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SMART CITY CONCEPT SYSTEM FOR THE MUNICIPAL WASTE DISPOSAL

Marek Moravec[1] - Pavol Liptai[2]

Abstract: *The development of modern technology affects all spheres of life. The use of such advanced technologies in urban management of individual processes and services is a concept of smart cities. The use of these innovative means leads to the efficient functioning of cities, reduce costs and often improve the quality of life of residents. Smart cities is a concept aimed at introducing information and communication technologies and tools for the effective management of sites and integrating citizens into his work. Smart cities create plans for future investments using information technology, with the participation and support of all stakeholders operating in the territory. Develop the new ideas and services that will benefit the population, local economy and the wider public. One such area where it is possible to apply this advanced technology is an area of waste management and disposal of municipal waste.*

Keywords: Municipal waste, waste disposal, smart city, modern technology, environment.

1 INTRODUCTION

People want to live in cities with a high quality of life. This requirement raises a lot of pressure on infrastructure cities and the natural resources available. Therefore, we need access to intelligently and try to keep the prosperity of cities and good environment with the help of advanced technology, a better understanding of the systems and their interconnections. SmartCity is a city that with innovative solutions and technologies addressing public problems, whether in the field of energy, transport, urban planning, or others. Smart cities areas:

- Public traffic.
- Companies and business.
- Public and social services.
- Waste management.
- Infrastructures.
- Environment.
- Energy efficiency.
- Tourism.
- Research and innovations.

Recent trends show an increase in urbanization in Slovakia Marking the trend turned around, and more and more people are starting to move from rural to urban areas. The need for effective long-term solutions in areas such as energy, transport, waste management and ecology is with growing populations increasing. Strong arguments for cities are particularly saving of resources in the long terms improve the image and providing its citizens a better quality living environment.

Incentives for residents also do not need to look long and hard. Of course, saving public funds, better environment are important factors. But there comes into consideration the time factor. In Slovakia the program smart cities involved in Bratislava, Nitra, Banská Bystrica and Košice.

2 SMART COLLECTION SYSTEM

Current waste collection system is on the base by emptying containers according to predefined schedules and routes which are repeated at a set frequency [9].

Inefficiency of the current waste collection system:

- Time consuming.
- High costs.
- Increased fuel consumption.
- Unnecessary noise and air pollution as a result of more trucks on the road.

Due this reasons public institutions want to optimize the collection system of this service to reduce infrastructure, operating and maintenance costs, as well as reduce contamination directly associated with waste collection [1], [2].

Until now the collection of municipal waste has been realized using fixed schedules where containers are collected with a set frequency, if they are full or not. One of the solutions is using smart wireless sensors to gather fill level data from waste containers and processing these data is a complete solution that automates the planning of waste collection and optimizes collecting routes. It uses wireless ultrasonic sensors to remotely measure the fill level of waste containers and a cloud service to compute and forecast when containers become full and optimize the collection routes and schedules. The service then automatically generates schedules and optimized routes. These routes smart plans are then delivered to the drivers cellular enabled tablet [9].

Smart Plans consist of collection routes for the next period. Each plan is calculated by first taking into account the fill up forecasts for each individual container and then taking into account collection constraints and costs (e.g. fleet availability, road restrictions and traffic). The system then calculates different alternatives and selects the most economically efficient collection plan for the next period. Smart plans are automatically generated and delivered to each individual truck via our Smart Driver tablet application. Obtained data are very valuable to understand waste generation patterns and how much waste is being generated.

The sensor will send alerts when abnormal activity or events occur. These alerts are visible by web services but will also be sent out as email notification. Alerts are sent out for following events:

- Overfull containers.
- Partial or uncompleted collections.
- Unscheduled collections (theft etc.).
- Temperature changes.
- Container position.

Benefits of smart collection system:

- Increased collection efficiency through route optimization.
- Real-time information on the fill level of waste bins.
- Monitored truck routes.
- Remote and dynamic configuration of the routes of vehicles.
- Reduced pollutions of the cities (air, noise).

3 SEMI - UNDERGROUND CONTAINERS APPLICATIONS

Application of underground container in the cities is an efficient solution of improvement in the field of waste collections. Underground containers are positioned under the ground (about 60% of volume). Underground large capacity containers have several advantages including, for example [6]:
space saving - even 5 to 10 times greater capacity to same area compared to conventional surface bin,
only 40% of the container is visible, while the remaining 60% is underground, with the vertical, semi-underground design and resulting compaction, up to 5 times greater capacity per area can be achieved compared to surface containers:

- Coolness of the underground keeps bacterial development slow and keeps the waste odourless.
- Of influence of gravity is lower waste compressed with upper waste.
- filling lid is light and easy to use and wind or animals cannot remove waste.
- Fewer collections means less truck traffic and lower emission.
- The emptying process is easy and safe.
- Since waste is emptied through the bottom of the reusable lifting liner instead of being tipped, the container, its user lid and surroundings stay clean.
- Oldest waste is at the bottom.
- Temperatures are naturally lower underground, and these lower temperatures slow the development of bacteria, significantly reducing decomposition and as a result, odors.
- Semi-underground design keeps containers secure and in place for years to come.
- Emptying method containers is easy and safe for collection staff, there is no need to handle heavy loads or come into contact with waste materials.
- Waste is continuously compacted by gravity due to the weight of the waste being disposed, this results in reduced emptying frequencies.

The disadvantage of the underground containers is that are emptied through the bottom of the reusable lifting liner, using a hydraulic arm. Special vehicles with hydraulic arm are needed, which is related to increase in investment costs [6].

3.1 Types of containers

Large volumes of waste generated in condensed urban areas create both logistical and ergonomic issues. Semi-underground containers can solve these problems with comprehensive range of different underground types of waste bins which provide a cleaner, greener and more aesthetic collection solution. Nowadays there are producers of these kinds of containers with similar constructions and used materials.

Classic containers - combines economic efficiency, hygiene, safety and efficient space utilization. For its round shape the container adapts to all kinds of different environments (Fig. 1) [6].

Fig. 1 Classic semi – underground containers [6]

Module system containers - the rectangular deep collection system is constructed of modules so it is

easy to adapt to the waste collection type. Individual containers can be divided into two or three parts (fig. 2) [6].

Fig. 2 Module system containers [6]

City container - it is based on the deep collection method and it is designed for modern city environment. The material, measurement and construction solutions of the container have been developed to fulfill the high standards of the architecture in city parks, streets, landscape and other furnishing (fig. 3) [6].

Fig. 3 City containers [6]

4 EVALUATION OF APPLICATION SMART COLLECTION SYSTEM WITH USE OF SEMI-UNDERGROUND CONTAINER IN SELECTED AREA

For assessment of the application of smart collection system with semi-underground container was selected urban zone area called KVP in Košice. After detailed analysis current state of collection system, collection points and operational costs was proposed the new system of collection with application of smart collection system. In this project was proposed new quantity of containers and collection points.

In 2014, the city district of KVP was 24,582 people registered [7]. In this communal area was in the same year 731 pcs of 1100 l classic containers for municipal waste, plastics, glass, paper and tetrapack placed and 9621 t of total amount of waste produced. These containers are located at 125 collection points. Afterwards was realized assessment the efficiency and financial savings, the investment and operating costs for the implementation of underground containers and smart collections system. Price of classic 1100 l container is in the range of 320 to 380 EUR. Price of the proposed underground containers (3 m3 and 5 m3) ranging from 2500 to 3300 EUR. Number of collections points was reduced to 94 and number of containers was reduced to 282 [4].

Calculations of investment, operational costs of existing waste collection with the proposed smart collection systems and underground containers are summarized in Table 1.

Table 1 Economical assessment of the project

Costs		**Existing containers (1100 l)**		**Proposed underground containers (3 m^3 and 5 m^3)**	
		Number (pcs)	Price (EUR)	Number (pcs)	Price (EUR)
Investment costs	Containers	731	253 682	282	823 800
	Realization of collection point	125	37 500	94	188 000
	Collection trucks	8	1 360 000	3	960 000
	Sensors + electronic unit	-	-	282	42 300
	Implementation of smart system	-	-	1	105 000
	Σ	-	1 651 182	-	2 119 100
Operational costs per year	Work costs	24	216 000	14	126 000
	Maintenance	-	10 150	-	2 500
	Smart collection system maintenance	-	-	1	15 000
	Fuel	-	176 600	-	85 300
	Σ	-	402 750	-	228 800

5 CONCLUSION

Until now, collecting waste has been done using fixed routes and schedules that require a lot of manual planning. Containers are collected on a set schedule whether they are full or not. This causes unnecessary costs, poor equipment utilization, wear and tear on the roads and excessive emissions. By the applications of semi – underground containers and using the level sensors with smart collection systems is able save about 40 % of operational costs. Investment costs are higher by using these systems in the range of 25-30 %. Also by using the smart collection system and semi-underground container there are other benefits according the air and noise pollution, quality of environment, space savings and others. Application of new technologies, information and communication tools brings new aspects also for waste disposal system and helps to make whole system more efficient to save financial costs and also improve the quality of the life and life environment.

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AUTHORS ADDRESSES

[1] Marek Moravec

Technical University of Kosice, Faculty of mechanical engineering, Institute of construction and process engineering, Department of process and environmental engineering, Letná 9, 042 00 Košice, Slovensko

E-mail: marek.moravec@tuke.sk

[2] Pavol Liptai

Technical University of Kosice, Faculty of mechanical engineering, Institute of construction and process engineering, Department of process and environmental engineering, Letná 9, 042 00 Košice, Slovensko

E-mail: pavol.liptai@tuke.sk