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THE DEVELOPMENT OF ENVIRONMENTAL-SAFETY TECHNOLOGY FOR REMEDIATION OF TAILINGS PONDS OF POWER PLANT

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Abstract: *Authors in the framework of the paper presents partial findings from the research and development of fundamentally new environmental-safety technology biological recultivation of tailing ponds of slag and ash mixture. New technology-based on structured layers of stabilisation material - a waste product of desulphurisation technologies - soil and land with waterproofing properties replaces the standard previously used system hydrofoil overlap with the drainage system. On the recultivated areas of the tailing pond will verify the possibility of energy crops for biomass production on the co-incineration with coal. Laboratory experiments and small parcels experiments on tailing pond show the applicability of new environmental-safety technology with synergistic environmental-economic effects of energy coal combustion processes.*

Keywords: Tailings ponds of slag and ash mixture, environmental safety technologies overlap, experimental verification, biomass production, technical-economic benefits

1 INTRODUCTION

Tailing ponds are the water constructions for storage of waste. Scientific and practical problem is, how to store the waste in the long term environmentally safe and economically effective. A method of storing waste in tailings ponds is set by legislation. Practice shows, that it is necessary to look to new solutions based on BAT, that would eliminate potential environmental disasters and negative effects on the environment and human health. As one of the appropriate ways of environmentally safe and economically effective way for closed tailing ponds seems to be their biological reclamation. In the present article are presenting results of research and development of new technology such tailings remediation based on the use of another waste product - stabilisation material and on the biomass planting on reclaimed areas.

2 CHARAKTERISTICS OF THE OBJECT OF RESEARCH (TAILINGS PONDS OF SLAG AND ASH MIXTURE), EXPERIMENTAL PROJECT FROM INCEPTION TILL NOW

Vojany power plants are located in the eastern part of Slovakia. In the power plant has been built in the past two manufacturies: Power plant Vojany I (coal energy production power plant) and Power plant Vojany II (energy production power plant for fuel gas). Currently, the power plant Vojany II is out of service.

The development of environmental-safety technology for remediation of tailings ponds of power plant is linked precisely with a functioning coal production in Vojany power plant I. Coal combustion in these power plants tends to develop slag and ash mixture, which is then hydraulically abolition by pipeline in the area of a tailing pond located near power plant EVO I. Another waste product is called stabilisation material. This comes as a byproduct of desulphurization technology within the power plant combustion processes.

It can therefore be concluded, that the power plant has two objects which imposes waste, and they are landfill of stabilisation material and tailing pond of slag and ash mixture. For both objects is required environmental-technology-security solution for their disposal in an attempt to reduce their negative impacts on the environment and human health. Faculty of Business Economy with seat in Košice, University of Economics in Bratislava, in the form of contract research and practice through the VEGA project aimed at addressing the biological reclamation of the tailings of slag and ash mixtures in power plant Vojany. This reflects the fact that since 2009 have power plant Vojany an obligation to co-incinerated with coal also a certain percentage of biomass. [1]New environmental-safe solution for remediation of tailings ponds also encompasses the use of various (appropriate) variant grown biomass.

This solution is not only environmental-safe, but also cost effective in terms of reducing costs associated with biomass plants, that will be able to produce and plant on directly overlaps tailing pond and in the surrounding area. Within the studies were realized some small plot experiments in laboratory terms, but also in real terms (6 + 6), which had to verify water-permeable properties of stabilisation material after solidification. Based on their results, followed by several years also conducted experiments on small fields, on which was experiment with structured layers of stabilisation material, subsoil and topsoil, where was planted a type of biomass for for its energy use directly in the power plant.[2]

2.1 Tailing pond of slag and ash mixture

Tailing pond of slag and ash mixture was built in 1965, located in the catastral territory of the municipalities Vojany and Drahňov. It consists of two cassettes, cassette no. 1 (area 29 ha) on which was made experiments is already closed. The way how to close functional cassette no. 2 (area of 27 ha) is not yet finalized.

Storage space of tailing pond is created through dams, that are located around the perimeter of the tailing pond. The perimeter dam of casette no.1 also separates casettes. Drainage system cassette no.1, its technical condition and the exact location are not known. The documentation of the construction of the drainage system in the 70s - 80s years of the last century was not preserved, respectively, it is not known the status of the drainage system, and where is it located at present. It can be expected, that the steel pipe is degraded to a large extent just by corrosion, or may be a shift pipelines given the volatility of materials contained in the tailing pond.

In Slovak Republic is legislatively established safety oversight of operations of the tailing pond as a water building. I tis the same also in case, that tailing pond is already closed. [5]

3 SELECTED RESULTS OF THE SMALL PLOT EXPERIMENTS WITH A STABILISATION MATERIAL

Large-area experimenting of biological reclamation preceded laboratory experiments in containers verifying, that stabilisation material will in contact with water solidified and that will has a waterproofing property. In this case, it would be possible to use this by-product waste as replacement for the standard technology, which is used today, hydrofoil system with drainage system. Followed by layering subsoil and topsoil could grow on overlap tailing pond for example willow swedish or also other energy grasses, which have been considered in the early stages of the research project.

In laboratory experiments, 12 containers have been fulfilled by structured layers (stabilisation material, subsoil and topsoil) with different thickness. In each vessel were the individual layers arranged in various proportions:

- 6 vessels were placed in the laboratory terms which simulate extreme precipitation. Leakage through the layers was measured and record the amount of water.
- Another six containers were placed in real terms and relative to the investigational pond - in this case was the water absorbed by layers of stabilisation material, subsoil and topsoil, probably also due to low rainfall in the period.

In the Table. 1 are recorded values of the simulated amount of rainwater. The measured real maximum average precipitation during the period was likely dropped by 1/3. The simulation was carried out until the water leaked all the layers, that have been placed in containers. [3]

Table 1 Results of laboratory experiments in containers

	The quantity of rainwater [l]	Day in the order, when the water begins to seep	The quantity of seepage of water [l]	Average le waters [%
Container n	40	4	18,1	45,25
Container n	60	6	15,2	25,33
Container n	70	7	11,4	16,28
Container n	120	12	8,1	6,75
Container n	160	16	9,1	5,69
Container n	270	27	1,5	0,56

In the following Fig.1 and Fig.2 are plots of the thickness of the stabilizer and the amount of water impermeability by the thicknesses of subsoil - 300 and 500 mm. [3]

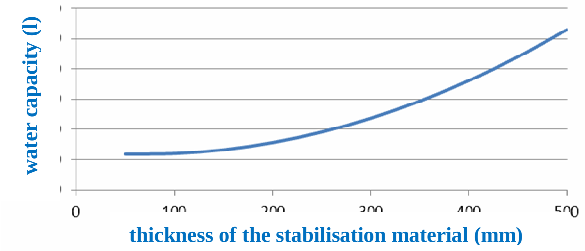

Fig.1 Dependence of the water volume on the thickness of stabilisation material (subsoil 300mm)

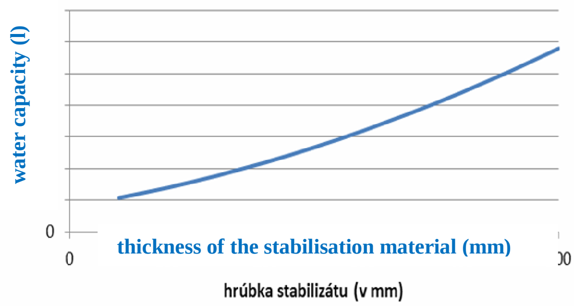

Fig.2 Dependence of the water volume on the thickness of stabilisation material (subsoil 500 mm)

Considering the results of laboratory experiments deems for experiments on small plots as the most appropriate version - stabilisation material with thickness of 300 mm and 500 mm.

The dismantling of the laboratory experiments demonstrate ability of stabilisationa material solidify depending on the amount by introducing water in the establishment of the experiment (in the hall, resp. outside).

4 SMALL PLOT EXPERIMENTS OF BIOMASS PRODUCTION

After verification impermeability of stabilisation material in the form of small plot experiments, proceed with the verification possibilities of biomass cultivation on the construction of small fields directly on the tailing pond (4 large size parcels of 7 meters x 20 meters), where they were stored on hydrofoil with different layers of stabilisation material, subsoil and topsoil. By the dismantling of the fields were made cuts to verify the state solidification of stabilizer and the state of the root system planted biomass.

Fig.3 Dismantling cuts in the plots

So that rainwater on experimental fields penetrated into the body of a pond, as the bottom layer was applied waterproofing foil GSE UltraFlex thick 2.0 mm in the case of three boxes, one box was without hydrofoil. On the top of hydorfoil was deposited layer of stabilisation material at a thickness of 300 mm and 500 mm, based on the results of laboratory experiments. On the layer of stabilisation material were deposited layer of subsoil and topsoil, into which were planted the Willow Swedish and selected energy grasses.

Subsoil layer varies depending on the type of planted energy cultivation. For planting grass (Rapid Prosoil) was deposited subsoil with a thickness of 300 mm, for fast growing tree species 500 mm. A layer of topsoil in the experimental plots was 200 mm.

In November 2015, experimental plots have been removed with a view to examining the state of the waterproofing layer of stabilisation material and the state of the root system of Willow Swedish, planted on fields with different deposited structures of layers. Using techniques and manually has been revealed each layer of structure hydrofoil - stabilisation material - subsoil - topsoil. Several sections were performed manually, in order of least destruction of the root system grown Willow Swedish.

4.1 Results of small plot experiments

Uncovering of the individual components of experimental plots was shown, that in the edge of the experimental plotss did not result to formation continual solidified layer of stabilisation material. Coherent layer of solidified stabilisation material was formated in cuts, which was made closer to the center of the plot. This situation could significantly affect the rainfall, whose intensity was at a time of experimentation very low. On the edges of the plots rainfalls withered quickly, more in opposed to the center of the plots, in which the water was maintained for longer. In the edge was stabilisation material loose, but gradually toward the center were produced visible larger chunks of hardened stabilisation material Fig.4.

Fig.4 Pieces of solidified stabilisation material from the edge of the experimental plots

The dry period also acted negatively on planted individuals of Willows Swedish, which gradually began to dry up. For this reason, the driest months was Willow Swedish watered with water (uneven watering - more centered, could also be due to drought rim of experimental plots).

5 RESULTS IN THE CULTIVATION OF ENERGY CROPS - WILLOW SWEDISH, GRASSES

Manually cut in the plots were taken samples of root systems of Willow Swedish. Selected root systems different in length, branching and direction depending on structured underlays of various plots. We can conclude, that in terms of length, the root system corresponds to the length of the part above the topsoil (mutually correlated).

Another factor that can not be ignored is, that the root system of Willow Swedish did not crush the layer of stabilisation material in the vertical direction (in parts where has been fixed by the rainwater soaking).

The roots have been branched out

progressively along the length of stabilisation material (horizontal), as can be seen in Fig. 6.

Fig.5 Willow Swedish in the experimental sectional small plot

Fig.6 Horizontal branching of Willow Swedish

Willow Swedish grows to the maximum on the plots with structure without layer of hydrofoil and layer of stabilisation material. The root system reached deep into more than 3 meters.

It can be conclude, that willow planting on the plots containing layer of stabilisation material did not have enough moisture for their substantial growth. Stabilisation material did not accept root growth in the vertical direction, so the root system of Willow Swedish could not pump moisture from the underlying of tailing pond. Since it was a relatively dry period, as we previously mentioned, willow could not required to draw water from subsoil and topsoil. In this regard, the question arises, if the Willow Swedish is biomass appropriate for this type of new environmental-technological security solutions for reclamation of tailing pond of slag and ash mixture. Based on the experiments, we recommend focusing on other types of biomass (energy grass verified, but also other, with proven high yield).

5.1 Other energy crops - sudan grass

Due to the constantly changing climatic conditions in our experiment, but also generally, it is necessary to take account of this fact in the selection and plantation of biomass for energy purposes. In connection with the predicted dry and warm summers, milder and wetter winters, it is necessary to focus on crops with economic efficiency of plantation.

Experimental plantation of Willow Swedish on the plots were found, that the root system extends horizontally in the ground and on the surface layer of stabilisation material. This is a problem, especially during the dry season. Rainfalls for its growth are not enough. It offers in this respect the choice of other energy crops, with proven and in practice confirmed characteristics.

Sudan grass (Sorghum sudanense Piper)

Sudan grass in the scientific literature known as well as the concepts Sorghum sudanense. A distinction is several species that are present in the subtropical and tropical areas. It belongs to the plants, that can survive and at the same time achieve high production during dry periods - even sorghum is considered as one of the crops, that are most resistant towards dry.

Sorghum is known for its strong and well-developed root system. It can used not only water from the lower layers of soil, but even a small amount of rainfall, through so-called "dew roots". Aerial roots provide strength of this plant in the soil, making it resistant to strong winds. Resistance to dry provide the leaves, because they contain waxy surface.

Economically is sorghum preferred, because it is not too expensive in view of cheap seed, low fertilizers needed, capacity for adjustment and the like. Another advantage is this plant's ability to regenerate, for example if there would be a period of abundant rainfall, sorghum is able to regenerate after a drop of water, which was also confirmed by experiments with Sorghum in the Eastern plains, near the tailing pond of slag and ash mixture EVO.[4]

6 THE CONSLUSIONS FROM EXISTING RESEARCH AND DEVELOPMENT WITH A RECOMMENDATION FOR THE PRACTICAL IMPLEMENTATION

Research and development of new environmental-safety technology remediation of tailings showed some new findings:

- Based on laboratory experiments and small plots experiments is confirmed, that stabilisation material in contact with water solidify. Solidification of stabilisation material depends on the amount by introducing water. Stabilisation material can be used as a substitute for the waterproofing layer to overlap the pond.

- Structured layers of stabilisation material, subsoil and topsoil are in case of planting Willow Swedish in need to be adjusted. Willow Swedish needs enough moisture for growth. By inserting layer of stabilisation material willow can not accept moisture of the soil long enough for its growth. It is therefore appropriate to focus on other types of energy crops, that are profitable even in drier conditions, or a layer of subsoil and topsoil significantly increase (about 1 meter).
- Planting Willows Sweden are based on experiments carried out shows tailings reclamation not so effective. We therefore recommend the cultivation of certified energy grasses and experimenting with other energy crops, as mentioned Sudan grass, Reed and others.

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