeri mesafelerin farklılığından dolayı bitki boyu değerlerinin çalışmalarda farklı olduğu düşünülmektedir.

B. Sap Çapı (mm)

Sap çapı bakımından sıra arası farklılıklar ile çeşitler arasındaki farklılıklar istatistiki anlamda önemli bulunurken, sıra arası x çeşit interaksiyonu önemsiz olmuştur (Tablo 3.1). Tablo 3.2 incelendiğinde görülebileceği gibi, sıra arası mesafe arttıkça sap kalınlığının arttığı tespit edilmiştir. Duncan testine göre 45 cm sıra arası 9.5 mm ile ilk grupta (a) yer alırken, 30 cm ve 15 cm sıra araları sırasıyla, 8.5 mm ve 7.9 mm ile II. grubu (b) oluşturmuşlardır.

Araştırmada sap çapı bakımından çeşit ortalamaları incelendiğinde, en yüksek değer 9.5 mm ile Hasankendi çeşidinde belirlenmiş ve ilk grubu (a) oluşturmuştur. Zirkon çeşidi ise 7.2 mm ile son grupta (c) yer almıştır (Tablo 3.2).

Şekil 3.2'de sap çapına ait sıra arası x çeşit interaksiyonu incelendiğinde, genelde sıra arası mesafe arttıkça çeşitlerin sap çapının arttığı görülmektedir. Sap kalınlığı en düşük 6.0 mm ile 15 cm sıra arasında ekilen Zirkon, en yüksek ise 11.1 mm ile 45 cm sıra arasında ekilen Hasankendi çeşidinde tespit edilmiştir.

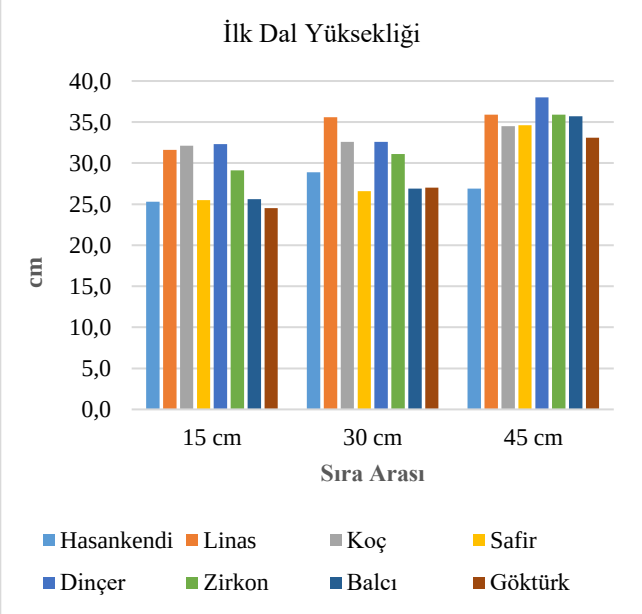


Şekil 3.2 Sap çapına ait sıra arası x çeşit interaksiyonu

Arslan [15] sap kalınlığının birim alandaki bitki sayısına göre değiştiğini ifade etmiştir. Yaptığımız bu çalışmada sıra arası mesafenin artması ile genel olarak sap çapının arttığı belirlenmiştir (Tablo 3.2). Nitekim Sefaoğlu [9] tarafından aspirde ekim normu üzerine yapılan araştırmada da, bu araştırma sonucu ile uyumlu olarak ekim normundaki artışa bağlı olarak sap çapının azaldığı bildirilmiştir. Sap çapının kalın olması bitkide yatma oranını azaltmakla birlikte, çok kalın olması hasadı güçleştirmesi sebebiyle arzu edilmemektedir. Aspirde sap çapını Kıllı ve Küçükler [16] 7.40-10.57 mm, Polat [17] 5.6-6.5 mm, Keleş [18] 4.00-7.88 mm, Yurteri [19] 5.69-6.84 mm, Sefaoğlu [9] Dinçer çeşidinde 0.47 cm, Yenice çeşidinde 0.52 cm ve Özaydın [20] 4.65-5.48 mm olarak bildirmişlerdir. Araştırma sonuçları arasında sap çapı bakımından görülen farklılıkların, lokasyon, çeşit, ekolojik ve kültürel faktörlerin farklılıklarından kaynaklanmış olabileceği söylenebilir.

C. İlk Dal Yüksekliği (cm)

İlk dal yüksekliği bakımından, sıra arası ve çeşit farklılıkları önemli bulunurken, sıra arası x çeşit interaksiyonu önemsiz olmuştur (Tablo 3.1). Sıra arası mesafe arttıkça ilk dal yüksekliğinin arttığı çalışmada, en uzun 34.3 cm ile 45 cm, en kısa 28.3 cm ile 15 cm sıra arasında tespit edilmiştir. Duncan testi sonucuna göre; ilk grubu (a) 45 cm sıra arası oluştururken, 15 cm ve 30 cm sıra arası mesafelerden elde edilen değerler arasındaki farklılıklar istatistiki olarak önemsiz bulunmuş ve aynı grupta (b) yer almışlardır. Araştırmada ilk dal yüksekliği bakımından çeşit ortalamalarına bakıldığında 34.4 cm ile Linas ve 34.3 cm ile Dinçer çeşitleri ilk grubu (a) oluştururken, 27.0 cm ile Hasankendi çeşidi son grubu (d) meydana getirmiştir ((Tablo 3.2).
Her ne kadar istatistiki anlamda önemsiz olsa da ilk dal yüksekliğine ait çeşit x sıra arası interaksiyonu incelendiğinde, en uzun 38.0 cm ile 45 cm sıra arasında ekilen Dinçer, en kısa 24.5 cm ile 15 cm sıra arasında ekilen Göktürk çeşidinde tespit edilmiştir (Şekil 3.3).
Çamaş ve ark. [21], ilk dal yüksekliğinin makineli hasat açısından oldukça önemli olduğunu bildirmişlerdir. Aydın [22] tarafından Ankara koşullarında farklı sıra arası ve sıra üzeri mesafelerde yapılan çalışmada, ilk dal yüksekliğinin sıra arası arttıkça belli bir noktaya kadar artış gösterdiği ve 33.85-40.95 cm arasında değiştiği bildirilmiştir. Yapılan bazı çalışmalarda ilk dal yüksekliği; 33.60-106.10 cm [23], 21.08-52.35 cm [24], 19.80-60.16 cm [21], 39.27-61.47 cm [18], 34.53-50.00 cm [25], 21.23-35.96 cm [19] ve 31.30-35.19 cm [20] olarak tespit edilmiştir. Araştırma sonuçları arasındaki benzerlik ve farklılıkların lokasyonlarını iklim ve toprak özelliklerinin farklı olması, çeşit farklılıkları, ekim ve hasat zamanlarının ve uygulanan bakım tekniklerinin farklı olmasından kaynaklanmış olabileceği söylenebilir.



Şekil 3.3 İlk dal yüksekliğine ait sıra arası x çeşit interaksiyonu

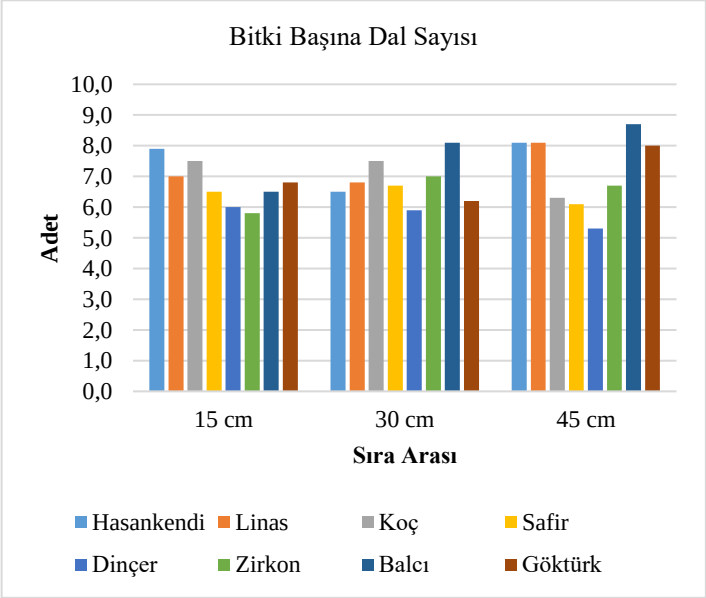
D. Bitki Başına Dal Sayısı (adet)

Tablo 3.1'de görülebileceği gibi, sıra arası farklılıkların bitki başına dal sayısına etkisi önemsiz bulunsa da sıra arası genişledikçe bitki başına dal sayısı nispeten artış göstermiştir. Nitekim, 45 cm sıra arasında ortalama 7.1 adet, 15 cm sıra arasında 6.7 adet olmuştur (Tablo 3.2).

Çeşit ortalamaları arasındaki farklılıkların bitki başına yan dal sayısı bakımından önemli bulunduğu araştırmada (Tablo 3.1), Balcı çeşidi 7.8 cm ile ilk grubu (a), Dinçer 5.8 cm ile son grubu (c) meydana getirmiştir (Tablo 3.2).

Bitki başına dal sayısına ait sıra arası x çeşit interaksiyonu önemsiz bulunmakla birlikte (Tablo 3.1), en yüksek değer Balcı x 45 cm (8.7 adet), en düşük Dinçer x 45 cm (5.3 adet) interaksiyonlarında tespit edilmiştir (Şekil 3.4). Sıra arası ile çeşitler arasındaki ilişkiye baktığımızda, bitki başına dal sayısı bakımından çeşitlerin sıra aralarına farklı tepki verdiği gözlemlenmiş, sadece Balcı çeşidinde sıra arası mesafe arttıkça bitki başına dal sayısında artış olduğu belirlenmiştir (Tablo 3.2).

Polat [17] tarafından Erzurum koşullarında yapılan araştırmada, ekim sıklığı arttıkça bitki başına dal sayısının arttığı belirtilmiştir. Araştırmada 15, 30, 45 ve 60 cm sıra arası mesafelerde yan dal sayısı sırasıyla 4.26, 4.88, 5.39, 5.74 adet/bitki olarak belirlenmiştir. Aydın [22] tarafından Ankara koşullarında yapılan çalışmada ise, ekim sıklığı ile yan dal sayısı arasında paralel bir ilişki olduğu belirtilmiştir. Araştırmada 15, 20, 25 ve 30 cm sıra arası mesafelerde yan dal sayısı sırasıyla; 4.00, 4.25, 4.30 ve 4.54 adet/bitki olarak belirlenmiştir.

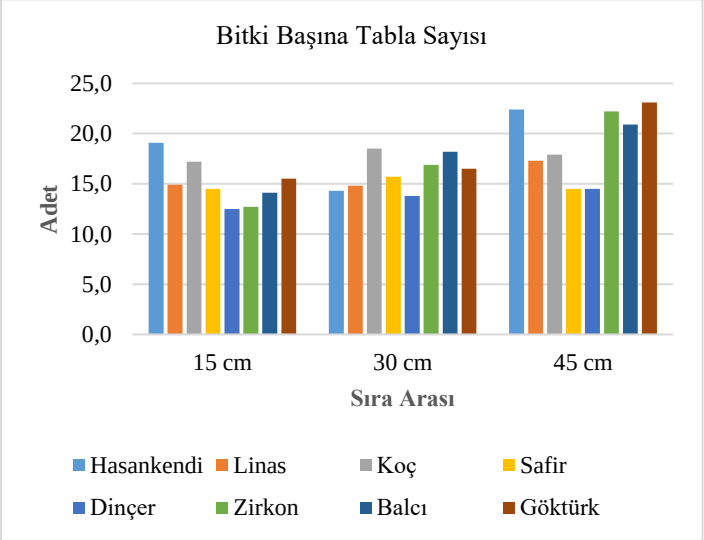


Şekil 3.4 Bitki başına dal sayısına ait sıra arası x çeşit interaksiyonu

Aspir bitkisinde ana sap üzerinde birinci dereceden yan dallar ve bunların üzerinde de ikinci dereceden yan dallar meydana gelmektedir. Hem birinci hem de ikinci dereceden dallar birer tabla ile son bulduğu için, dal sayısı aspir bitkisinde dolaylı olarak tabla sayısını belirleyici bir karakterdir [26]. Ayrıca, bitki başına dal sayısı, tabla sayısını belirleyen bir çeşit özelliği olduğundan iklim ve yetiştirme şartlarından etkilenmesi beklenen bir özelliktir [18]. Aspirde farklı iklim ve yetiştirme koşullarında yaptıkları çalışmalarda bitki başına dal sayısını; Bayraktar [27] yazlık ekimde 6.78-8.96 adet, Atakan (1992) [28] 9.10-11.50 adet, Öztürk [29] 7.06-8.42 adet, Kıllı ve Küçükler [16] 6.42-7.43 adet, Yılmazlar [24] 3.97-10.20 adet, Atam [4] 4.10-5.95 adet, Keleş [18] 4.07-9.27 adet, Sirel [30] 4.40-8.12 adet, Hatipoğlu ve ark. [31] 4.5-8.1 adet, Kayan [11] 12.30-16.14 adet, Öner ve Şeker [13] 5.08-6.93 adet, Öztürk ve ark. [32] 3.7-5.6 adet arasında tespit etmişlerdir. Bu çalışmada, aspir çeşitlerinde bitki başına yan dal sayısı değerleri 5.8-7.8 adet arasında değişmiş olup, bu değer ile araştırma sonuçları arasında görülen benzerlik ve farklılıkların, sıra arası, çeşit, araştırmanın yürütüldüğü lokasyon ve ekolojiden kaynaklandığı düşünülmektedir.

E. Bitki Başına Tabla Sayısı (adet)

Araştırmada, sıra arası mesafelerin bitki başına tabla sayısına etkisi her ne kadar önemsiz bulunsa da (Tablo 3.1) sıra arası mesafe arttıkça bitki başına tabla sayısı artmış, 19.1 adet ile 45 cm sıra arasında en yüksek, 15.1 adet ile 15 cm sıra arasında en düşük değer tespit edilmiştir (Tablo 3.2). Çeşitler arasındaki farklılıkların önemli bulunduğu çalışmada (Tablo 3.1), en yüksek bitki başına tabla sayısı 18.6 adet ile Hasankendi çeşidinden elde edilmiş, bu değer ile aralarındaki farklılığın istatistiki anlamda önemsiz olduğu Göktürk, Koç ve Balcı çeşitleri (sırasıyla; 18.4 adet, 17.9 adet, 17.8 adet) ilk grubu (a) oluşturmuşlardır. Son grubu ise (b) 13.6 adet/bitki tabla sayısı değeri ile Dinçer çeşidi meydana getirmiştir (Tablo 3.2).
Bitki başına tabla sayısına ait sıra arası x çeşit interaksiyonu incelendiğinde, en yüksek değer 23.1 adet ile 45 cm sıra arasında Göktürk, en düşük değer 12.5 adet ile 15 cm sıra arasında Dinçer çeşidinde tespit edilmiştir (Şekil 4.8.1). Dinçer, Balcı, Zirkon ve Göktürk çeşitlerinde sıra arası mesafe arttıkça bitki başına tabla sayısı artış göstermiştir (Çizelge 4.8.2).

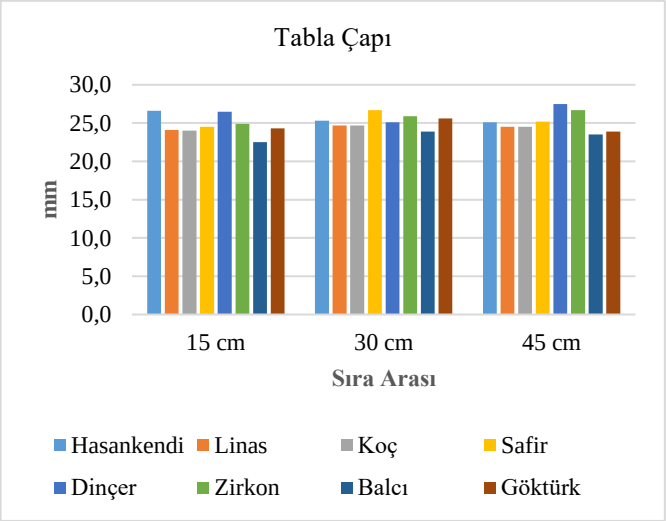


Şekil 3.5 Bitki başına tabla sayısına ait sıra arası x çeşit interaksiyonu

Bitki başına tabla sayısı, aspirde tohum verimini belirleyen en önemli seleksiyon kriterlerindendir. Bitki başına tabla sayısı, her kadar çevre koşullarından (özellikle ekim sıklığından) fazlaca etkilenen bir özellik olsa da yüksek verimli aspir çeşitlerini belirleyici kriterlerden biridir [26]. Tabla çapı ile de orantılı olarak, bitki başına tabla sayısı arttıkça tohum veriminin artacağı düşünülmektedir. Modern aspir çeşitlerinde iyi gelişmiş 12-14 adet tabla yeterli görülmektedir [33].
Bitki başına tabla sayısının, Bayraktar [27] 13.31-19.58 adet, Baydar ve Turgut [34] 6.37-20.95 adet, Öztürk [29] 13.39-19.76 adet, Kızıl [23] 3.0-25.6 adet, Eryiğit) [35] 25.75-29.86 adet, Öztürk ve ark. [32] 10.3-19.2 adet ve Keleş [18] 4.13-16.33 adet arasında değiştiğini tespit etmişlerdir.
Aydın [22] tarafından yapılan çalışmada, 15, 20, 25 ve 30 cm sıra arası mesafelerde bitki başına tabla sayısı sırasıyla; 5.67, 6.38, 6.17 ve 6.25 adet olarak belirlenmiştir. Yapılan bu çalışmada da genel olarak sıra arası mesafe arttıkça tabla sayısı da artış göstermiş olup, bu sonuç çalışmamız ile uyum içerisindedir. Ancak bu çalışmada bitki başına tabla sayısı değerleri daha yüksek bulunmuştur. Bu farkın; araştırmalar da kullanılan çeşit ve çevre koşulları farklılıkları, kültürel teknikler ve ekolojik koşulların farklı olmasından kaynaklanabileceği düşünülmektedir.

F. Tabla Çapı (mm)

Tabla çapı bakımından, çeşitler arasındaki farklılık istatistiki olarak önemli, sıra arası ve sıra arası x çeşit interaksiyonu önemsiz bulunmuştur (Tablo 3.1).
Tablo 3.2'de farklı sıra arası mesafelerde elde edilen tabla çapı değerlerine göre, en düşük tabla çapı 15 cm (24.7 mm), en yüksek (25.6 mm) 30 cm sıra arasında elde edilmiştir.



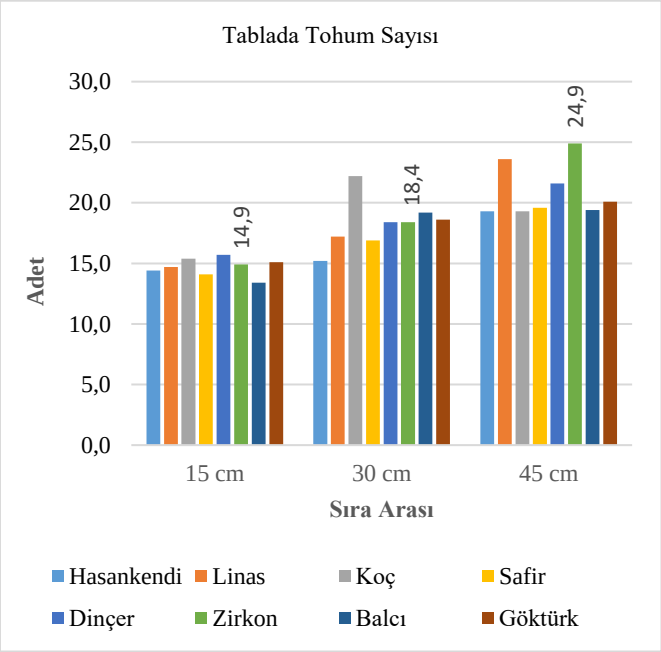
Şekil 3.6 Tabla çapına ait sıra arası x çeşit interaksiyonu

Tabla çapı bakımından çeşitler arasındaki farklılıkların önemli bulunduğu araştırmada (Tablo 3.1), en yüksek değer 26.4 mm ile Dinçer çeşidinde tespit edilmiş ve bu değer ile aralarındaki farklılığın istatistiki olarak önemli bulunmadığı Zirkon (25.8 mm) ve Hasankendi (25.7 mm) çeşitleri ilk grupta (a) yer almışlardır. En düşük tabla çapı ise 23.3 mm ile Balcı çeşidinde belirlenmiş ve son grubu (b) oluşturmuştur (Tablo 3.2).
Tabla çapına ait sıra arası x çeşit interaksiyonuna göre (Tablo 3.2), tabla çapı en geniş (27.5 mm) 45 cm x Dinçer, en dar ise (22.5 mm) 15 cm x Balcı interaksiyonunda tespit edilmiştir (Şekil 3.6).
Kunt [25] tarafından yapılan çalışmada, 10, 15 ve 20 cm sıra üzeri mesafede, ortalama tabla çapı değerleri sırasıyla; 20.96, 20.27 ve 21.38 mm olarak belirtilmiş, Bayraktar [27] aspirde tabla çapının 19.7-25.7 mm, Eryiğit [35] 21.0-27.5 mm, Eren [36] 20.4-37.8 mm, Çamaş ve ark. [21] 20.67-21.14 mm, Yılmazlar [24] 16.5-23.8 mm, Keleş [18] 13.90-18.35 mm, Sirel [30] 18.6-2.53 mm, Ferhanoğlu [37] 34-40 mm ve Akış [38] 18.3-19.5 mm arasında değiştiğini bildirmişlerdir. Araştırma sonucunda bulduğumuz tabla çapı değerleri, bu çalışmaların bazıları ile uyum içerisindeyken, bazı araştırmalara göre düşük veya yüksek olmuştur. Değerler arasındaki bu farklılıkların, lokasyon, sulama, gübreleme gibi bakım teknikleri, çeşit özellikleri, ekolojik koşullar, ekim ve hasat tarihleri arasındaki farklılıklardan kaynaklanmış olabileceği söylenebilir.

G. Tablada Tohum Sayısı (adet)

Tablada tohum sayısı bakımından, sıra arası farklılıkları önemli, çeşit ve sıra arası x çeşit interaksiyonu önemsiz bulunmuştur (Tablo 3.1). Tablada tohum sayısı açısından 30 cm ve 45 cm sıra arası mesafeler (sırasıyla, 18.3 adet ve 21.0 adet) ilk grubu (a) oluştururken, 15 cm sıra arası 14.7 adet ile diğer grubu (b) meydana getirmiştir (Tablo 3.2).
Araştırmada her ne kadar istatistiki anlamda önemsiz olsa da çeşitler arasında tablada tohum sayısı en yüksek 19.4 adet ile Zirkon, en düşük 16.3 adet ile Hasankendi çeşidinde tespit edilmiştir (Tablo 3.2).
Şekil 3.7'e göre; tablada tohum sayısına ait sıra arası x çeşit interaksiyonu bakımından, en yüksek değer 24.9 adet ile 45 cm x Zirkon, en düşük 13.4 adet ile 15 cm x Balcı interaksiyonunda belirlenmiştir. Çeşitlerin

farklı sıra aralarında tablada tohum sayısına olan tepkilerine baktığımızda ise; Koç çeşidi dışında tüm çeşitlerde sıra arası mesafe arttıkça tablada tohum sayısının arttığı belirlenmiştir (Tablo 3.2).
Hoag ve ark. [39] aspirde sıra arası genişledikçe tablada tohum sayısının arttığını bildirirken, Ögetürk [40] tarafından yapılan çalışmada da, tablada tohum sayısı üzerine ekim sıklığının etkisinin önemli olduğu, sıra arası genişledikçe tablada tohum sayısının arttığı, 15, 30 ve 45 cm sıra arası mesafelerde tabla başına sırasıyla, 25.76, 28.62 ve 30.78 adet tohum elde edildiği belirtilmiştir. Bu araştırmalarda sıra arası mesafeler ile tablada tohum sayısı arasında bildirilen bu sonuç çalışmamız ile uyum içerisinde olmakla birlikte, çalışmamızdaki değerlerden daha yüksek olduğu görülmüştür. Bu farkın çeşit farklılıklarından kaynaklandığı düşünülmektedir.



Şekil 3.7 Tablada tohum sayısına ait sıra arası x çeşit interaksiyonu

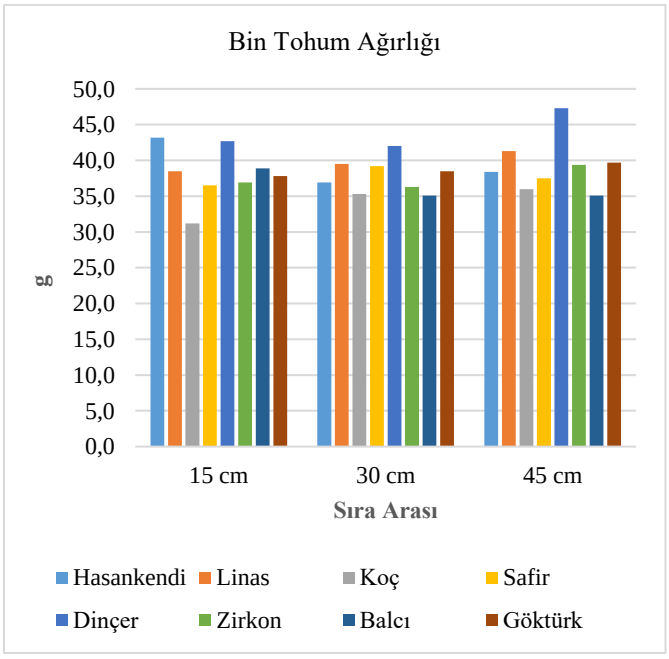
Tablada tohum sayısı aspir için önemli bir verim kriteri olup tabla iriliği ile de doğrudan ilişkilidir. Tabla iriliği arttıkça tablada tohum sayısı da artmaktadır [26]. Sapa kalkma, dallanma ve çiçeklenme dönemlerindeki nem yetersizliği ve yüksek sıcaklıklar tablada tohum sayısının azalmasına neden olmaktadır. Böyle bir durum, bitkideki tabla sayısı, tabla başına tohum sayısı ve tabla çapı gibi verimi doğrudan etkileyen komponentlerde de azalmaya neden olmaktadır [17].
Aspirde tablada tohum sayısı değerlerini Öztürk [29] 23.54-29.51 adet, Kızıl [23] 14.8-39.2 adet, Öztürk ve ark. [32] 32.2-43.1 adet, Yılmazlar [24] 26.7-42.1 adet, Keleş [18] 6.73-22.00 adet, Sirel [30] 12.20-23.16 adet, Ferhanoğlu [37] 15.5-24.0 adet, Birben [7] 13.73-24.60 adet, Keyvanoğlu [41] 7.5-92.2 adet, Yurteri [19] 20.33-27.30 adet arasında bildirmişlerdir. Bu çalışma sonucunda bulunan tablada tohum sayısı ortalama değerleri bu konuda yapılan çalışmaların bazıları ile uyum içerisindeyken, bazı araştırmalara göre düşük veya yüksek olmuştur. Bu farklılıkların, lokasyon, bakım teknikleri, çeşit özellikleri, iklim, ekim ve hasat tarihleri arasındaki farklılıklardan kaynaklanabileceği söylenebilir.

H.Bin Tohum Ağırlığı (g)

Tablo 3.2'e göre; bin tohum ağırlığı bakımından, çeşitler arasındaki farklılıklar önemli, sıra arası ve sıra arası x çeşit interaksiyonu önemsiz bulunmuştur. Her ne kadar aralarındaki farklılık istatistiki olarak önemsiz olsa da bin tohum ağırlığı en yüksek 45 cm sıra arasında 39.3 g olarak tespit edilmiş, bu değeri 15 ve 30 cm (sırasıyla, 38.2 g ve 37.9 g) izlemiştir (Tablo 3.2).
Aydın [22] tarafından yapılan çalışmada, 15, 20, 25 ve 30 cm sıra arası mesafelerde bin tohum ağırlığı sırasıyla 42.82, 42.68, 43.54 ve 43.48 g olarak belirtilmiştir. Ögetürk [40] tarafından 15, 30 ve 45 cm sıra

arası mesafelerde yapılan çalışmada ise, bin tohum ağırlığı sırasıyla 35.48, 34.49 ve 35.89 g olarak bildirilmiştir. Bu araştırmada farklı sıra arası mesafelerden elde edilen bin tohum ağırlığı ortalamalarına baktığımızda, Aydın [22] tarafından yapılan çalışma sonuçlarının altında, Ögetürk [40] tarafından yapılan çalışmanın üstünde tespit edilmiştir.
Çeşitler arasında bin tohum ağırlığı açısından oluşan ve istatistiki anlamda önemli bulunan farklılıklar için yapılan Duncan testi sonucuna göre; 44.0 g ile Dinçer çeşidi ilk grubu (a), Hasankendi, Linas ve Göktürk çeşitleri (sırasıyla; 39.5 g, 39.8 g ve 38.6 g) II. grubu (ab), Safir (37.8 g), Zirkon (37.5 g), Balcı (36.3 g) ve Koç (34.2 g) çeşitleri III. grubu (b) oluşturmuşlardır (Tablo 3.2).
Her ne kadar istatistiki anlamda önemsiz olsa da sıra arası x çeşit interaksiyonu bakımından, bin tohum ağırlığı en yüksek 47.3 g ile 45 cm sıra arasında Dinçer, en düşük 31.2 g ile 15 cm sıra arasında Koç çeşidinde tespit edilmiştir (Şekil 3.8).
Aspirde tohum verimini belirleyen önemli kriterlerin başında bin tohum ağırlığı gelmektedir. Bin tohum ağırlığı, tohumun biriktirdiği yağ ve protein oranının bir göstergesi olması bakımından olduğu kadar, tohumluk olarak kullanılacak tanelerin çimlenme, çıkış ve ilk gelişmesinde gösterecekleri gücün de bir anlamda göstergesi olduğu için önemsenen bir özellik olup, kalıtım derecesi yüksektir. Yani değişen çevreden daha az etkilenmektedir [6], [13].

Aspirde bin tohum ağırlığını Öztürk [29] 29.77-41.74 g, Eryiğit [35] 42.16-46.75 g, Yılmazlar [24] 38.84-45.39 g, Keleş [18] 29.17-36.03 g, Sirel [30] 30.7-48.5 g, Ferhanoğlu [37] 11.61-38.46 g, Akış [38] 40.58- 43.95 g, Keyvanoğlu [41] 27.6-78.6 g, Birben [7] 27.36-43.20 g, Yurteri [19] 53.66- 58.46 g olarak bildirmişlerdir. Veriler arasındaki bu farklılıkların, araştırmanın yürütüldüğü lokasyonun iklim ve toprak yapısındaki farklılıklar, bakım teknikleri, çeşit özellikleri, iklim özellikleri, ekim ve hasat tarihleri arasındaki farklılıklardan kaynaklanabileceği söylenebilir.

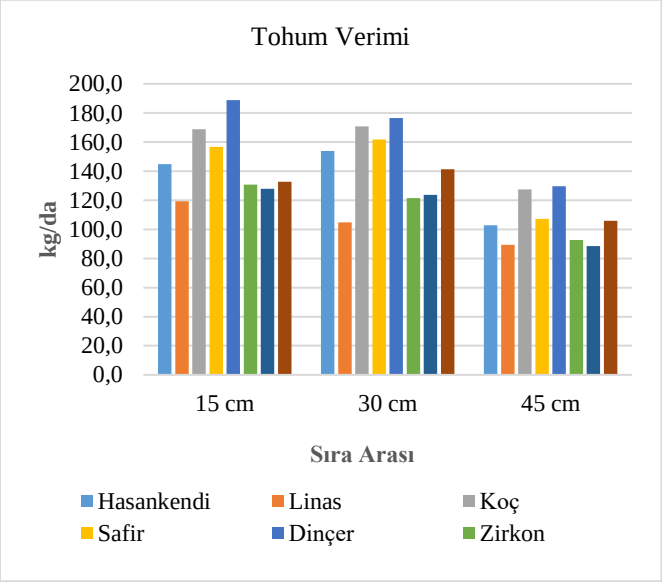


Şekil 3.8 Bin tohum ağırlığına ait sıra arası x çeşit interaksiyonu

I. Tohum Verimi (kg/da)

Araştırmada; tohum verimi bakımından, çeşit ve sıra arası farklılıklar istatistiki anlamda önemli olurken, sıra arası x çeşit interaksiyonu önemsiz bulunmuştur (Tablo 3.1).
Tablo 3.2 incelendiğinde görülebileceği gibi, en yüksek tohum verimi 146.2 kg/da ile 15 cm sıra arasında elde edilmiştir. Bu değer ile 30 cm sıra arasından elde edilen tohum verimi (144.3 kg/da) arasındaki farklılık istatistiki olarak önemli bulunmamış ve aynı grupta (a) yer almışlardır. En düşük tohum verimi ise 105.4 kg/da ile 45 cm sıra arasında tespit edilmiş ve diğer grubu (b) meydana getirmiştir. Çeşitler arasında tohum

verimi farklılığının önemli bulunduğu çalışmada ilk grubu (a) Dinçer (165.0 kg/da), son grubu (e) Linas çeşidi (104.5 kg/da) meydana getirmiştir (Tablo 3.2).
Tohum verimine ait sıra arası x çeşit interaksiyonu her ne kadar önemli olmasa da en yüksek tohum verimi 188.7 kg/da ile Dinçer çeşidi ile 15 cm sıra arasında, en düşük ise 88.5 kg/da ile Balcı çeşidi ile 45 cm sıra arasında yapılan ekimde belirlenmiştir (Şekil 3.9).



Şekil 3.9 Tohum verimine ait sıra arası x çeşit interaksiyonu

Tohum verimi, aspir için bir çeşit özelliği olmasına rağmen kültürel uygulamalardan, iklim ve çevre koşullarından önemli derecede etkilenmektedir [17]. Bir ürünün yetiştirilmesinde kalite ile birlikte iki ana amaçtan biri olan verim, üretici için öncelikli olanıdır. Hem genetik hem de çevrenin etkileri altında oluşan verimin üst düzeyde oluşabilmesi için yüksek performanslı genotipin, kendine uygun çevrede üretilmesi gerekir. Çevrenin önemli komponenti olan iklim faktörlerine fazla bir müdahale yapılamamakla birlikte, yetiştirme tekniklerinin doğru uygulanması verimin artmasını sağlamaktadır. Bu nedenle yüksek tohum verimi için uygun bitki sıklığında ekim yapmak önem taşımaktadır [6]. Aspir verimi için uygun sıra arası çeşit özelliklerine bağlı olarak değişiklik göstermektedir [32]. Aydın [22] tarafından Ankara şartlarında yapılan çalışmada, sıra arası genişledikçe tohum veriminin azaldığı belirlenmiştir. Araştırmada, 15, 20, 25 ve 30 cm sıra arası mesafelerde tohum verimi sırasıyla, 231.22 kg/da, 172.66 kg/da, 118.90 kg/da ve 106.91 kg/da olarak bildirilmiştir. Bitki sıklığı artışına bağlı olarak tohum veriminin artması, birim alandaki bitki sayısının fazla olmasından kaynaklanmaktadır [42]. Sefaoğlu [9] seyrek ekimlerde parsellerden buharlaşmayla su kaybının, sık ekimlere göre daha fazla olduğunu ve bu durumun tohum verimini etkilediğini belirtmiş ve yapılan birçok çalışmada da sıra arasının artışına paralel olarak tohum veriminin azaldığı bildirilmiştir [9], [17], [38], [43], [44]. Konu üzerinde yapılan benzer çalışmalarda aspirde tohum veriminin, 49.15-343.10 kg/da arasında değiştiği belirlenmiştir [10], [13], [25], [27], [29], [30], [35], [41]. Tohum verimi bakımından araştırma sonuçları arasındaki farklılıklar, genotip, iklim, toprak ve kültürel işlemlerdeki farklılıklardan kaynaklanmış olabilir.

IV. SONUÇ VE ÖNERİLER

Aspir her ne kadar kurak koşullara oldukça dayanıklı bir yağ bitkisi olsa da yetişme dönemi boyunca toplam yağışın ve yağışın aylara dağılımının uygun olmadığı kıraç koşullarda aspirden tatmin edebilecek bir verim elde edilebilmesi mümkün değildir. Bu nedenle, iklimsel değişiklikler, yağış biçimi ve değişik boyutlarda yaşanan kuraklık dikkate alınarak, farklı aspir çeşitleri ile birlikte farklı lokasyonlarda uzun süreli adaptasyon ve yetiştirme tekniklerinin belirlenmesine yönelik çalışmalarının yapılması, aspir tarımının yaygınlaştırılmasını olumlu yönde etkileyecektir. Bu sayede, bölge koşullarına iyi uyum sağlamış,

yetiştirici açısından yüksek tohum verimi, sanayici açısından yüksek yağ oranı ve istenen yağ asitleri bakımından özellikli, ekstrem şartlara dayanıklı çeşitlerin üretime alınması ve uygun bitki sıklığı ve diğer yetiştirme tekniklerinin tespit edilmesi ile hem daha fazla verim hem de kaliteli ürün elde edilmesi mümkün olabilecektir.

Bazı aspir çeşitlerinde farklı sıra arası mesafelerin Ankara şartlarında verim ve verim unsurlarına etkisini belirlemeye yönelik bu araştırmada; sap çapı, ilk dal yüksekliği, tablada tohum sayısı ve tohum verimi üzerine sıra arası mesafelerin etkisinin istatistiksel olarak önemli olduğu görülmüştür. Sıra arası mesafe artışına paralel olarak sap çapı, ilk dal yüksekliği ve tablada tohum sayısı artış göstermiştir. En yüksek sap çapı, ilk dal yüksekliği ve tablada tohum sayısı 45 cm sıra arası mesafede sırasıyla; 9.3 mm, 34.3 cm ve 21.0 adet olarak elde edilmiştir. Bununla birlikte, artan sıra arası mesafelerin tohum verimine etkisi ise olumsuz olmuştur. Nitekim 146.2 kg/da tohum verimi ile 15 cm en yüksek değeri verirken 30 cm sıra arası (144.3 kg/da) ile aralarındaki fark önemli bulunmamış ve bölge koşullarında aspir tarımı için her iki sıra arasının da uygun olacağı sonucuna ulaşılmıştır. Araştırma sonucunda Ankara kuru koşullarında en yüksek tohum verimine sahip çeşit Dinçer (165 kg/da) olmuş, bu çeşidi Koç (155.6 kg/da) ve Safir (141.9 kg/da) takip etmiştir. Bununla birlikte, bölgede aspir bitkisinin kuru koşullarda ekilmesi ve iklim faktörleri göz önüne alınarak bu çalışmalardan daha sağlıklı sonuçlar elde edebilmek için bu ve benzeri araştırmaların birkaç yıl daha devam ettirilmesinin; yıllara göre aspir bitkisinin verdiği tepkilerin tam sonuçlandırılması bakımından önem arz ettiği düşünülmektedir.

DİP NOT

Bu makale, S.Ü. Fen Bilimleri Enstitüsü Tarla Bitkileri Anabilim Dalı'nda tamamlanan yüksek lisans tez çalışmasından özetlenmiştir. Aynı çalışmanın verim ve kalite özelliklerini içeren bölümü, "Ankara International Congress On Scientific Research-VII" isimli kongrede sözlü olarak sunulmuş ve bildiri kitabında yayınlanmıştır.

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Özet **–** Plakalar mühendislikte çok farklı amaçlarla kullanılan elemanlardır. Havacılık ve uzay mühendisliğinde uçuş ve kontrol yüzeyi, makine ve inşaat mühendisliğinde tavan, taban veya destek elemanı, üretim bantlarında taşıyıcı olarak plakalardan yararlanılır. Ayrıca savunma sanayinde farklı amaçlarla geniş bir kullanım alanları vardır. Kullanım alanlarına göre farklı türlerde kuvvetlere ve titreşimlere maruz kalan plakaların hareketlerinin incelenmesi bu anlamda önemlidir. Bu inceleme sayesinde meydana getirilen tasarlanan mühendislik yapısının işletme ömrünün tahmini rahatlıkla yapılabilir. Gerekli tedbirler alınarak bu ömür uygun şekilde uzatılabilir. Mevcut çalışmada Kalınlığı h_p ve genişliği b olan z yönünde sonsuz uzun olan ve iki kenarından basit mesnetlenmiş alüminyum bir plakanın serbest titreşimi incelenmiştir. Plakanın titreşimine ait olan öz değerler hem analitik hem de Galerkin yöntemiyle hesaplanmıştır. Ağırlıklı Kalanlar Yöntemlerinden birisi olan Galerkin yöntemi sayesinde göz önüne alınan problemin çözümü lineer bir denklem sisteminin çözümüne indirgenmiştir. Yöntem her ne kadar integrasyon işlemi içerse de sınır şartlarını sağlayacak şekilde polinom şeklinde önerilmiş olan deneme fonksiyonu ailesinin kullanımıyla ve basit bir programlama ile hesaplamalar yapılabilmiştir. Deneme fonksiyonun derecesinin artışıyla beraber yeterli hassiyette öz değer bulmak mümkün olmuştur. Sayısal sonuçlar incelendiğinde Galerkin yöntemiyle alüminyum plakanın ilk üç değeri hesabın sonucunda ilk iki özdeğer olan ω_1 ve ω_2 de 0.00074 bağıl yüzde hata varken bu hata değeri üçüncü öz değer ω_3 için 0.00069 olmuştur. Çalışmamız akış kaynaklı titreşime maruz kalan düz, delikli veya farklı türde çatlağa sahip vb. plakaların titreşiminin incelenmesinde önemli bir alt yapı sağlayacaktır.

Anahtar Kelimeler – Plaka, Titreşim, Öz değer, Ağırlıklı Kalanlar, Galerkin Yöntemi

I. GİRİŞ

Mühendislik uygulamalarında farklı türde ve boyutlarda kiriş, plaka, kabuk gibi yapısal elemanlar kullanılmaktadır. Plakalar havacılık, uzay taşıtları veya uyduların uçuş ya da kontrol yüzeyi olarak kullanılırken, makine, inşaat mühendisliği ve mimarlıkta tavan, taban, koruma ve destek elemanı olarak iş görürler. Kullanım alanlarına göre farklı türde kuvvet ve titreşimlere maruz kalan plakaların hareketlerinin incelenmesi bu anlamda önemlidir. Böylece tasarlanan mühendislik yapısında kusurların belirlenmesi ve bunlara yönelik önlem alınması mümkün olur. Literatür incelendiğinde serbest titreşimle ilgili çözümlerde farklı yöntemlerinin araştırmacılarca kullanıldığı görülmektedir.

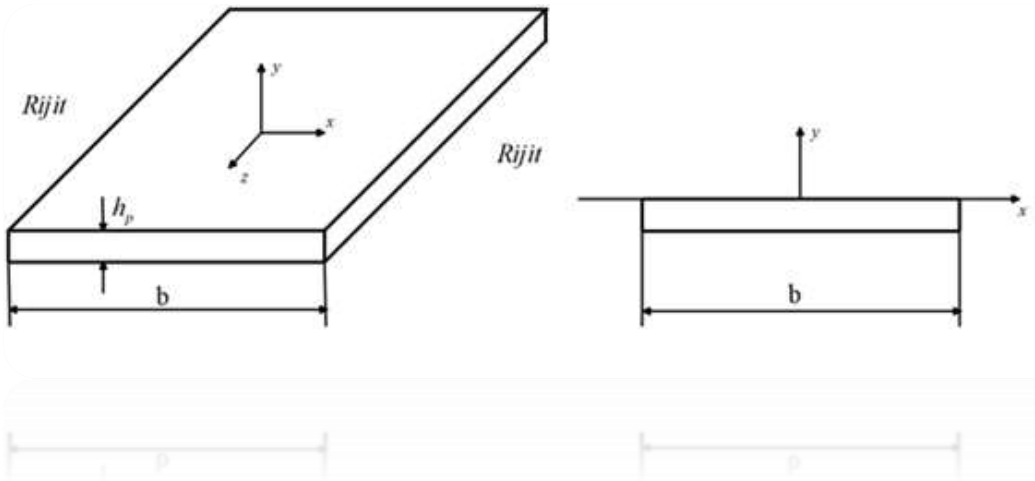
Serbest, basit desteklenen ve sabit kenarlar birleştirilerek elde edilebilecek olası tüm sınır koşullarına sahip dikdörtgen plakaların serbest enine titreşimleri incelenmiştir. Bu çalışmada Rayleigh yöntemi tüm titreşim modları için basit bir yaklaşık frekans ifadesi elde etmek için kullanılmıştır [1].

II. MATERYAL VE YÖNTEM

Plakaların serbest titreşiminde öz değerler hesaplanarak bu hareket sırasında alacakları şekiller (modeshape) çizdirilebilir. Ayrıca akış kaynaklı bir titreşim sırasında bulunan öz değerlerin sanal kısımlarının işaret değişimi incelenerek plakanın çırpınma (flutter) hızı hesaplanmaya çalışılır. Bu çalışma iki ana bölümden oluşmaktadır. Birinci bölüm plaka serbest titreşiminin analitik çözümü yapılarak öz değerler hesaplanmıştır. İkinci bölümde ise Galerkin yöntemiyle aynı öz değerler bulunmuştur.

A. *PROBLEM VE ANALİTİK ÇÖZÜMÜ*

Şekil 1 de kalınlığı h_p ve genişliği b olan z yönünde sonsuz uzun bir plakayı göz önüne alınmıştır. Plaka iki kenarından basit mesnetlenmiştir ve yan tarafları rijit bir zemindir.



(a) Ön görünüş (b) Sol yan görünüş

Şekil 1: z yönünde sonsuz uzun ve basit mesnetlenmiş plaka.

Plaka hareket denklemi çeşitli yayınlarda aşağıdaki şekilde verilir. [2], [3], [4]

$$D\frac{\partial^4 \mathrm{v}}{\partial x^4}+\rho_p h_p \frac{\partial^2 \mathrm{v}}{\partial t^2} \tag{1}$$

Bu denklemde D plaka eğilme rijitliği olarak adlandırılır ve aşağıdaki şekilde verilir.

$$D=\frac{Eh_p{}^3}{12(1-\upsilon^2)} \tag{2}$$

Burada $\boldsymbol{E}$ Elastite modülünü, $\boldsymbol{h_p}$ plaka kalınlığını ve $\boldsymbol{\nu}$ ise possion oranını göstermektedir. Plaka yer değiştirmesi $\mathbf{v}=\boldsymbol{V(x)e^{i\omega t}}$ şeklinde olsun bu ifade denkleme yazılarak ve boyutsuzlaştırma yapılmasıyla denklem (1) ile verilen hareket denklemi aşağıdaki basit hale gelecektir.

$$\begin{aligned} &D\frac{d^4V}{dx^4}-\omega^2\rho_p h_p V=0 \\ &V(-1/2)=V(+1/2)=0 \\ &\frac{d^2V}{dx^2}(-1/2)=\frac{d^2V}{dx^2}(+1/2)=0 \end{aligned} \tag{3}$$

Bu diferansiyel denklemin karakteristik denklemi ve çözümü

$$\begin{aligned} &r^4-k^4=0 \\ &k=\sqrt[4]{\frac{\omega^2\rho_p h_p}{D}} \\ &V(x)=C_1\,\mathrm{Cos}(kx)+C_2\,\mathrm{Sin}(kx)+C_3\,\mathrm{Cosh}(kx)+C_4\,\mathrm{Sinh}(kx) \end{aligned} \tag{4}$$

denklem (3) deki sınır şartları (4) denklemine yazılarsa aşağıdaki gibi matris formunda gösterilen denklem sistemine ulaşılır.

$$\begin{bmatrix} \cos(\mathrm{k}/2) & \sin(\mathrm{k}/2) & \cosh(\mathrm{k}/2) & \sinh(\mathrm{k}/2) \\ \cos(\text{-k}/2) & \sin(\text{-k}/2) & \cosh(\text{-k}/2) & \sinh(\text{-k}/2) \\ \text{-}\cos(\mathrm{k}/2) & \text{-}\sin(\mathrm{k}/2) & \cosh(\mathrm{k}/2) & \sinh(\mathrm{k}/2) \\ \text{-}\cos(\text{-k}/2) & \text{-}\sin(\text{-k}/2) & \cosh(\text{-k}/2) & \sinh(\text{-k}/2) \end{bmatrix} \begin{bmatrix} \mathrm{C}_1 \\ \mathrm{C}_2 \\ \mathrm{C}_3 \\ \mathrm{C}_4 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \tag{5}$$

Bu denklem sisteminde $C_1, C_2, C_3, C_4 \neq 0$ şeklinde bir çözüm olması için katsayılar matrisinin determinantı ω nın bir fonksiyonu olup sıfır olmalıdır. ω incelenen problemin öz değeridir. Aşağıda verilen değerler kullanılarak öz değerler hesaplanabilir.

$$\upsilon = 0,3$$

$$E = 70.10^9\ N/m^2$$

$$D=\frac{Eh_p{}^3}{12(1-\upsilon^2)} = 6410,26\,kgm^2/s^2$$

$$h_p = 0.01m$$

$$\rho_p = 2720\,kg/m^3$$

İlk üç özdeğer $n = 1, 2, 3$ için öz değerler;

$\omega_1 = 151.5130$
$\omega_2 = 606.0520$
ω_3 1363.6170

B. PROBLEMİN GALERKİN ÇÖZÜMÜ

Denklem (3) ile verilen problemin için sınır şartlarını sağlayan

$$\varphi_n(x) = x^{n+3} - \frac{(2n+1)}{(4n-2)} x^{n+1} + \frac{(2n+3)}{16(2n-1)} x^{n-1} \tag{5}$$

şeklindeki fonksiyonlar ve bunların lineer kombinasyonları da sınır şartlarını sağlar. C_n sabit katsayılar olmak üzere bu fonksiyonların lineer kombinasyonları da sınır şartlarını sağlar. Plakanın yer değiştirmesi

$$V(x) = \sum_{n=1}^{N} C_n \varphi_n(x) \tag{6}$$

(6) nolu denklem (3) nolu denkleme yazılırsa kalan

$$R(x) = D\left(\sum_{n=1}^{N} C_n \frac{d^4 \varphi_n(x)}{dx^4} \right) - \omega^2 \rho_p h_p \left(\sum_{n=1}^{N} C_n \varphi_n(x) \right) \tag{7}$$

olacaktır. (7) denklemindeki ω ' ları (problemin öz değerlerini) bulmak için aşağıdaki

$$W_n = \frac{\partial V(x)}{\partial C_n} \tag{8}$$

ile verilen Ağırlık fonksiyonu ile kalan çarpılarak problemin sınırlarında integre edilir ve en son sıfıra eşitlenerek bir denklem sistemi kurulur. Buna göre

$$R_n = \int_{\frac{1}{2}}^{\frac{1}{2}} R(x) W_n(x) dx \qquad n = 1,2,3, \ldots \ldots, N \tag{9}$$

Bu denklemin açık hali

$$R_n = \sum_{n=1}^{N} \int_{-1/2}^{1/2} \left[C_n D \frac{d^4 \varphi_n(x)}{dx^4} - \omega^2 \rho_p h_p C_n \varphi_n(x) \right] \varphi_n(x) dx \qquad n = 1, 2, 3, \ldots\ldots, N \tag{10}$$

(9) denklemindeki R_n ifadesi sadece C_n ve ω 'nın fonksiyonudur. N'e değerler verilerek bulunan $R_1, R_2, R_3, \ldots \ldots, R_N$ ifadeleri ayrı yarı sıfıra eşitlenir. Böylece bir denklem sistemine ulaşılır. Bu denklem sisteminin matris gösterimi

$$[R_n(\omega^2)]_{NxN} . [C_n]_{Nx1} = [0]_{Nx1} \tag{11}$$

şeklindedir. Denklem (11) deki katsayılar matrisinin determinantı sıfıra eşitlenerek $C_1,\ C_2,\ C_3, \dots, C_n \neq 0$ olacak çözümler bulunur.Yani plaka çökmesinin sıfır olmadığı çözümler elde edilir. Örneğin $N = 2$ için bu denklem sistemi denklem (12) deki gibidir.

$$\begin{bmatrix} 30769.248 - 1.3584\omega^2 & 0 \\ 0 & 3052.504 - 0.081\omega^2 \end{bmatrix} \begin{bmatrix} C_1 \\ C_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \quad (12)$$

Burada katsayılar matrisinin determinantı sıfıra eşitlenerek

$$-0.0109442\omega^4 - 4337.11\omega^2 + 9.99233x10^7 = 0 \quad (13)$$

denklemine ulaşılır. (13) deki ifadenin kökleri ise bize plaka serbest titreşiminin öz değerlerini $\omega_{1,2} = \pm 151.622\ \ \omega_{3,4} = \pm 610.986$ olarak verir. Tablo 1' de ilk üç öz değer analitik olarak ve Galerkin yönteminde N'nin farklı değerleri için verilmiştir.

Tablo 1. Öz değerlerin analitik ve galerkin yöntemiyle bulunan değerleri

Öz değer	Analitik	N = 2	N = 3	N = 4	N = 5	N = 6	N = 7	N = 8	N = 9
ω_1	151.5130	151.6224	151.5141	151.5141	151.5141	151.5141	151.5141	151.5141	151.5141
ω_2	606.0520	610.9855	610.9855	606.0747	606.0747	606.0565	606.0565	606.0564	606.0564
ω_3	1363.6170	--------	1401.7918	1401.7918	1364.1302	1364.1302	1363.6294	1363.6294	1363.6271

III. BULGULAR

Deneme fonksiyonun derecesinin artışıyla beraber yeterli hassiyette özdeğer bulmak mümkün olmuştur. Sayısal sonuçlar incelendiğinde Galerkin yöntemiyle alüminyum plakanın ilk üç değeri hesabın sonucunda ilk iki özdeğer olan ω_1 ve ω_2 de 0.00074 bağıl yüzde hata varken bu hata değeri üçüncü özdeğer ω_3 için 0.00069 olmuştur.

IV. TARTIŞMA

Sınır şartlarını sağladığı sürece herhangi bir test (deneme) fonksiyonu seçilebilir. Başka bir problemde seçilen deneme fonksiyonunun derecesinin arttırılmasıyla mutlak hatanın gittikçe azalamaması gibi bir sorun olması durumunda çözüm için özel polinomlar (Chebyshev, Legendre, Lagurre vb.) alınarak bu güçlük aşılabilir. Bu çalışmada da yapıldığı gibi Galerkin yönteminde integrali kolay alınabilen polinomları veya herhangi bir özel fonksiyon seçmek bir avatanjdır. Integral alma işlemleri simgesel matematik yazılımları ile yapılırsa yöntemin programlaması daha kolay olmaktadır.

V. SONUÇLAR

Plakanın titreşimine ait olan öz değerler hem analitik hem de Galerkin yöntemiyle hesaplanmıştır. Ağırlıklı Kalanlar Yöntemlerinden birisi olan Galerkin yöntemi sayesinde göz önüne alınan problemin çözümü lineer bir denklem sisteminin çözümüne indirgenmiştir. Yöntem her ne kadar integrasyon işlemi içerse de sınır şartlarını sağlayacak şekilde polinom şeklinde önerilmiş olan deneme fonksiyonu ailesinin kullanımıyla ve basit bir programlama ile hesaplamalar yapılabilmiştir. Çalışmamız akış kaynaklı titreşime maruz kalan düz, delikli veya farklı türde çatlağa sahip vb. plakaların titreşiminin incelenmesinde önemli bir alt yapı sağlayacaktır.

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Modeling Melting Points of Polycyclic Aromatic Hydrocarbons: A QSPR Approach Using Multiple Linear Regression

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Abstract **–** The goal of this study is to predict the melting points (Mp) of 58 polycyclic aromatic hydrocarbons (PAHs). To achieve this, a quantitative structure-property relationship (QSPR) analysis was conducted utilizing multiple linear regression (MLR) to correlate the melting point values of these polycyclic aromatic hydrocarbons with their structural descriptors. The dataset was initially divided into a training set of 41 compounds and a test set of 17 compounds using the Kennard and Stone algorithm (CADEX) for robust external statistical validation.

A predictive model incorporating six descriptors was developed, leveraging theoretical descriptors obtained from DRAGON software. These descriptors were selected through a Genetic Algorithm-Variable Subset Selection (GA-VSS) procedure to enhance model efficiency. The applicability domain of the multiple linear regression model was evaluated using a William's plot, which helped identify outliers and compounds outside the expected range.

The robustness and predictive capability of the model were confirmed through both internal and external statistical validation. The model demonstrated excellent statistical performance, with high-quality parameters (R^2 = 91.18%, Q^2_{LOO} = 87.62%, Q^2_{EXT} = 81.6%, F = 58.61, s = 25.119). These results underscore the stability and accuracy of the proposed model, highlighting its effectiveness in predicting the melting points of polycyclic aromatic hydrocarbons.

Keywords – Melting point, Polycyclic aromatic hydrocarbons, QSPR, Multiple linear regression, Predictive modeling.

I. INTRODUCTION

Polycyclic Aromatic Hydrocarbons, or PAHs, are organic compounds that arise from incomplete burning of carbonaceous materials as a result of volcanism, minors, and mostly anthropogenic processes. They are discharged into every section of the environment. Over the past 150 years, there has been a notable increase in the concentration of PAHs in the environment [1].

PAHs, even at low concentrations, pose a significant toxicological danger. For the description and prediction of the properties of complex chemical systems in various contexts, Quantitative Structure-(Activity/Property) Relationships (QSAR/QSPR) have emerged as a potent theoretical tool substitute for quantum mechanics during the past few decades.

The foundation of the QSAR/QSPR method is the presumption that a compound's molecular structure and any of its physical characteristics, chemical affinity, and biological activity match to one another.

In our QSPR study, we aimed to predict the melting points, utilizing hybrid methods that combine Genetic Algorithms (GA) and Multiple Linear Regression (MLR) to develop the model.

II. MATERIALS AND METHOD

A. Data collection

The aim of this research is to forecast the melting points of a set of 58 PAHs sourced from the literature [2]. Following the molecular geometry optimization using HYPERCHEM software [3], we employed Dragon software [4] to compute 3224 descriptors.

Table 1. Description of the selected descriptors by GA

N°	Descriptors	Signification
1	Mor14p	3D-MoRSE - signal 14 / weighted by atomic polarizabilities
2	E2u	2nd component accessibility directional WHIM index / unweighted
3	Gm	G total symmetry index / weighted by atomic masses
4	ISH	standardized information content on the leverage equality
5	H5e	H autocorrelation of lag 5 / weighted by atomic Sanderson electronegativities
6	qnmax	maximum negative charge

III. RESULTS AND DISCUSSION

Our complete set of 58 observations was split into two groups using the CADEX algorithm by Kennard and Stone: one for calibration, consisting of 41 compounds, and another for validation, containing 17 compounds. We aimed to identify a reduced set of descriptors that most effectively explains the dependent variable (the melting points). Genetic algorithms in the Mobydigs software were utilized for this descriptor selection [5].

III.1. Multiple Linear Regression

The genetic algorithm selection resulted in a robust model with six descriptors that best represent the melting points for MLR modeling. The chosen model is as follows:

Melting-point (°C) = - 233 - 146 **Mor14p** + 895 **E2u** + 41.2 **Gm** - 109 **ISH** + 164 **H5e** + 1684 **qnmax**

The statistical parameters displayed in Table 2 indicate a strong correlation between the six selected variables and the studied property, evidenced by excellent parameters $Q^2_{LOO} > 0.5$ [6]. All statistical parameters of the model are satisfactory, demonstrating that the models are stable, robust, and predictive. Consequently, the developed models were used to predict the test set data.

Table 2. Results and statistical parameters of GA- MLR.

R^2	Q^2_{loo}	Q^2_{ext}	SDEC
91.18	87.62	81.60	22.874
SDEP	**$SDEP_{ext}$**	**F**	**s**
27.107	33.046	58.6063	25.1186

The value of R^2 indicates the quality of the fit, while the small difference between R^2 and Q^2_{LOO} reflects the robustness of the model, which is further supported by the high Fisher statistic value. The similar values of SDEC and SDEP suggest that the model's internal prediction capability is closely aligned with its fitting power. External statistical validation (Q^2_{ext} and $SDEP_{ext}$) confirms the model's strong predictive ability for compounds not included in the model's development.

The quality of the adjustment can be evaluated by presenting the experimental values against the calculated melting points values for the calibration set, and the predicted values for the validation set.

Figure 1 shows a low dispersion, characteristic of a good adjustment, which is further confirmed by the high R^2 value of 91.18%.

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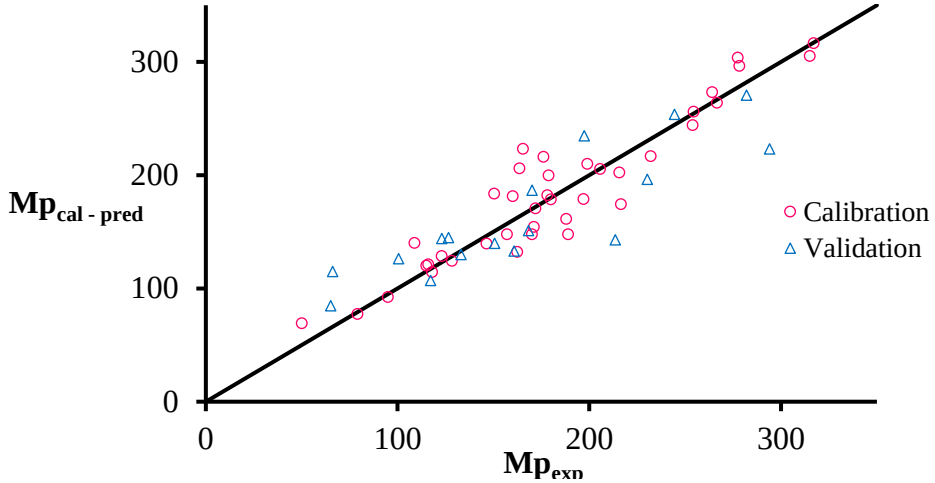

Fig. 1 Cross-validation vs. experimental Mp.

Figure 2 enables a comparison between the results obtained for the randomized models (empty circles) and the original model (filled circle). It is evident that the statistics for the modified vectors of the melting point are lower than those of the actual model, with most Q^2 values being less than 0. This confirms that the model's performance is not due to random chance.

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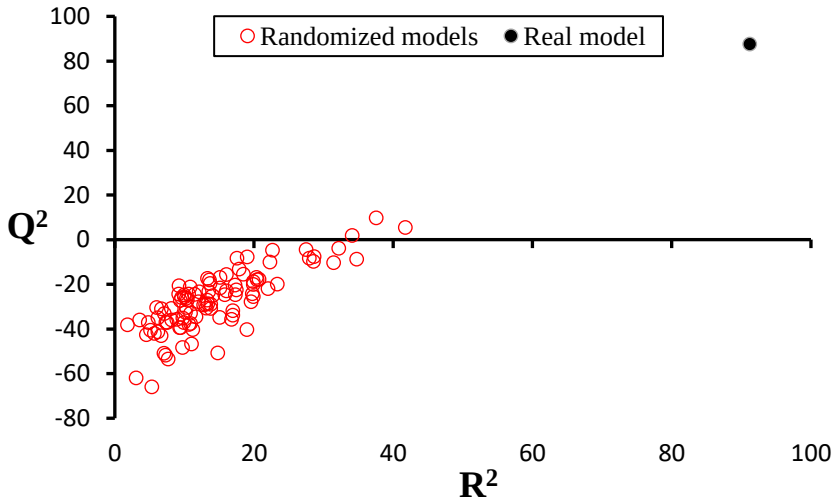

Fig. 2 Randomization test.

IV. CONCLUSION

We applied the QSPR methodology to link the melting points of 58 PAHs with different chemical properties to theoretical molecular descriptors obtained through genetic algorithms. We sought linear correlations between independent and dependent variables using multiple linear regression. The presented multilinear model is the best from all perspectives: quality of fit, internal and external robustness, and predictive capability.

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Karbon Fiyatlandırılmasının Isı Pompalarının Birim Maliyetine Etkisi

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Özet **–** Yenilenebilir enerji kaynakları küresel enerji pazarındaki etkisi giderek artmaktadır. Enerji güvenliğini sağlamak ve sürdürülebilirliği artırmak açısından kritik bir rol oynayan yenilenebilir enerji kaynakları, aynı zamanda karbon salınımını azaltma konusunda da büyük bir potansiyele sahiptir. Temel olarak binaların iklimlendirilmesi için kullanılan farklı tip ısı pompaları yenilenebilir enerjinin doğrudan kullanımı açısından önemli etkiye sahiptir. Bu çalışmada, farklı güçteki ısı pompalarının yılda 2000 saat çalıştığı varsayılarak birim maliyetleri hesaplanmıştır. Ayrıca farklı karbon fiyat senaryoları altında birim maliyetlerdeki değişim incelenmiştir. Karbon fiyatlandırması arttıkça daha az enerji harcayıp daha az karbon salınımı yapan düşük kapasiteli cihazların birim maliyetinin daha düşük olduğu görülmüştür. Bu gelişme, yatırımcılar ve enerji şirketleri için yenilenebilir enerji projelerini daha çekici hale getirmektedir. Karbon fiyatlandırma politikası ile ısı pompalarının birim maliyetinde kısmi bir artış olsa bile karbon salınımı yüksek diğer fosil yakıtların maliyetleri daha yüksek oranda artacağı için ısı pompaları gibi daha temiz enerji türlerinin cazibesi ekonomik olarak da artacaktır. Ayrıca, çevresel etkilerin azaltılması ve sürdürülebilir enerji üretimi hedeflerine ulaşma yolunda önemli bir adım olarak değerlendirilmektedir.

Anahtar Kelimeler – Isı pompası, karbon fiyatlandırması, emisyon, maliyet analizi, sürdürülebilirlik

I. GİRİŞ

Petrol ve fosil yakıt enerji kaynaklarının gitgide artan kullanımları, fiyatlarındaki ani dalgalanma, yoğun bir şekilde tüketilmesi, yenilenebilir ve maliyet açısından uygun yeşil, alternatif ve sürdürülebilir enerji bulma ve kullanma eğilimlerinin artmasına neden olmuştur.

Isı pompaları, endüstriyel sektörlerde yaygın olarak kullanılan doğal ısı kaynaklarından, havadan, topraktan ve sudan faydalanarak etkin bir şekilde çalışmaktadır. Bu sistemler, enerji tasarrufu sağlama, atık ısıyı değerlendirme, güvenilirlik, düşük bakım maliyetleri, uzun ömür, düşük yüklerde yüksek verimlilik ve çevre dostu olma gibi bir dizi avantaj sunarlar. Düşük sıcaklıkta bulunan yenilenebilir enerji kaynakları, örneğin hava, su, jeotermal sular, deniz suyu, göller ve güneş enerjisi gibi kaynaklar, ısı pompası sistemlerinde kullanılabilmektedir. Ancak, bu avantajlara rağmen, henüz geniş çapta benimsenmemişlerdir ve hedeflenen pazar payına ulaşamamışlardır. Türkiye'nin bu kaynaklardan zengin olması, ısı pompaları için önemli bir avantaj sunmaktadır.

Kaya (2009), yaptığı çalışmada ısı pompası sisteminin kondenser sıcaklığına karşı kombi sistemini ekonomik olarak karşılaştırmıştır. Kondenser sıcaklığı 60°C'de birim maliyet toplamı 0.007449 $/kWh iken 180°C'de ise 0.05553 $/kWh, kombi sisteminin birim maliyeti ise yaklaşık olarak 0,020$/kWh olduğu hesaplanmıştır. Yapılan çalışmada ısı pompası sistemi 100°C kondenser sıcaklığında doğalgaz kullanılan kombi sistemiyle aynı maliyettedir. Daha yüksek sıcaklıklarda kombi daha avantajlıdır, daha düşük sıcaklıklarda ise ısı pompası sistemi avantajlı olduğu belirtilmiştir.

Kuş ve Çomaklı (2015) çalışmada, farklı ısı pompası sistemleri için Net Bugünkü Değer ve Geri Ödeme Süresi Metodunu kullanılarak ekonomik analiz yapmıştırlar. Isıtma tesir katsayısının buharlaştırıcı kaynak akışkan sıcaklığındaki değişimine bağlı olarak incelenme yapmıştırlar. Havadan suya ısı pompası sisteminde en yüksek yıllık elektrik maliyeti, sudan havaya ısı pompası sisteminde ise en düşük yıllık elektrik maliyeti hesaplamıştırlar.

Coşman (2013), yaptığı çalışmada, fore kazıklara entegre edilen ısı pompası uygulaması ve bu sistemin ekonomik analizini yapmıştır. Isı pompası ve klasik sistem için yıllık enerji maliyetleri hesaplanmıştır. Isı pompası için yıllık toplam maliyet 209.810 €, klasik sistem için ise 320.245,1 € olarak bulunmuştur. Klasik sistem, birim ısıtma enerjisi açısından %35 daha pahalı ve geri ödeme süresi 1,1 yıl olduğunu hesaplamıştır.

Zozan (2009) tarafından yapılan çalışmada, Antalya ili için güneş enerjisi kaynaklı ısı pompası destekli ısıtma sisteminin termodinamik ve termoekonomik analizi yapılmıştır. Isıtma sezonu boyunca ortalama olarak ekserji kaybının kolektörde 1050€, depoda 9344€, akümülasyon tankında 4633€, ısı pompasında 11529€ ve kazanda 2820€ olarak gerçekleştiği belirlenmiştir. Tesisin toplam ortalama ekserji kaybı 20 kW ve bu kaybın senelik maliyeti 293755€ olarak hesaplanmıştır. Yapılan analizde, önerilen sistemin kullanılmasıyla ciddi yakıt tasarrufu sağladığını, ancak artan elektrik tüketimiyle birlikte ilk yatırım maliyetlerinin yüksek olduğunu göstermiştir. Bu nedenle, sistem bugünkü koşullarda uygun bulunmadığı belirtilmiştir.

Serpen ve Palabıyık (2006) tarafından yapılan bu çalışmada, konutların lpg, jeotermal ısı pompası ve güneş enerjisi ile ısıtılmasının ekonomik analizi yapılmıştır. Alternatif sistemlerin ekonomik yönü "ömür boyu maliyet" ve LCC (life cycle costing) yöntemi kullanılarak incelenmiştir. LCC (Sosyal Maliyet ve Klima Dahil) maliyeti sırasıyla doğalgaz için 23.597 $, ısı pompası kullanımı için 30.261 $, LPG yakıt kullanımı için 35.992 $, güneş enerjisi ile 38.341 $ olarak hesaplanmıştır. Çalışmanın sonucunda, kısa dönemde doğal gazla ısıtmanın en ekonomik sistem olduğu belirlenmiştir.

Lu ve ark. (2017), Avustralya, Melbourne'deki bir konut için SEPD programı içindeki farklı tasarıma sahip toprak kaynaklı ısı pompası sistemi ile hava kaynaklı ısı pompası sisteminin

performanslarının karşılaştırmalı analizini yapmıştırlar. Bu analizde, sistemlerinin maliyetleri çeşitli ekonomik göstergeler kullanılarak diğer geleneksel ısıtma/soğutma yöntemleriyle karşılaştırılmıştır. Yapılan analiz sonucunda, tasarım ömrü 40 yıl boyunca yıllık 592$'lık eşdeğer bir kazanç sağlayan toprak kaynaklı ısı pompası sistemi kurmanın daha avantajlı olduğu ortaya konmuştur.

Rad ve ark. (2013), Kanada, Toronto Milton Şehri'nde gerçek bir evde güneş enerjisi kollektörlerini kullanarak hibrit toprak kaynaklı ısı pompası sistemlerinin uygulanabilirliğini incelemiştirler. Genel sistem ekonomik uygulanabilirliği, 20 yıllık bir yaşam döngüsü maliyet analiziyle değerlendirilmiştir. Yapılan analizde, geleneksel toprak kaynaklı ısı pompası sistemine kıyasla düşük bir ekonomik fayda olduğu gösterilmiştir. 20 yıllık yaşam döngüsü maliyet analizine dayalı olarak önerilen hibrit sistemin net bugünkü değerinin, geleneksel toprak kaynaklı ısı pompası sistemlerine göre %3,7-%7,6 (veya 1500 ila 3430 Kanada doları) arasında daha düşük olduğu tahmin edilmiştir. Bu farkın güneş destekli sistemin daha az sondaj ve boru maliyetinden kaynaklandığı belirtilmiştir.

Blum ve ark. (2011), Almanya'daki dikey toprak kaynaklı ısı pompası sistemlerinin tekno-ekonomik, mekânsal analizini ve iklim koşulları ile mekânsal korelasyonu, güney Almanya'da yürütülen bir sübvansiyon programı kullanılarak değerlendirilerek yapmıştırlar. Önerilen sistem için ortalama toprak kaynaklı ısı pompası sisteminin, ısıtma talebi 11 ± 3 kW ve ısıtma alanı yaklaşık 190 ± 57 m2 olan bir evde kurulmuştur. Sistem genellikle sıcak su ve ısınma amaçlı kullanılmaktadır. İki sondaj kuyusuna ısı eşanjörü kurulumu yapılmıştır ve bunlar ayrı ayrı 95 ± 34 m derinliğe ve toplamda 180 ± 90 m uzunluğa sahip çift U-borulardan oluşmaktadır. Çalışma sonucunda, Almanya'da toprak kaynaklı ısı pompası sisteminin ortalama maliyeti yaklaşık 23.500 € ± 6.800 € olarak hesaplanmıştır. Bu maliyetin %51'i toprak ısı değiştiricisini yerleştirmek için yapılan sondaj işlemleri için, geriye kalan %49'un ise ısı pompası cihazı için olduğu tespit edilmiştir.

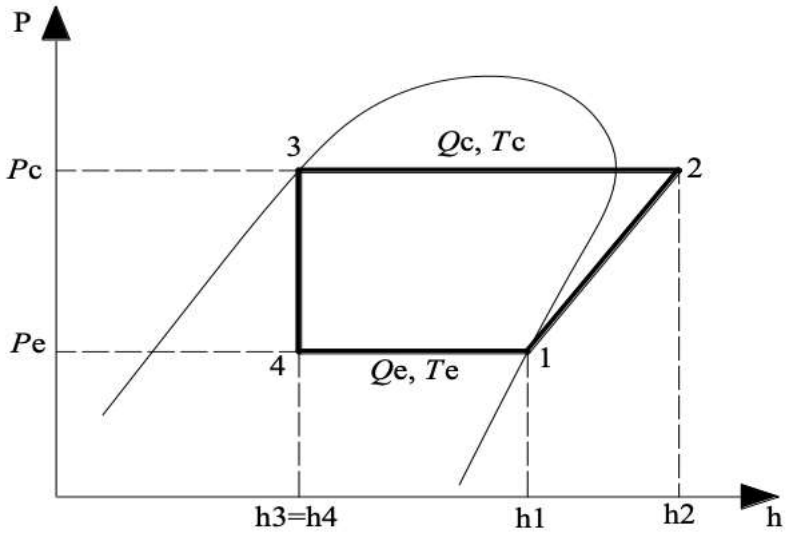
Atılgan ve ark. (2023), yaptıkları çalışmada Konya ilinin rüzgâr hızı verileri incelenmiş, gelecek dönemler için rüzgâr hızı tahminleri yapılmış ve bu tahminler doğrultusunda elektrik üretim miktarlarını hesaplamıştırlar. 3 farklı rüzgâr türbininin ekonomik açıdan değerlendirilip, birim maliyetlerini karşılaştırmıştırlar. Rüzgâr hızı verileri mevsimsel olarak değiştiği için tahmin yönetimi olarak mevsimsel ARIMA modelini kullanmıştırlar. Karbon fiyatlaması dikkate alındığında, rüzgâr türbinlerinin boyutuna bağlı olarak birim maliyetlerde %9,4 ile %16 arasında azalma tespit edilmiştir.

Bu çalışmada üç farklı kaynaklı ısı pompaları için 2000 saat çalışma saatine karşılık, sistemin birim maliyeti hesaplanmış, farklı karbon fiyatı senaryolarına göre ısı pompalarının birim maliyet analizi yapılmıştır. Yapılan analizle karbon fiyatlandırmasının farklı güçlerdeki ısı pompalarının maliyetlerine etkisi incelenmiştir.

II. MATERYAL VE YÖNTEM

A. Isı Pompası Çalışma Prensibi

Düşük sıcaklıktaki bir ortamdan yüksek sıcaklıktaki başka bir ortama ısıl enerji aktaran makinelere soğutma makinesi denir. Isıtma ya da soğutma yapmak amacıyla, ısının bir yerden başka bir yere transfer edilmesini sağlayan makinelere ise ısı pompası denir. Soğutma makineleri ve ısı pompaları aynı çevrimi gerçekleştirirler. En yaygın kullanılan sistemlerden biri buhar sıkıştırmalı soğutma (BSS) çevrimleridir. Bu çevrimlerde, bir miktar soğutucu akışkan sırasıyla yoğuşturulup buharlaştırılır. Şekil 1'de buhar sıkıştırmalı sistemin p-h diyagramı görülmektedir.



Şekil 1. Buhar Sıkıştırmalı Sistemin P-H Diyagramı

Şekil 1'de görüldüğü gibi çevrim sırasındaki yoğuşma ile buharlaşma işlemleri sırasındaki basınçlara sırasıyla yoğuşma basıncı (P_c), buharlaşma basıncı (P_e), sıcaklıklara ise yoğuşma sıcaklığı (T_c), buharlaşma sıcaklığı (T_e) denir. BSS çevriminde sürekli akışın olduğu elemanlar mevcuttur. Bir girişli ve bir çıkışlı sürekli akışlı açık sistem için enerjinin korunumu (birim kütle için TD 1. yasası) Denklem 1 ile ifade edilir.

$$q - W = \Delta h + \Delta E_k + \Delta E_p \quad (1)$$

Burada q ve w sırasıyla birim kütle için ısı geçişi ve işi; ΔE_p ve ΔE_k ise sırasıyla potansiyel ve kinetik enerjileri ifade etmektedirler. BSS'de dolaşan soğutucu akışkanın potansiyel ve kinetik enerji değişimleri, iş ve ısı geçişi değerlerine göre çok düşük olduğundan ihmal edilebilir. Bu durumda, sürekli akışlı açık sistemin birim kütle için enerjinin korunumu Denklem 2 ile ifade edilir.

$$q - W = h_{out} - h_{in} \quad (2)$$

Şekil 1'den de anlaşıldığı üzere, kompresörde adyabatik olarak (q=0) dışarıdan iş alınmaktadır. Bu durum için Denklem 2 yeniden düzenlenerek kompresörün çektiği enerji,

$$W_k = \dot{m}(h_2 - h_1) \quad (3)$$

W_k, Denklem 3 ile hesaplanabilmektedir. Bu denklemde, sistemde dolaşan soğutucu akışkan debisini ($\dot{m}$), akışkanın kompresör giriş entalpi değeri (h_1) ve çıkış entalpi (h_2) değeridir.

Yoğuşturucu ve buharlaştırıcıda iş etkileşimi yoktur ($W = 0$). Bu durumda yoğuşturucudan dış ortama atılan enerji Q_c ve buharlaştırıcıda çekilen enerji miktarı, Q_e, Denklem 4 ve Denklem 5 ile hesaplanabilir.

$$Q_c = \dot{m}(h_2 - h_3) \quad (4)$$

$$Q_e = \dot{m}(h_1 - h_4) \quad (5)$$

Denklem 4'te yoğuşturucu çıkışındaki akışkanın entalpisi (h_3) ve buharlaştırıcı girişindeki akışkanın entalpisi (h_4)ile gösterilmiştir.

BSS'nin soğutma performans katsayısı, COP, buharlaştırıcıda çekilen enerjinin kompresörde harcanan enerjiye oranıdır ve Denklem 6 ile gösterilmiştir.

$$COP = \frac{Q_e}{W_{cp}} \quad (6)$$

Isı pompası ünitesinin ısıtma performans katsayısı COP_{hp} Denklem 7 ile sistemin ısıtma performans katsayısı COP_{sys} Denklem 8 ile hesaplanır.

$$COP_{Ip} = \frac{Q_e}{W_{cp}} \quad (7)$$

$$COP_{SIS} = \frac{Q_e}{W_k + W_{p1} + W_{p2}} \quad (8)$$

Denklem 8'de, kompresörün şebekeden çektiği güç (W_k), dolaşım pompasının şebekeden çektiği güç (W_{p1}) sisteme bağlanan güç analizörü ile ölçülmüştür.

Yoğuşturucudan havaya transfer olan ısı miktarı (Q_c), Denklem 9 ile hesaplanır.

$$Q_c = \dot{m} c_p (T_{out} - T_{in}) \quad (9)$$

Denklem 9'da havanın debisini ($\dot{m}$) (kg/s), havanın özgül ısısını (c_p) (kj/kgC), havanın buharlaştırıcıdan çıkış sıcaklığını (T_{out}) (C), havanın buharlaştırıcıya giriş sıcaklığını (T_{in}) (C) ile gösterilmektedir.

Toprak ısı değiştiricisi içerisinde dolaştırılan su-antifriz karışımı tarafından topraktan çekilen ısı miktarı (QTID) Denklem 10 ile hesaplanmaktadır.

$$Q_{GHE} = \dot{m}_{mix} c_{p,mix} (T_{mix,out} - T_{mix,in}) \quad (10)$$

B. Karbon Fiyatlandırması Hesaplaması

Mühendislik projeleri ve yatırımlarının ekonomik analizinde en sık kullanılan yöntem, net bugünkü değer (NBD) metodudur. Bu metot, gelecekteki tüm nakit akışlarını şimdiki değere indirgeyerek alternatif yatırımları karşılaştırır ve en ekonomik olanı seçmeyi sağlar. Eğer alternatifler arasında maliyet karşılaştırması yapılıyorsa, toplam masrafların şimdiki değerinin en düşük olduğu seçenek tercih edilir. Net bugünkü değer yöntemiyle, yatırım yapılacak projenin nakit akışları, paranın zaman değeri dikkate alınarak değerlenir. Bu değerleme işleminde, işletmenin yatırımdan beklediği getiri oranı göz önünde bulundurulur. Yapılan yatırım harcamaları nakit çıkışı gerektirdiği için negatif, kazançlar ise pozitif alınır. Sonuç olarak, net bugünkü değer negatifse yatırım projesi gerçekleştirilmez; ancak pozitif bir sonuç, yatırımın yapılabilir olduğunu gösterir. Isı pompalarında birim yatırım maliyeti formülü kullanılarak net bugünkü değer metoduna göre hesaplanır.

Birim maliyet, net bugünkü değerin toplam üretim miktarına oranı ile hesaplanır, denklem 11'de gösterilmiştir.

Birim Maliyet = Net Bugünkü Değer /Toplam Üretim (11)

Net bugünkü değer hesaplanırken, İlk yatırım maliyeti ile, elektrik tüketim maliyetinin toplamıdır.

$$NBD = I_0 + \sum_{t=0}^{T} \frac{C_t}{(1+r)^t} \quad (12)$$

Denklem 12'de I_0, ilk yatırım maliyetini, C_t, Elektrik maliyetini, r, faiz oranını, T, cihazın yaşam ömrünü temsil etmektedir. Hesaplamalar yapılırken cihazın yaşam ömrü 30 yıl olarak kabul edilmiştir. Elektriğin birim fiyatı 0,058 Euro/kWh olarak alınmıştır.

$$C_t = \frac{2}{35} \frac{E}{COP} \quad (13)$$

Tablo 1'de farklı tip kaynağa sahip ısı pompaları için ilk yatırım maliyeti, verim değerleri (COP) ve CO_2 salınım miktarları verilmiştir.

Tablo 1. Isı Pompaları Verileri

Kaynak Tipi	Güç				
	5 kW	**8 kW**	**10 kW**	**12kW**	**16kW**
Hava Kaynaklı Isı Pompası					
Fiyat (Euro)	1700	2500	2700	3600	3900
COP (Verim)	5	4,65	4,69	4,78	4,85
CO_2 ton/MWh	3,13	5,32	5,77	6,06	8,35
Toprak ve Su Kaynaklı Isı Pompaları					
COP (Verim)	4,47	4,67	4,6	4,57	4,4
CO_2 MWh	2,66	3,19	3,73	3,55	3,55
Fiyat (Euro)	8200	8400	8900	9100	9500

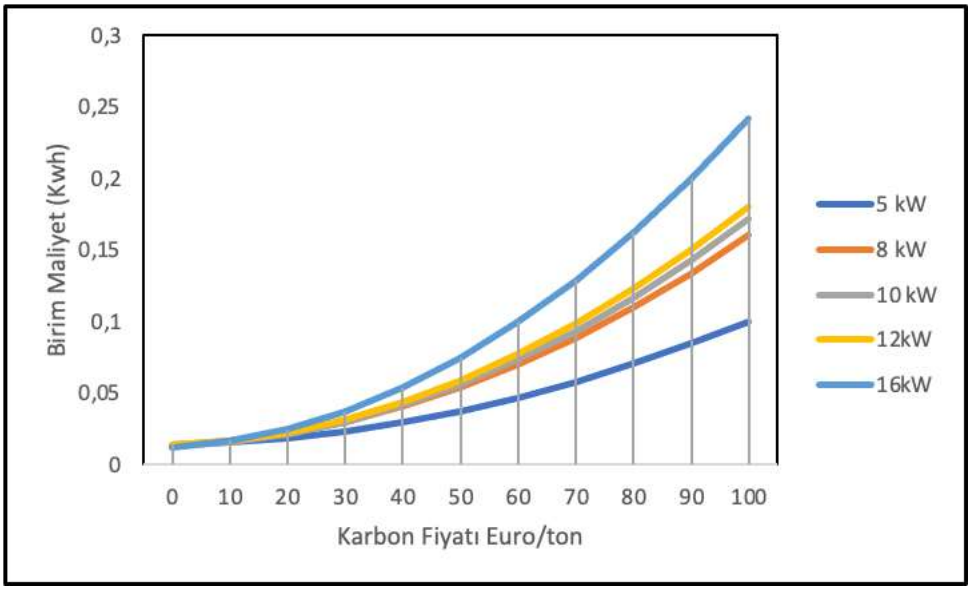
III. BULGULAR

Seçilen ısı pompalarının yılda 2000 saat çalıştığı varsayılarak birim maliyetleri hesaplanmıştır. Ayrıca farklı karbon fiyat senaryoları altında birim maliyetlerdeki değişim incelenmiştir. Tablo 2'de farklı karbon fiyatlarının farklı güçlerdeki ısı pompalarının maliyet değişimi verilmiştir.

Tablo 2. Karbon Fiyatlandırmasının birim maliyete etkisi

Karbon	5 kW	8 kW	10 kW	12kW	16kW
0	0,014	0,014	0,0125	0,0135	0,012
10	0,015565	0,01666	0,015385	0,01653	0,016175
20	0,018695	0,02198	0,021155	0,02259	0,024525
30	0,02339	0,02996	0,02981	0,03168	0,03705
40	0,02965	0,0406	0,04135	0,0438	0,05375
50	0,037475	0,0539	0,055775	0,05895	0,074625
60	0,046865	0,06986	0,073085	0,07713	0,099675
70	0,05782	0,08848	0,09328	0,09834	0,1289
80	0,07034	0,10976	0,11636	0,12258	0,1623
90	0,084425	0,1337	0,142325	0,14985	0,199875
100	0,100075	0,1603	0,171175	0,18015	0,241625

Karbon fiyatlandırmasının birim maliyetteki değişimi Şekil 2'de verilmiştir. Herhangi bir karbon fiyatlaması uygulanmadığında, birim maliyet en düşük 16 kW gücündeki ısı pompasında, en yüksek maliyet ise en düşük güçlerdeki 5 ve 8 kW'lık ısı pompalarında görülmüştür. Karbon fiyatı 10 Euro olduğunda ise en düşük maliyet en düşük güçteki 5 kW'lık ısı pompasında hesaplanmıştır. Karbon fiyatının en yüksek olduğu durumda ise en yüksek maliyet 16 kWlık ısı pompasında, en düşük maliyet ise 5kW'lık ısı pompasında tespit edilmiştir.



Şekil 2. Birim Maliyet-Karbon Fiyatı

Karbon fiyatlanması olmadığı durumda en yüksek kapasiteli olan 16 kW'lık ısı pompalarının birim maliyeti en düşük olduğu görülmüştür. Karbon fiyatlandırması arttıkça daha az enerji harcayıp daha az karbon salınımı yapan düşük kapasiteli 5kW'lık ısı pompasının birim maliyetinin daha düşük olduğu görülmüştür.

III. SONUÇLAR

Sürdürülebilirlik açısından ekonomik, çevresel ve sosyal faktörlerin birlikte değerlendirilmesi gereklidir. Yenilenebilir enerji kaynakları, enerjide dışa bağımlılığın etkileri göz önüne alındığında büyük önem taşımaktadır. Son yıllarda hızla artan yenilenebilir enerji kurulu gücü bu önemi vurgulamaktadır. Ancak, bu yenilenebilir enerji kaynakları mevsimsel koşullara bağlı olduğundan çeşitli kısıtlamalara sahiptir. Dolayısıyla, mevcut sınırlı kaynaklarla, yenilenebilir enerjiye yapılan yatırımlardan en yüksek verim elde edilebilmesi için doğru planlama ve ekonomik analiz gerekmektedir. Bu durum, enerjinin tüm yönlerini detaylı bir şekilde ele alacak şekilde mevcut çalışmaların geliştirilmesini gereklidir.

Bu çalışmada hava, su ve toprak kaynaklı ısı pompaları karbon fiyatlandırması temelli birim maliyet hesaplanmıştır. Karbon fiyatlarının yükselmesiyle birlikte, düşük kapasiteli cihazların birim maliyetlerinde düşüş gözlemlenmiştir, zira bu cihazlar daha az enerji tüketip daha az karbon salınımı yapmaktadır. Yenilenebilir enerji projelerinin çekiciliğinin artması, yatırımcılar ve enerji şirketleri için cazip bir alan sunmanın yanı sıra çevresel etkilerin azaltılması ve sürdürülebilir enerji üretimi hedeflerine ulaşmada önemli bir adımdır.

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THE IMPORTANCE OF BEEKEEPING FOR THE FERTILIZATION OF PLANTS

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Abstract – With its bee colonies, honey-rich vegetation and suitable climate, it has great potential for beekeeping. Bees make a contribution to the country's economy that is approximately double the economic contribution of beekeeping by contributing to the efficiency and quality of crop production.

The purpose of this study is to explain that honey bees play an important role in pollination and can increase the efficiency and quality of crop production. In crop production, an external pollinator is often used to maintain the majority of species. When you look at this from this perspective, it becomes clear that many people realize how important beekeeping is to the continuity of the world.

Keywords – Beekeeping, pollination, plant production, quality

INTRODUCTION

1. Pollination and the importance of bees in pollination

The life cycle and continuity of most flowering plants in nature depend on the presence of suitable factors that ensure pollination or seed dispersal. Flowering plants need mechanisms that bring pollen to the stigmas of their flowers and thus ensure reproduction. Pollen transfer in this sense is called pollination or pollination. In terms of pollination, plants are studied under 3 main headings: polyphyletic (pollinated by several pollinators), oligophyletic (pollinated by several pollinator species) and monophyletic (pollinated by only one or very few pollinator species); in terms of pollination, pollinators are studied under 3 main headings: polytrophic (pollinating many plant species), oligotrophic (pollinating only a few plant species) and monotrophic (pollinating one or two plant species). All pollinators except the honeybee fall into one of these groups. However, although the honeybee is polytrophic, it exhibits very different characteristics, ranging from polytrophic to monotrophic behavior [1, 2].

The use of insects in pollination plays a role in increasing product quality in agricultural production and indirectly in animal production, and they create an ecological balance by ensuring the continuity of the

plant population. Bees provide 90% of pollination for plants that require cross-pollination [3, 2]. In addition, honey bees are considered primary pollinators due to their large colonies, ease of transportation and management [4]. For this reason, the use of bees for effective pollination in increasing the productivity of crop products will make a great contribution to the agriculture of our country [5]. The main reason why honeybees are the most effective pollinators is the hairiness of their bodies. Thank you to these structures, to which the pollen sticks and is carried, the pollination of plants is guaranteed. Worker bees, which collect nectar and pollen, are also indispensable elements of pollination. In addition, the attachment of honey bees to the flower, plot and region during nectar and pollen collection also makes an important contribution to this mechanism [6]. Pollination is the basis of fruit and seed production, and in many species, fruit and seed production is not possible without pollination. For this reason, bee colonies are needed during the flowering period to ensure sufficient pollination. If there is no pollination and fertilization, the fruits of many garden plant species fall off before they can complete their development. If there is insufficient fertilization, the fruits will remain on the plant by forming some seed heads, but the fruit shape will be distorted and the product quality will be low. In garden plants such as apple, pear, strawberry, fig, kiwi, tomato, eggplant and bell pepper, the formation and development of flowers, pollination and fertilization directly affect the quality and quantity of the product [7].

The lack of pollination by honeybees means that the species cannot produce enough seeds, and in terms of food production this means that they cannot produce seeds or fruit to be used as food. When you consider how many endemic plant species there are in our country and that most of them are pollinated by insects and the role that bees play in pollination, it becomes clear that beekeeping is an agricultural activity that does not harm nature, but on the contrary is very beneficial.

Advantages of pollination;

- The continuity of nature is guaranteed.

- The quality and quantity of the product increases.

- Earlier and more uniform products are obtained.

- The oil content of the seeds increases.

- The shape of the fruit is not distorted.

- High-quality hybrid seeds are obtained.

- Harvesting takes place on the plot at the same time.

- The variety of bee products is guaranteed.

- The population of bee colonies is increased.

- Timely harvesting means that the plants are less affected by diseases and pests.

The way in which the bees are positioned in the field or garden, the number of hives, the size of the hives, the bee colony, the type of plant, the air temperature and the quality of the product are also important factors in increasing pollination. If possible, the hives should be spread across the garden or field and not in a single area. It is also reported that 1-2 colonies per 4 decares may be sufficient for pollination of crops such as peach, cherry, plum, almond, apple, pear, mandarin, watermelon, pumpkin, vetch and cotton; 3-4 colonies per 4 decares may be sufficient for pollination of onion, sunflower, carrot, clover and red clover crops. The use of bees for pollination, which is not yet very well developed in our country, will become increasingly important in the coming years. The beekeeping sector in our country is developing day by day and new approaches are paving the way. New bee products and production techniques are spreading and pollination, which was not even known in the past, is taking its place on our agenda. Pollination, which is the basis of crop productivity, is also an inseparable part of the system on which the life of honeybees depends when it comes to obtaining a food source. It is not possible to consider one separately from the other. The ecosystem, which has reached a balance over millions of years of evolution and in which all living things have found their place, is constantly being damaged by the unnatural practices of humans. In this process, many pollinators involved in pollination are disappearing or their habitat is shrinking and their effectiveness is decreasing. While on the one hand agricultural pesticides are used to obtain more food, on the other hand non-target organisms are killed and destroyed.

This disruption of the natural balance inevitably brings other living beings to the fore. In this case, honeybees fill the gap left by the decline of wild pollinators by participating in pollination rather than contributing to the production of bee products. The sharp decline in honey bee colonies in recent years shows that more caution is needed in this regard. The fact that the problems that will arise from the loss of efficiency in crop production due to the lack of pollinators will affect the balance between supplyand demand for crop products has not yet reached a level that will cause unrest among the population. A solution can be found with the measures to be taken at this stage. Trying to increase the presence of wild pollinators is always on our agenda as a proposed solution. However, this is not so easy. Despite everything, honeybees are still an alternative in this respect. This is because, unlike other pollinating insects, honey bees are commercially and economically important in every respect, as they provide bee products such as honey, pollen and royal jelly in addition to pollination. For these reasons, it is a positive development for both plant breeders and beekeepers to understand this fact. In countries where beekeeping is advanced, this

problem has been overcome and breeders from both sectors are working together by creating an organic link. In order to be able to say that I am in the agricultural sense in a rapidly developing world where this process is inevitable in our country, it is a prerequisite to produce on large areas and maximize the product obtained from the unit area. To this end, in addition to cultural practices such as the use of quality seeds, fertilization and irrigation, it is also necessary to ensure pollination instead of leaving it to chance. This awareness is not far off for our growers. The fact that some local practices have begun in this regard are important pointers for the future. This process, which has partially started especially in sunflower and rapeseed growing areas, will also be reflected in other plant products [8].

Conclusion

With regard to pollination practices in agriculture, both farmers and beekeepers should be made aware of this issue through government measures and public studies. Interest in environmentally friendly agricultural practices and organic agricultural products is increasing day by day. The prices of naturally produced products for a healthy life are an indicator of this. However, the goal of reducing the use of pesticides in agriculture, which is the biggest factor in the decline of the bee population, will be the biggest gain if awareness continues to grow. As the use of bees in pollination increases, the profit that beekeepers make in this way will empower our country, which has an important place in the world in beekeeping. Considering all these situations, one should know well the pollination necessary for the continuity of plants and bee generations, and more importantly, the fertilization biology of plants for the continuity of ecological balance and human generation, and understand the importance of bees in this regard.

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Statistical and Psychometric Analysis of a Test

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Abstract – This material presents the statistical and psychometric study of a test with SPSS and Tia Plus. Referring to the results database, the test as a whole and each question in particular is analysed. In this way, we can understand which parts of the program have been learned properly or not by the students. The data obtained from both software SPSS and Tia Plus were used to organize information in graphical form and tables.

Keywords – exam test, SPSS, Tiaplus, difficulty, graph

I. INTRODUCTION

Creating a test for students requires knowledge of the program at all levels of study and includes different levels of cognitive difficulty and the relative weight of the program content. Referring to the difficulty distribution table, a blueprint is constructed.

This study includes:

- The assessment objectives based on which each test is designed
- Statistical and psychometric data
- Interpretations of some questions
- Conclusions on the progress of each test
- Tips for subject teachers guiding them in studying the textbook.

II. METHODOLOGY

For the preparation of the material, the national assessment database for all tested students was used for comparative statistical analysis, while for the technical analysis, data obtained from sampling around 10% of students from each directorate or educational office were used. Data processing and analysis were carried out according to the following procedure:

- Statistical and psychometric processing was done using SPSS and TiaPlus software
- Information is organize in graphical form and tables.

III. Statistical and Psychometric Indicators for Technical Analysis:

- Average scores obtained by students in the test
- Standard deviation of scores obtained by students
- Percentage of student responses for each item
- Standard deviation (SD) of test item difficulties
- Average student achievement (ability)
- Test reliability coefficient
- Item difficulty coefficient RSK
- Item discrimination coefficient Rit
- Standard error of measurement
- Average value-p
- Average Rit coefficient
- Guttman's Lambda2 coefficient
- GLB coefficient

IV. General Statistical and Psychometric Indicators of the Test:

- Number of students in the exam: 7275
- Number of test items: 27
- Minimum score in the test: 0
- Maximum score in the test: 50
- Maximum score obtained in the test: 50
- Average test score: 23.03
- Difficulty level of the test (for students): Average
- Standard deviation (SD): 10.30
- Average value-p: 46.06
- Standard error of measurement: 3.68
- Test reliability coefficient (Cronbach Alpha): 0.87
- Test reliability: High
- Guttman's Lambda2 coefficient: 0.89
- Standard error according to Alpha coefficient: 0
- GLB coefficient: 0.93

A. Figures and Tables

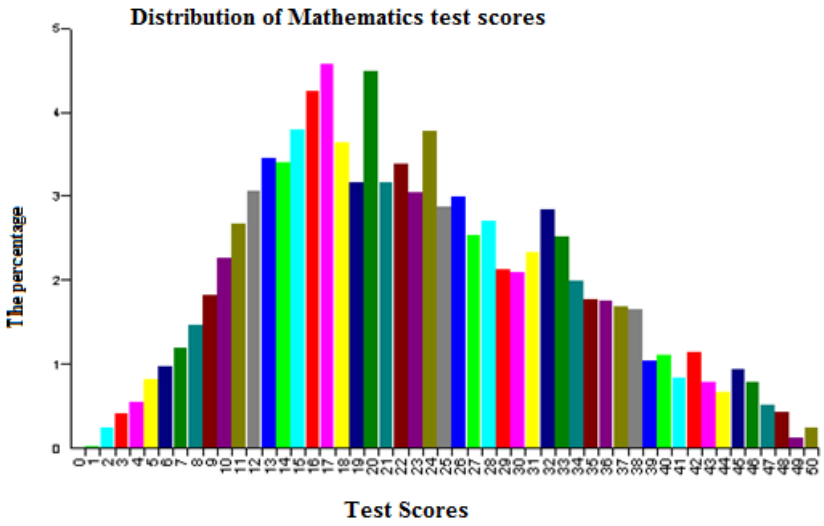


Fig 1. Distribution of test scores

Table 1. Table of Psychometric Indicators of the Test

Request	*Max*	*Average*	*P*	*Sd*	*RSK*	*[Low-Rit-High]*	*Rir*	
1	1	0.92	92	0.28	0.28	2 4 6		2
2	1	0.69	69	0.46	0.46	38 40 42		36
3	1	0.89	89	0.31	0.31	23 25 27		23
4	1	0.74	74	0.44	0.44	32 34 36		30
5	1	0.45	45	0.50	0.50	33 35 37		31
6	1	0.80	80	0.40	0.40	33 35 37		32
7	1	0.68	68	0.47	0.47	37 39 41		35
8	1	0.88	88	0.33	0.33	23 25 27		22
9	1	0.76	76	0.42	0.42	28 30 32		26
10	1	0.81	81	0.39	0.39	25 27 29		23
11	1	0.82	82	0.39	0.39	23 25 27		22
12	1	0.84	84	0.37	0.37	29 31 33		27
13	1	0.75	75	0.43	0.43	26 28 30		24
14	3	1.96	65	1.32	0.44	56 58 59		48
15a	2	1.40	70	0.79	0.40	58 60 61		54
15b	1	0.35	35	0.48	0.48	44 45 47		42
16	3	1.73	58	1.32	0.44	62 63 64		54
17	3	1.13	38	1.16	0.39	63 64 66		57
18	3	0.25	8	0.63	0.21	47 49 51		44
19	3	1.18	39	1.28	0.43	71 72 73		66
20	3	0.62	21	1.07	0.36	61 62 64		55
21	3	0.40	13	0.95	0.32	54 55 57		49
22	3	1.24	41	1.29	0.43	69 70 71		63
23	3	1.06	35	1.19	0.40	72 74 75		68
24a	2	0.58	29	0.84	0.42	61 63 64		57
24b	2	0.52	26	0.79	0.39	61 62 64		57
25	3	0.59	20	0.81	0.27	57 58 60		53

Table 2. Tables of Percentages for Each Test Item Alternative

Request	**Alternatives**				**More than one answer**	**No answer**
	A	**B**	**C**	**D**		
1	3.63%	2.68%	91.55%	1.31%	0.78%	0.04%
2	2.71%	69.47%	2.52%	21.28%	3.85%	0.18%

3	3.49%	89.13%	3.52%	2.32%	1.40%	0.14%
4	8.27%	73.95%	9.28%	4.93%	3.31%	0.25%
5	45.33%	20.69%	15.93%	13.65%	3.96%	0.44%
6	80.07%	14.65%	3.77%	0.82%	0.63%	0.04%
7	4.60%	11.41%	13.55%	67.68%	2.32%	0.41%
8	6.30%	87.74%	2.49%	1.94%	1.32%	0.21%
9	7.04%	5.32%	76.41%	8.76%	2.35%	0.12%
10	3.97%	5.92%	6.03%	81.17%	2.60%	0.30%
11	6.74%	81.70%	3.78%	5.48%	1.70%	0.59%
12	83.74%	4.22%	5.70%	4.21%	1.66%	0.45%
13	14.54%	3.60%	74.78%	4.12%	2.20%	0.76%

The table below provides the frequencies of points according to the number of students and percentages, as well as the cumulative frequencies for the Mathematics test:

Table 3. Percentage tables for each test score point

Points	***Absolute***	***Absolute percentage***	***Cumulative frequency***	***Cumulative frequency percentage***
1	2	0.03	2	0.03
2	17	0.23	19	0.26
3	30	0.41	49	0.67
4	40	0.55	89	1.22
5	60	0.82	149	2.05
6	71	0.98	220	3.02
7	86	1.18	306	4.21
...	...	...	...	...
49	9	0.12	7257	99.75
50	18	0.25	7275	100.00

Table 4. Cumulative score distribution graph

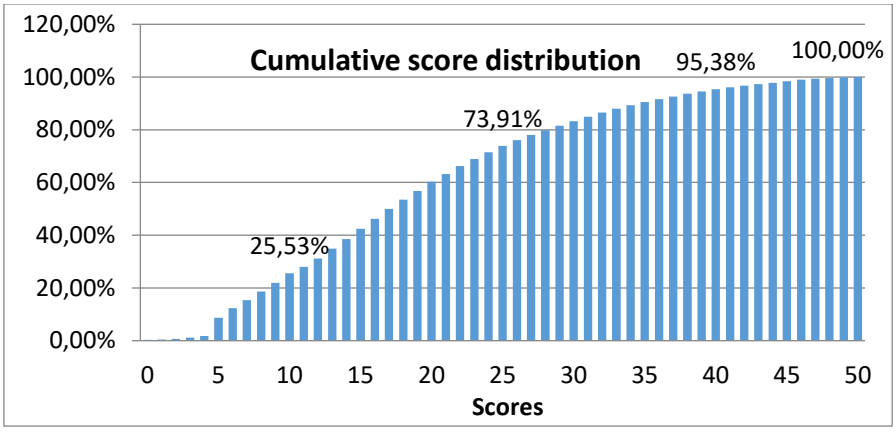


Table 5. Percentage table

Percentages	Points	Z	Number of students
P1	4.1	-1.8	69
P5	8.0	-1.5	359
P10	10.6	-1.2	626
P15	12.3	-1.0	1014
P25	15.2	-0.8	1762
P50	21.7	-0.1	3476
P75	30.6	0.7	5369
P85	34.8	1.1	6075
P90	37.7	1.4	6466
P95	42.0	1.8	6907
P99	47.1	2.3	7198

V. GRAPHS FOR EACH TEST QUESTION

The following graphs provide the respective percentages of students based on the answers they gave to each question. Students are classified into 4 groups based on the points they scored on the test.

In the group:

- 1 are the students who scored 0-12 points;

- 2 are the students who scored 13-25 points;

- 3 are the students who scored 26-38 points;

- 4 are the students who scored 39-50 points.

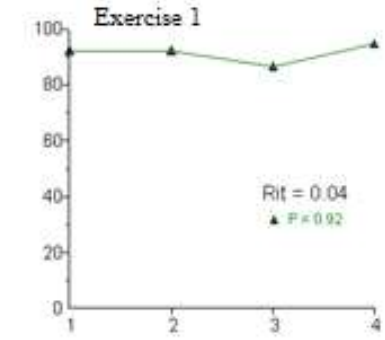
Thus, for the graph of question 1, approximately:

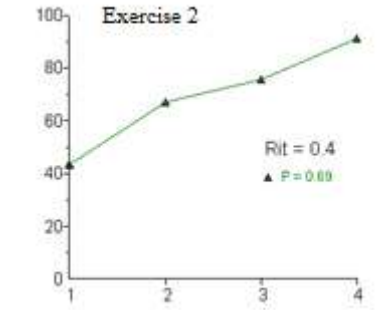
- 92% of the students in group 1 responded

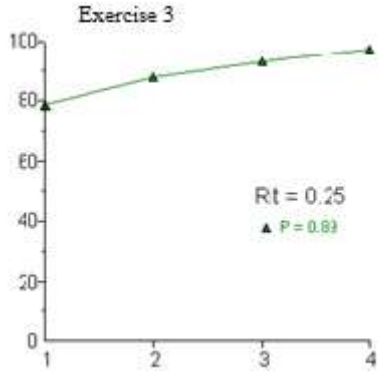
- 94% of the students in group 2 responded

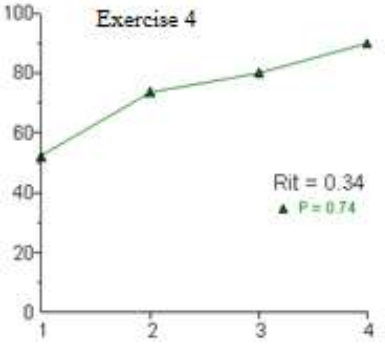
- 90% of the students in group 3 responded

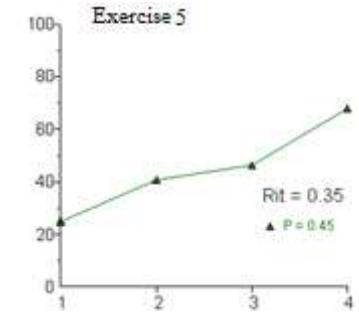
- 98% of the students in group 4 responded

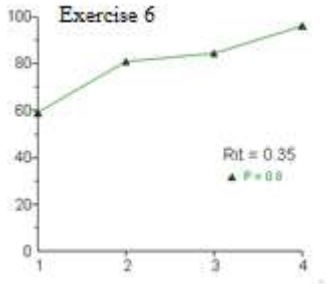

Exercise 1
100
80
60
40
20
0
1
2
3
4
Rit = 0.04
P = 0.92

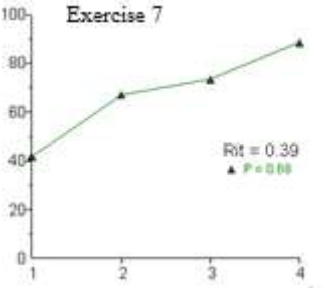

Exercise 2
100
80
60
40
20
0
1
2
3
4
Rit = 0.4
P = 0.69

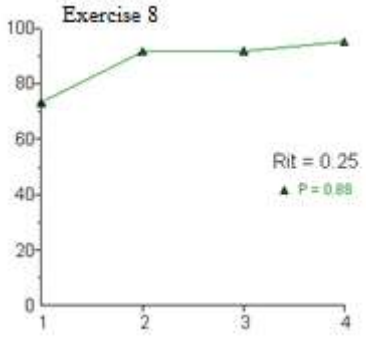

Exercise 3
100
80
60
40
20
0
1
2
3
4
Rit = 0.25
P = 0.83

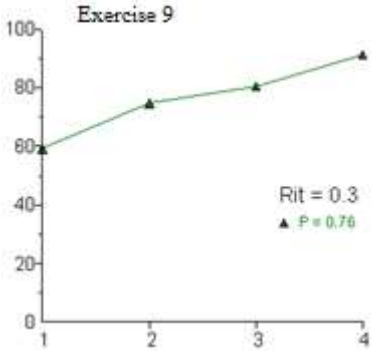

Exercise 4
100
80
60
40
20
0
1
2
3
4
Rit = 0.34
P = 0.74


Exercise 5
100
80
60
40
20
0
1
2
3
4
Rit = 0.35
P = 0.45


Exercise 6
100
80
60
40
20
0
1
2
3
4
Rit = 0.35


Exercise 7
100
80
60
40
20
0
1
2
3
4
Rit = 0.39


Exercise 8
100
80
60
40
20
0
1
2
3
4
Rit = 0.25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60
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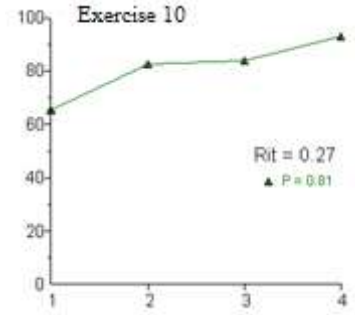
20
0
1
2
3
4
Rit = 0.3
P = 0.76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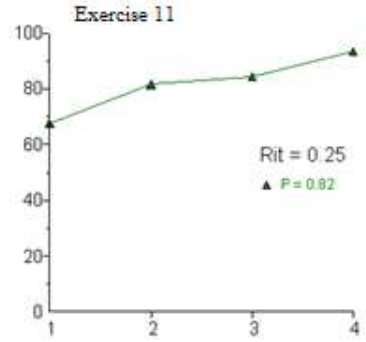
80
60
40
20
0
1
2
3
4
Rit = 0.27
P = 0.81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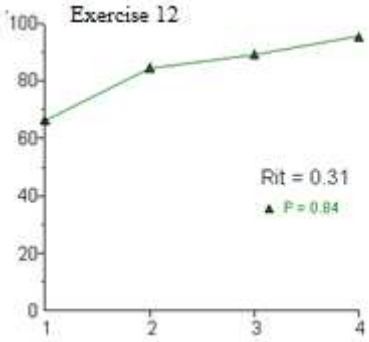
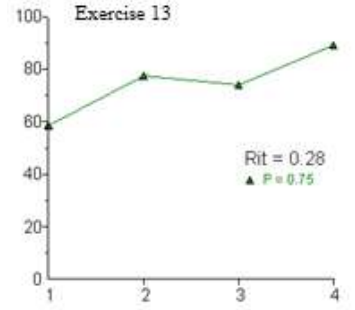
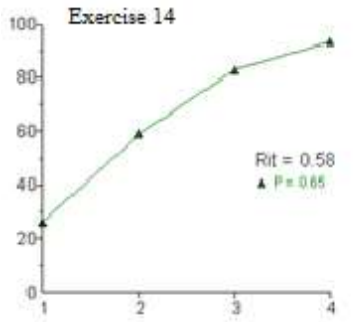
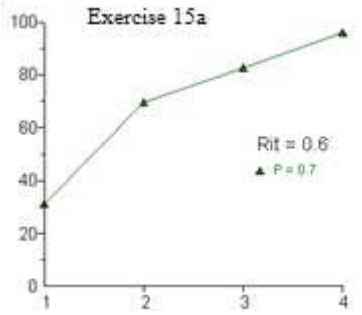
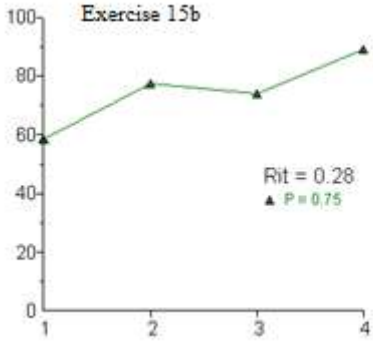
80
60
40
20
0
1
2
3
4
Rit = 0.25
P = 0.82

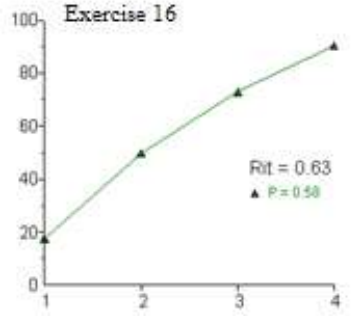

Exercise 12
100
80
60
40
20
0
1
2
3
4
Rit = 0.31
P = 0.84

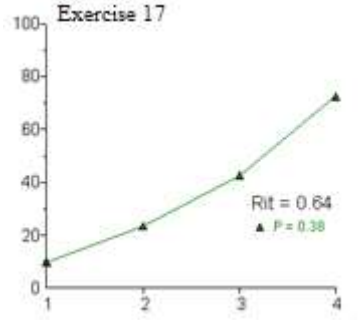

Exercise 13
100
80
60
40
20
0
1
2
3
4
Rit = 0.28
P = 0.75

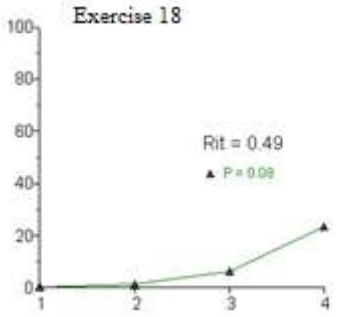

Exercise 14
Rit = 0.58
P = 0.65

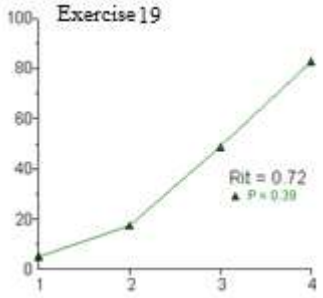

Exercise 15a
Rit = 0.6
P = 0.7

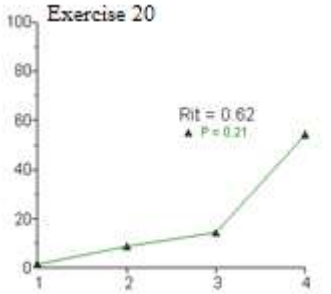

Exercise 15b
Rit = 0.28
P = 0.75

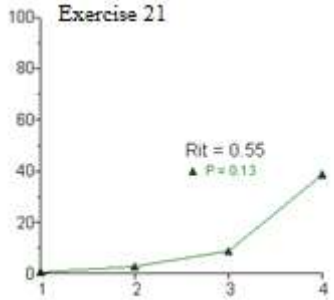

Exercise 16
Rit = 0.63
P = 0.58

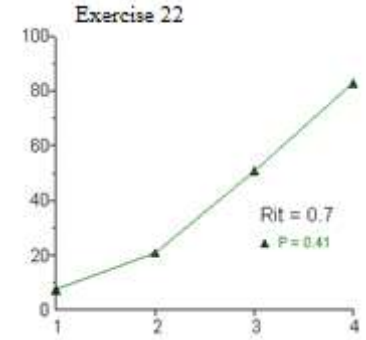

Exercise 17
Rit = 0.64
P = 0.38

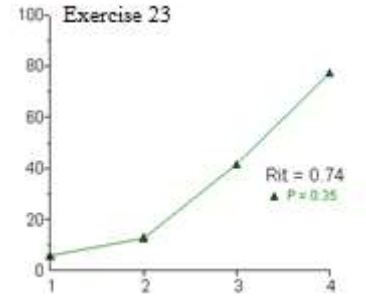

Exercise 18
Rit = 0.49
P = 0.09

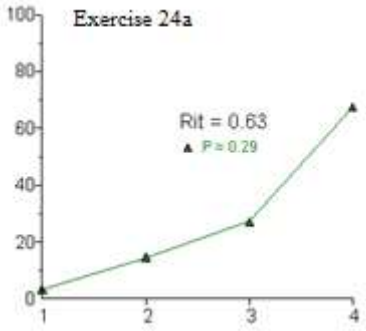

Exercise 19
Rit = 0.72
P = 0.39

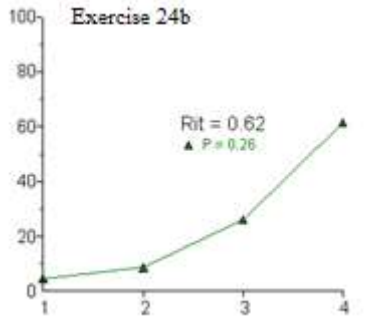

Exercise 20
Rit = 0.62
P = 0.21

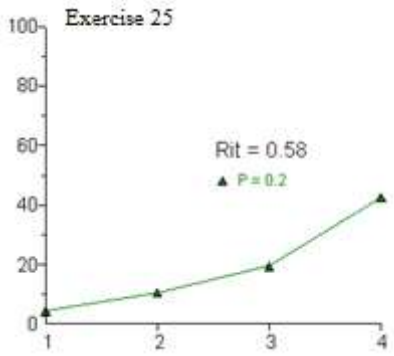

Exercise 21
Rit = 0.55
P = 0.13


Exercise 22
100
80
60
40
20
0
1
2
3
4
Rit = 0.7
P = 0.41


Exercise 23
100
80
60
40
20
0
1
2
3
4
Rit = 0.74
P = 0.35


Exercise 24a
100
80
60
40
20
0
1
2
3
4
Rit = 0.63
P = 0.29


Exercise 24b
100
80
60
40
20
0
1
2
3
4
Rit = 0.62
P = 0.26



VI. COMMENTS AND ANALYSIS

Difficulty level of the test (for students): Medium

Average points scored on the test: 23.03

- Maximum points on the test: 50
- Maximum points scored on the test: 50
- Comments on multiple-choice questions
- From the graphs, we conclude:
- Comments on open-ended questions
- These questions have performed well in
- accordance with the test's objective. They all turned out
- to be at the first level of difficulty.
- The questions easier than the others are 1, 3, 8, 10, 11, 12.

Table 5. Coefficient of difficulty

Ex	P(co of difficulty
1	92
2	65
3	89
4	74
5	45
6	80
7	68
21	13
...	...
22	41
23	35
24a	29
24b	26
25	20

Comments on open-ended questions
These questions have proven to work very well from a statistical perspective. There were no questions that were easier
than necessary, or in other words, too easy. The easiest questions compared to the others in this group are questions 14,
15a, and 16. Among these, the easiest is 15a.

VII. CONCLUSION

Statistical and psychometric processing was done using SPSS and TiaPlus software.
Students achieved an average score in the mathematics test. In the group of multiple-choice questions, the hardest question is 5.

In the group of open-ended questions, the hardest question is 18, in fact, it was planned to be at level three of difficulty. In the group of multiple-choice questions, the achievements are high. This is also explained by the fact that most of these questions are planned to be at levels I and II.

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Impact of Microcredit on the Albanian Economy

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Abstract – The aim of this study is to evaluate the impact that microfinance institutions have on individuals and the Albanian economy by analyzing a series of variables. Microfinance is considered a financial innovation for the role it plays in the development of poor countries. This paper analyzes the impact of microloans and the factors that positively or negatively influence them.

Keywords – microloans, impact, microfinance institutions, economy

I. Introduction

The Albanian economy is still developing, along with a series of countries that were under the communist system for decades. The financial system is very important for an economy as it is its main engine, financing the economy.

The microfinance market has over 50% of its distribution outside urban areas, which also constitutes the concentration of the lower-income population. By 2018, the microloan portfolio reached 16.3 billion lek, which constitutes 3% of the financial sector and about 20% of total credit.

The issue at hand is how much the microfinance sector has really influenced so far and what are the possibilities for development. An important point is to understand whether the lending to different individuals has positively or negatively impacted their social and economic development.

Digitalization has also influenced the development of this sector, where some microfinance institutions use technology as their source of demand, greatly facilitating the procedures required to obtain credit. These are mainly applied for small amounts and are primarily used for consumption.

Hypothesis of the Study

Microfinance Institutions positively impact economic development in Albania.

II.a Purpose of the Study

The main purpose of this study is to understand the importance of microfinance institutions in the country's economy and its development. Another aim of our paper is to understand the recent growth trend of this sector and to understand how microcredit realistically impacts the individuals/businesses that are credited.

This sector is particularly important in helping economically disadvantaged individuals, but on the other hand, these institutions aim for positive results in their financial statements.

Research Questions

- Has microfinance positively impacted economic development in Albania?
- Is it easy to obtain financing from the microcredit sector?

II.b Research Objectives

- To assess the positive or negative impact that lending from the microfinance sector has.
- To evaluate the reasons for this positive or negative impact.
- To assess the difficulties encountered in obtaining a microloan.
- To investigate the current environment of the microfinance sector.
- To evaluate the development of this market, how it has evolved, and the challenges it faces for the future.

II.c Importance of the Study

Microfinance has often been seen as a solution to combat poverty. Especially in poor countries where it has been applied, it has been concluded that it plays an important role in the economic development of a developing society and significantly reduces poverty.

With access to financial services, many individuals manage to have a better livelihood, better education, etc.

Many researchers have paid attention to microfinance by studying new application methods and how credit products can be improved.

III. Overview of Microfinance Institutions

Microfinance Institutions are a set of financial services created to serve individuals who cannot access the banking sector. "It's not the people who are not creditworthy. It's the banks that are not worthy of having people" [10]. This was one of the famous quotes of Muhammad Yunus in the book "Banker to the Poor".

Access to improved financial services - the ability to convert savings into larger sums - helps poor people avoid sinking deeper into poverty and helps them lay the foundation for their ambitions to improve themselves and their families [12]. Ndiaye (2005) defined microfinance as providing financial services to the poor who traditionally are not served by conventional financial institutions.

To understand how microcredit can perform better in the country it operates, we must consider the individuals it targets for financing. Egerta Marku (2016) writes that lenders want borrowers to have collateral opportunities to have sufficient incentives to repay, and as a result, poor borrowers receive small loans.

IV. What is a Microfinance Institution?

Simply put, a microfinance institution is considered an organization that, among other things, offers financial products to poor families.

Many microfinance institutions are non-governmental organizations committed to helping certain sectors of the low-income population.

The concept of microfinance institutions has over time included more and more types of these organizations offering these services, for example, non-governmental organizations, credit unions, private and commercial banks, non-bank financial institutions, and also non-private banks.

V. The Impact of Microfinance on the Development of Poor Countries

Microfinance has built a consistent record as a critical tool in the fight against poverty and has entered the mainstream financial flow.

The rapid growth of the industry over the past 20 years has reached about 130 million clients, according to recent estimates. However, microfinancing still reaches less than 20 percent of its potential market among the three billion or more poor in the world. IFC is one of the key global investors in terms of volume.

In 2014, the International Financial Corporation invested $519 million in 47 projects with IMF. IFC's cumulative microfinance investment portfolio exceeded $3.5 billion with outstanding commitments of $1.68 billion [7].

About three billion people in developing countries have little or no access to formal financial services. Financial services for the poor are a powerful tool for poverty reduction, enabling them to build assets, increase income, and reduce their vulnerability to economic stress. Formal financial services such as savings, loans, and money transfers enable poor families to invest in enterprises, better food, better living conditions, healthcare, and the education of their children. Microfinance has also been a powerful catalyst for women's empowerment.

Before the creation of Microfinance Institutions, banks were inaccessible to the poor, and lenders exploited many individuals who were not valued by banks as potential clients, especially in developing countries.

Today, access to the financial sector is more widespread, giving access to a large part of society. Microfinance can be described as an economic innovation that fights poverty [7].

Figure 1. Non-bank financial entities in Albania

Financial institutions not Banks	Loan	Microloans
FAF Sha	√	
Fondi BESA	√	
NOA Sha	√	
FIN - AL	√	
AK Invest	√	
Tranzit	√	
Credins Leasing	√	
Capital Invest		√
Microcredit Albania		√
Iutecredit Albania		√
Agro Partner		√
Kredo Financiare		√

Source: Bank of Albania, annual supervision report 2017

VI. Contribution of Microfinance Institutions to Society

Microfinance Institutions impact several aspects of society, but the two main aspects are social impact and economic impact.

VI.a Social Impact

Over the past 25 years, there have been financings for small entrepreneurs and farmers, promoting entrepreneurship to develop. Microcredit has also contributed to reducing unemployment and social exclusion, as access to financial services has enabled these individuals to access products and services that they would not otherwise have been able to possess.

Geographic Dimension

Microfinance is distributed in different areas of Albania, enabling nearly 100% coverage, being as close as possible to the demand for financing.

Gender Dimension

Over the years, it has been possible to empower women's entrepreneurship by providing equal access to financing. Now, women's responsibility has increased, although there is still much to be done.

VI.b Economic Impact

Microfinance also plays an important role in economic development. According to AMA, for every new loan, it is estimated that 1.4 new jobs are created, mainly for start-up businesses. Over the years, microfinance institutions have credited more than 350,000 small entrepreneurs, farmers, and families throughout Albania, injecting over 1 billion dollars into the national economy. It is also worth noting that microcredit has a higher quality portfolio than the banking sector. Currently, bad loans are estimated at 13% of the total, while microcredit estimates 5% bad loans of the total. In fact, microfinance has a small part compared to GDP. According to the Bank of Albania, it constitutes only 3% of the financial sector, a very small figure considering the need that many rural areas have for financing.

VII. Results: ECONOMETRIC ANALYSIS

We will address the impact that some variables have on the economic life of a borrower from microfinance institutions. We statistically evaluate which variables have influenced and how this can be used for prediction.

To analyze this model, we will use the Logit model, and the analyses will be processed through the statistical program Eviews.

In selecting the variables, three independent variables were considered for the first model, which are:

X1 = Loan Amount
X2 = Interest Rate
X3 = Duration of the Loan

These variables were chosen considering that in similar studies, they have been important variables regarding microfinance. And the dependent variable in this case is binary "Impact":

Y = 0 | Negatively
Y = 1 | Positively

Model Hypotheses

Base Hypothesis H0 = The model is not significant

Alternative Hypothesis Ha = The model is significant

H0 = The positive impact is not affected by the variables interest rate, loan amount, and its duration.

Ha = The positive impact is affected by the variables interest rate, loan amount, and its duration.

In the table below, the relationship between the independent variables is also presented, where the relationship between the amount and time is noted, which is normal since the time distribution of the installments is based on the amount.

Figure 2 Correlation between independent variables

Correlation

	Vlera	Kohezjatja	Norma
Vlera	**1**	0.7321	0.1166
Kohezjatja	0.7321	**1**	0.0009
Norma	0.1166	0.0009	**1**

Figure 3 Result of econometric analysis

Convergence achieved after 4 iterations
Coefficient covariance computed using observed Hessian

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.947830	0.682720	2.853042	0.0043
VLERA	0.599858	0.304039	1.972967	0.0485
NORMA	0.298044	0.137919	2.161003	0.0307
KOHEZJATJA	-0.714321	0.273968	-2.607314	0.0091

McFadden R-squared	0.126233	Mean dependent var	0.843284
S.D. dependent var	0.364897	S.E. of regression	0.345436
Akaike info criterion	0.818454	Sum squared resid	15.51242
Schwarz criterion	0.904957	Log likelihood	-50.83642
Hannan-Quinn criter.	0.853606	Deviance	101.6728
Restr. deviance	116.3615	Restr. log likelihood	-58.18074
LR statistic	14.68863	Avg. log likelihood	-0.379376
Prob(LR statistic)	0.002103		

Obs with Dep=0	21	Total obs	134
Obs with Dep=1	113		

As can be seen from the table above, this model is statistically significant, where $p < 0.05$ according to the "LR statistic" indicator, and the relationship between the independent variables in this model is also significant as the probability $p < 0.05$.

We conclude that in this model the probability $p < 0.05$, thus rejecting H0 and accepting Ha.

Therefore, the impact of non-bank financial institutions is calculated using the binary probability according to the dependent variable and the scaled probability according to the independent variables as follows:

Logit: Y = 1.94 + 0.6 * Amount + 0.3 * Rate - 0.71 * Duration

$$P(Y) = \frac{e^{1.94 + 0.6*\text{Vlera} + 0.3*\text{Norma} - 0.71 * \text{Kohëzjatja}}}{1 + e^{1.94 + 0.6*\text{Vlera} + 0.3*\text{Norma} - 0.71 * \text{Kohëzjatja}}}$$

Value and rate have a positive relationship in this equation while duration has a negative relationship. In this sector, the amounts given as loans are small, the interest rate is high compared to the banking sector, and the duration is in the short term. Therefore, we can say that Microfinance Institutions influence the economic development of a country.

VIII. DISCUSSION

The main goals of Microfinance Institutions in Albania should be:

- Reduction of poverty,
- Increase of living standards,
- Promotion of small and medium-sized businesses.

Another evident recommendation from this research is that there should be more cooperation between microfinance institutions, banks, and non-governmental organizations. To have better performance and results, the process of technology exchange between these institutions is considered a strategic plan.

IX. Conclusions

Microfinance institutions worldwide have played and continue to play an important role in the economic and social development of developing countries and beyond.

It is estimated that access to financial services by low-income individuals offers them an opportunity to consume products or services that they would not otherwise possess, which positively impacts their social and economic development. In Albania, this sector is still developing, discovering new markets especially in rural areas where the need for financing is greater. It is noted that even though it is a competitive market, there are still areas that have not been financed.

This paper discussed the economic impact that microfinance institutions have on the economic development of a country. Many successful microcredit financial models have been implemented in developing countries with the support of international institutions such as the World Bank.

Additionally, microfinance has also played an important role in women's empowerment by providing them access to financial services, which proved to have a dual impact on their families as women used the borrowed funds more effectively.

Microfinance has positively impacted the financial support for small and medium-sized businesses, which in many countries constitute a large and important market for the economic development of a country.

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Effects of Udder Characteristics on Milk Yield, Mastitis and Somatic Cell Numbers in Dairy Cattle

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Abstract – Milk is an indispensable food in people's daily diet. Especially for healthy milk consumption, quality and safe production is required. The health status and genotypic characteristics of cattle also directly affect their milk yield.

There is a relationship between the health of the udder and the number of milk somatic cells in dairy cattle that cannot be ignored. When mastitis is encountered in dairy cattle, the number of somatic cells increases before clinical symptoms. Therefore, somatic cell count measurements are also used to detect mastitis in cattle. In a healthy breast, there are less than 200,000 somatic cells in 1 milliliter of milk. A somatic cell count above 200,000/ml is considered a sign of mastitis.

Different teat shapes have effects on mastitis and somatic cell number. In addition, there are genetic and phenotypic relationships between the number of somatic cells and breast characteristics such as mastitis and breast connection, diameter of the teats, height of the teats from the ground, teat length, and distance between the teats. Therefore, in reducing mastitis formations within the herd; When making selection, it is recommended to select dairy cattle with features such as low somatic cell count, tighter front teat connection, shorter teats and narrower teat placement. This study aimed to determine the relationships between mastitis and somatic cell number and the effects of different breast characteristics on mastitis and somatic cell number.

Keywords – Dairy cattle, milk yield, mastitis, somatic cell count, udder characteristics.

1.INTRODUCTION

Milk, one of the animal products, has a very important place in human nutrition. Milk contains many nutrients such as minerals, vitamins, proteins, fats and lactose and is beneficial for health. Milk is found on the table as a variety of products, cheese and milk being the most important ones. The udder, which is the part of the animal's body where milk is produced, is directly effective in milk production. Mastitis, especially in dairy cattle, poses a major problem for breeders. In fact, dairy cattle enterprises all over the world suffer millions of dollars in losses due to mastitis. Therefore, the case of mastitis should be determined immediately within the herd and the necessary precautions should be taken. For this purpose, Somatic Cell Count (SCC) is used as an indirect criterion in determining mastitis. Udder diseases disrupt milk production and milk quality. When udder health deteriorates, it is understood whether there are some problems by looking at the somatic cell count (SCC) before clinical symptoms are seen and mastitis is directly suspected. There are very large relationships between udder diseases and udder characteristics. Udder shapes that are prone to udder diseases also cause a decrease in milk yield. In the study, the relationship between udder characteristics and mastitis, somatic cell count and milk yield was mentioned.

2. STRUCTURE OF THE UDDER IN DAIRY CATTLE

As in all mammals, the udders are structures that produce external secretions as a result of skin differentiation. The normal empty udder load of a cow is between 12 and 30 kg [1]. The front udder sections (lobes) are smaller than the back udder sections. Each udder section consists of the head of the udder, the canal of the udder, the chamber of the udder, the chamber of the udder, the alveoli and the milk collection duct. The most important ligament connecting the udder to the body is the medial suspensory ligament. At the point where the udder gap is connected, there are 7-8 weakly structured Fürstenberg rings made of membranes and a groove surrounded by a strong muscle called the Sphincter. The function of the above-mentioned structures is to prevent the flow of milk from the reservoir of the mammary gland to the reservoir of the teat, except for milking and sucking by the calf. ([2], [3]). The alveoli, which form the secretory tissue of the udder, are microscopic, almost spherical in shape and are surrounded by a row of epithelial cells. Epithelial cells provide the secretion of milk by synthesizing the substances that make up milk from the nutrients carried to them by the blood [1]. The breast has a very large circulation organization; 400–500 liters of blood must come and go from the breast to produce one liter of milk [4].

3.MASTITIS

It is an inflammatory udder problem caused by microorganisms in the mammary glands that reduces milk yield in cows. Infection occurs due to infectious agents such as bacteria, yeast, fungi and viruses, litter, stress, injuries, high-calorie feeds, many factors related to the cow and the environment, and the number of blood proteins and white blood cells in the milk increases [5]. Mastitis, which is an infectious inflammation of the mammary tissue, negatively affects the welfare of animals. It is generally divided into 2 as clinical and subclinical. While clinical mastitis can be diagnosed visually by redness, swelling, pain, general condition disorder and change in the structure of the milk in the mammary gland, subclinical mastitis develops depending on the number of somatic cells in the milk and does not cause any clinical findings [6]. Mastitis causes a decrease in milk yield by approximately 10%, which results in a large annual economic loss. In the California Mastitis Test (CMT), SCC is used as a criterion for udder inflammation and it is reported that it should be less than 100,000 cells/ml in milk obtained from a healthy udder lobe [7]. In their study to determine the factors affecting mastitis [8], they found that mastitis increases with age and that Holstein cattle have a higher tendency to develop mastitis than Simmental cattle.

4. RELATIONSHIPS BETWEEN THE CHARACTERISTICS OF THE UDD AND MASTITIS AND SOMATIC CELL COUNT

The structural characteristics of the udder are considered as indirect selection criteria in terms of low somatic cell count and mastitis resistance ([9], [10], [11]).

4.1. Teat Diameter

This term is the thickness measurement of the central part of the teat. It is reported that CMT + cattle have larger teat diameters than CMT – cattle [12].

4.2. Teat Length

Ideal teats should be cylindrical, medium length and diameter, and of the same size. The front teat length is the vertical distance from the part where the front teat joins the udder to the tip of the teat. The back teat length is the distance from the part where the back teat joins the udder to the tip of the teat [13]. The optimum teat should be round, of appropriate size, medium thickness, and of equal size. The teat pens should extend from where they are attached to the udder to the ground at a right angle [14]. It is stated that there is a close relationship between teat pen length and mastitis, and that the teat pen length of CMT+ cattle is longer than that of CMT- cattle, but this ratio is not statistically significant [15]. Considering these, larger teats make them more prone to many negative effects. It has been stated in the study conducted by [16] that by selecting for smaller teat pens, also taking milking into account, the resistance of the next generation to mastitis and milk yield can be increased. [17] conducted a study to determine the relationship

between some udder characteristics and the number of somatic cells in milk, and conducted separate tests and teat measurements for each teat in high, medium and low yield groups. It was determined that the relationship between teat score and CMT in high and medium yield groups was statistically significant (p0.05), and it was determined that the relationship between CMT and teat score was significant in all other groups. In their study [18] to determine the relationships between udder and body measurements and somatic cell count, the relationship between milk yield and somatic cell count was not found to be statistically significant (P>0.05). The mean logSCC value was found to be the lowest 2.425±0.138 and the highest logSCC value was found to be 2.557±0.142 compared to the control months. Among the udder characteristics, significant relationships were found between the diameter of the front teats, the distance between the back teats and the length of the back teats and the number of somatic cells (P<0.05). In addition, the relationship between the diameter of the front teats and milk yield was found to be significant (P<0.05).

4.3. Distance Between Front Teats

It is the horizontal distance between the tips of the front teat pencils ([13], [14]). As the distance between the front teat pencils increases, the number of somatic cells and the probability of clinical mastitis have been observed to increase, there is a phenotypic interaction of up to 0.08 in the interaction between teats and somatic cells [19]. The decrease in the distance between the front teat pencils increases the resistance to mastitis [20].

4.4. Distance Between Back Teats

It is the horizontal distance between the tips of the back teat pencils ([13], [14]). As the distance between the back teats increases, the susceptibility to mastitis decreases, this was not found to be statistically significant. A phenotypic relationship of up to 0.22 was determined between somatic cell count and the back trait in question [19]. However, the use of those with a short distance between the back teat tips in breeding makes the next generation more resistant to mastitis.

4.5.Distance Between Lateral Teats

It is the horizontal length between the front and back teats ([13], [14]). In one study on the length between the side teats, a phenotypic relationship of 0.20 was found for clinical mastitis, while in another, this ratio was found to be 0.26. In another study, it was found to be -0.07 [21].

4.6.Udder Central Ligament

This ligament is the basic connection that extends from front to back, as if dividing the breast in two from the center, and holds the udder to the body. It is desired that this ligament is more visible, otherwise sagging will occur in the future and may harm the productive life of the animal ([22], [23]). The risk of mastitis increases as sagging udders are injured due to their proximity to the ground and are invaded by harmful microorganisms from the surroundings [21]. According to these, it is desired that the central udder ligament is strong, but it should not be so strong that it overlaps the udder.

4.7. Udder Depth

The maximum depth that the lowest part of the udder that is strongly attached to the body can reach is desired to be up to the ankle of the hind leg. Those above this distance have a lack of capacity, and those below have a sagging problem [23]. Having higher udders reduces somatic cell count and therefore reduces the tendency to mastitis [9].

4.8. Teat Placements

It does not refer to whether the udders face outward or inward, but to the point of attachment to the udder. The situation in question is important both for udder health and for machine milking [3].

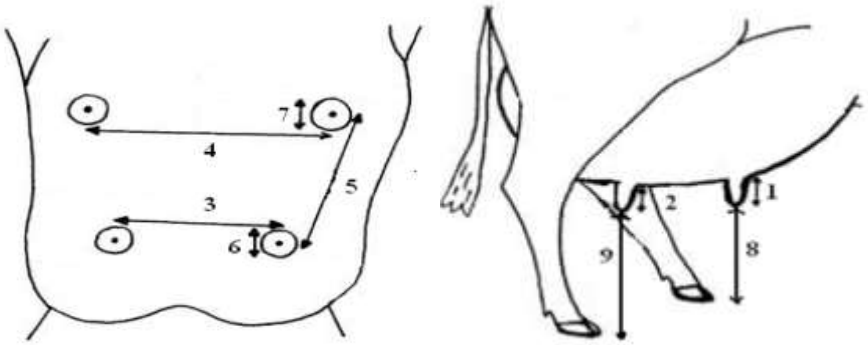

Figure 1. Udder measurements [19]

Front teat length 2. Rear teat length 3. Distance between front teats 4. Distance between rear teats 5. Distance between side teats 6. Front teat diameter 7. Rear teat diameter 8. Height of front teat from ground 9. Height of rear teat from ground

It has been reported that the placement of the teats without being far apart reduces the possibility of somatic cell count and mastitis [9]. Somatic cell count was found to be rg -0.42, rp -0.12 in the first lactation; and rg -0.26, rp -0.11 in the second lactation.

3.9. Height of the Front Teats from the Ground

It is the distance of the tip points of the front teats from the ground. It has been reported that the distance between the teat and the ground of the cows that were subjected to the CMT test was less than the distance between the teat and the ground of the cows that were negative [19] and that there was a phenotypic relationship of around (-)0.29 between these two parameters.

3.10. Height of the Rear Teats from the Ground

It is the distance between the head of the rear teat and the ground [20]. A phenotypic relationship of (-)0.30 was found between the distance between the rear teat and the ground and somatic cell count [19]. Therefore, the distance of the rear teat from the ground provides resistance to mastitis.

3.11. Front Udder Connection

According to [23], the front udder connection is the connection that connects the udder to the abdomen. It gives an idea about the capacity of the breast and whether it will sag in the future. It is examined from the two sides of the udder based on the connection of the udder to the abdomen and udders with strong and solid connections are preferred for a long and productive life [22]. While the interaction between the front udder connection and mastitis and somatic cell count has been mostly found to be negatively related [9], some studies have found positive relationships [24]. 3.12. Rear Udder (Milk Mirror) Height

It is the connection between the legs of the udder at the back and gives an idea about the capacity of the breast [24]. [9] stated that the height of the rear udder has little to do with mastitis, while [25] stated that the high rear udder connection increases the number of somatic cells.

4. RELATIONSHIPS BETWEEN SOMATIC CELL COUNT AND MASTITIS

The body cells present in milk content are formed together by white blood cells and epithelial cells. The cells in question, called somatic cell count, are expressed in numbers. White blood cells pass into milk through blood in some cases (injuries, diseases). Epithelial cells are released into milk from the mammary tissue. Approximately 98-99% of somatic cell count consists of white blood cells [26]. Based on this, somatic cell count is an indicator for the health status of the udder and milk quality [27] and if the cows have mastitis, the number of somatic cell count increases before clinical symptoms [28].

Normal somatic cell count in the mammary lobe (in the mammary lobe unaffected by infection) is usually below 200,000 cells/ml, and somatic cell count above 200,000 cells/ml is considered an abnormality and a sign of inflammation [29].

In the California Mastitis Test (CMT), somatic cell count is used as a criterion for breast inflammation and it is reported that it should be less than 100,000 cells/ml in milk obtained from a healthy breast lobe [7].

5. EFFECT OF DIFFERENT TEAT SHAPES ON SCC AND MASTITIS

5.1. CYLINDRICAL TEAT

It is a Teat with the same diameter from bottom to top and cylindrical in shape [30], in the study conducted by , it is reported that the Teat shape that is the most common and least affected by infection is cylindrical Teats, which determines the cylindrical-round ratio as 26%, the cylindrical-flat ratio as 12% and the cylindrical-concave ratio as 5.8% among the Teat shapes that do not carry the risk of infection, and that somatic cell count is found at the lowest level (43,000 cells/ml) in the lobes with this Teat shape.

5.2. FUNNEL-SHAPED

They are funnel-shaped Teats characterized by the thinning of the Teat from top to bottom. It has been stated that cows with funnel-shaped teats are less prone to subclinical mastitis than those with cylindrical teats [31]. The ratio of cows with funnel-round teat shapes to the total cows is 16%, and those with funnel-flat teats is 4.7%, and the highest somatic cell count amount was determined as 105,000 SCC/ml in funnel-round teats.

5.3. PEAR (BOTTLE) SHAPED

These are teats where the upper half of the udder is thicker and the lower half is thinner. This teat shape is not suitable for machine milking and the pear teat shape has the highest milk retention rate in the udder (Uzmay et al., 2003). Researchers have associated the fact that mastitis is rarely seen in this teat shape with insufficient observation [31].

5.4. LONG, THICK SHAPED

They are visibly thick and long teats compared to other teat shapes. Long and thick teats are the teat shape most prone to subclinical mastitis due to the abundance of milk ducts in the teat [31].

CONCLUSION

For herd health and economic gain, udder characteristics should always be among the most important selection criteria. Drooping udders, misshapen, long, badly positioned, thick teats trigger both mastitis and somatic cell count and shorten milk quality, milk yield and productive life of cows. When selecting breeding stock, udder shapes that cause mastitis susceptibility should not be overlooked and should be given importance in selection.

In addition, udder form is an important feature in terms of dairy cattle farming. Udder and teat characteristics are very important criteria in protecting against mastitis, which is the udder disease that causes the most economic damage to dairy cattle farming, and primarily udder depth, front udder connection and teat length and cylindrical teat shape are very important features in terms of udder health and machine milking. It should not be overlooked that choosing cows with lower somatic cell count, tighter front udder connection, shorter teats and narrower teat placement in reducing mastitis formations in the herd will also increase the profitability of the enterprises.

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