Miomir Mikić*, Ivana Jovanović*, Daniela Urošević*

RECLAMATION OF THE ASH AND SLAG LANDFILL GACKO - B&H**

Abstract

Technological process of coal combustion in thermal power plants produces the certain amounts of ash and slag that have to be transported and disposed at the selected location - landfill. Disposal of ash and slag from the power plant Gacko in Gacko, Bosnia and Herzegovina, was done in the cassette II, formed in the excavation area of the open pit Gračanica. With the need for a new space for disposal of ash and slag, the solution was found in forming the cassette III below the existing cassette II. After completion of exploitation and achieving the designed elevation of 940 meters above the sea level, the reclamation is carried out of all cassettes, which permanently eliminate any negative impact of ash from the landfill on the surrounding living space and air.

Key words: reclamation, landfill, ash, slag.

INTRODUCTION

Thermal power plant Gacko since 1995 has made a disposal of ash on the ash landfill - the first phase, cassette I, in the excavated area of the open pit mine Gračanica in a part of exploitation field A. After filling the cassette I, a continuation of ash and slag disposal was carried out in a continuation of cassette II, in the excavation area of the open pit Gračanica, which was formed in a continuation of cassette I. After many-year disposal of ash and slag in cassette II, there was a reduction of landfill area and it was necessary to provide a new area for disposal of

ash and slag, and thus to ensure a continuous operation of power plant Gacko. Adequate solution was found in formation of landfill in cassette III, in the excavation area of the open pit Gračanica. Cassette III is formed in a continuation of cassette II to the southern final slope of the open pit (Figure 1). Location of the landfill of ash and slag in cassette III was selected as the best techno-economic solution for disposal of ash and slag from the power plant Gacko with respect to the location of the settlement Gacko, developed infrastructure, availability of space, etc.

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Figure 1 *Provided area for cassette III*

Process of coal mining at the open pit Gračanica has resulted into environmental degradation, i.e. there was a large surface soil degradation as well as disturbance of surface and groundwater regimes. By construction the power plant Gacko, the environmental quality was additionally degraded. The ash and slag landfills have the major influence on this.

Fly ash is the finest fraction which remains after coal combustion in thermal plants [1]. Fly ash is a heterogeneous mixture of particles of different physical, chemical, mineralogical and morphological properties, produced by coal combustion in power plants and whose characteristics are determined by the quality of burnt coal, combustion technology and combustion conditions [1]. Fine ash fractions may have a

strong degrading effect on the living environment and environment, particularly during high winds, when blown in the environment, which may lead to the major ecological problems, especially damage the population health, having in mind that this raw material is categorized as a hazardous waste [2].

However, the air pollution is eliminated because the technogenic raw material is transported to the landfill in the form of hydro mixture, i.e. in wetted or submerged condition. Namely, the electro filter fly ash from PP Gacko belongs to the type of calcareous ash (high content of CaO), which means that it has the cementation properties and in contact with water builds a compact material of specific mechanical strength. In this way, the emission of fine ash particles into air is prevented.

Construction of landfill will be conducted in two phases. The initial situation for formation of landfill is the formed landfill on cassettes I and II to the finished elevation K+940 m, and the prepared base of phase 1, cassette III. The initial landfill area of 141 750 m² was formed by the construction of massive dike of waterproof material on three sides and slope of the terrain to cassette I. The bottom of the newly designed landfill

will be coated with a plastic foil to protect soil and groundwater from leachate. Underneath the plastic foil, the drainage for evacuation of underground water will be installed, which drains into the pumping station the seepage and drainage water. The initial situation in phase 2 is practically the final view of the landfill at the end of phase 1. The final view of the ash and slag landfill in phase 2 is shown in Figure 2.

Figure 2 Final view of the ash and slag landfill in phase 2, cassette 3, in the program Gemcom 6.2

Re-cultivation and revitalization of degraded areas caused by coal exploitation at the open pit Gračanica and later disposal of ash and slag into the excavated area of open pit means the reclamation.

For revitalization of degraded areas on the ash and slag landfill, the optimum reclamation will be applied with phases: technical and biological reclamation.

According to the physical and chemical characteristics of the soil, geomorphology of landfill, the exposed area to the south, climate and natural vegetation

in the region, the biological optimum stage of reclamation will be taken into consideration on the final planes of ash and slag landfill, where the afforestation with acacia will be carried out.

2 DEGRADED AREAS FOR RECLAMATION

Reclamation of degraded areas is planned on plateaus and slopes of the landfill. The surfaces for reclamation are shown in Tables 1 and 2

Table 1 *Surfaces in phase 1 for reclamation*

Location	Phase	Flat surfaces- level planes	Surface m ²	Reclamation method	Sloping surfaces – slopes of level panels	Surface m ²	Reclamation method
Landfill	1	plateau - 940	101 552	afforestation	E940/E937	4 558	filling
		937	5 375	filling	E937/E934	4 660	filling
		934	5 380	filling	E934/E931	4 600	filling
		931	5 390	filling	E931/E928	4 560	filling
		928	5 490	filling	E928/E925	3 898	filling
		925	3 535	filling	E925/E922	2 860	filling
		922	2 945	filling	E922/E919	2 580	filling
		919	2 500	filling	E919/E916	2 390	filling
		917	2 450	filling	E916/E913	2 247	filling
		913	2 240	filling	E913/E910	1 990	filling
		910	2 030	filling	E910/E907	1 800	filling
		907	1 880	filling	E907/E904	1 071	filling
		904	520	filling			
Total		141 287			37 214		

Table 2 *Surfaces in phase 2 for reclamation*

Location	Phase	Flat surfaces- level planes	Surface m ²	Reclamation method	Sloping surfaces – slopes of level panels	Surface m ²	Reclamation method
Landfill	1	plateau - 940	176 518	afforestation	E940/E937	5 571	filling
		937	5 730	filling	E937/E934	5 112	filling
		934	6 530	filling	E934/E931	3 875	filling
		931	4 265	filling	E931/E928	2 628	filling
		928	2 875	filling	E928/E925	2 250	filling
		925	2 300	filling	E925/E922	4 473	filling
		Total	198 218			23 909	

3 PEDOLOGICAL PROPERTIES OF NATURAL SOIL

A soil layer in detecting the deposit (investment overburden) is removed and disposed at the borrow of humus where it will be used to fill the plateau of landfill.

To determine the benefits of natural soil for reclamation of degraded areas on the landfill, the agro-chemical analyses of taken samples D1 and D2 were carried out in the laboratory of the Mining and Metallurgy Institute Bor. The results of agrochemical analysis are for the sample D1: pH = 7.55, CaO = 3.85; P₂O₅ = 0.15; K₂O = 2.20, and

the sample D2: pH = 7.69, CaO = 5.46; P₂O₅ = 0.16; K₂O = 1.33.

Data on analysis the samples D1 and D2 in this case were used to define the natural soil type and its properties. Natural soil from the borrow to the classification belongs to rendzinas, that is rendzinas on marl and marly limestone.

The soil is of neutral reaction, poorly supplied with phosphorous and NPK 10:20:30, in an amount of 400 kg/ha, should be included.

4 TECHNICAL RECLAMATION

Technical reclamation of the ash and slag landfill in the area of the open pit Gračanica is carried out under the European Regulation on disposal of waste at landfills (Council Directive 1999/31/EC of 26 April in 1999 on waste landfill - hereinafter the Directive).

Based on the recommendations of the Directive after disposal of ash and slag (elevation 940 m), on the entire surface of the landfill, a three final layers are placed, which serve as protection, as well as preparation for biological reclamation.

The first layer is formed by disposal of disposed material from the existing landfill. This material, based on geological data, belongs to marly limestone. It is estimated that the thickness of this material should be about 1 m. After formation the first layer, the formation of the second layer is made that presents a drainage layer. This layer consists of grit and sandy material. Layer height is 0.5 m. The final layer is a layer of humus, which would be a guarantee that the biological reclamation can be made on such base. It is estimated that the thickness of the final – third layer of humus should be 1 m. Humus is transported and disposed from the formed humus landfills in the vicinity of the landfill. The final view of the ash and slag landfill will be formed with slopes of about 1% to the drainage facilities in order to solve the drainage by gravity.

Technical reclamation includes the following activities:

- loading of materials for construction the service road and filling the slopes,
- loading of material for construction the layers - marl, drainage material, humus
- transport of materials,
- work of bulldozers on flattening and leveling of service road,
- work of bulldozers on flattening of landfill slope,
- work of bulldozers on flattening the layers of landfill plateau,

- placing of drainage pipes and canalettos,
- connecting the all segments of drainage system.

4.1 Works on Construction the Service Road

Works in this phase of technical reclamation would include construction the service road on the landfill plateau, and connection to the network of access roads to the landfill. The network of roads outside the landfill is constructed, and how it is in the constant use, it is maintained regularly, so that the road is in a good condition. With respect to the future works on landfill, the service roads will be constructed on the existing network.

Service road will be 5 meters wide. The construction consists of loading and transport of material from the landfill of marl and then filling the material - marl on the landfill plateau, and then flattening - leveling by bulldozer.

4.2 Description of Works for Reclamation the Landfill Slopes

Since the slopes of landfill are under a high incline, it is necessary to perform the reclamation of the same to stabilize the ground and prevent the eventual penetration of water. Technical reclamation of slopes includes filling the slopes to mitigate a decline where the angle of general slope of 18.3° (or 1:3 ratio) is formed.

Material for filling the slopes, i.e. placement a layer is taken from the formed marl landfills, located near the landfill. Loading and transport of this material is done on the landfill plateau. The material is unloaded in piles in various places as bulldozer would faster and more qualitative operate. Then the material is pushed along the slope of landfill. Height of mate

rial, i.e. the final layer over the slopes should be around 1 m. Upon completed leveling of material is the phase in which the material is compacted. These works are carried out by roller. Since the general angle is less than 20° , the conditions for roller operation on the slopes are possible.

4.3 Works on Forming the Final Layer on the Landfill Plateau

Material for placement the first layer on the landfill plateau is taken from the formed marl landfills. Loading and transport of this

material is done on the landfill plateau. By the work of planning machinery is formed a layer of marl in the height of 1 m (Figure 3). At the same time, the care is taken to put into position a single-ribbed drainage pipe $\varnothing 160$ mm. These pipes are placed at a distance of 80 m.

The function of these pipes is to collect the water and to drain the water by the set drainage system to the drain ditches, which are connected to the main drainage channels that drain this collected water into the river Gračanica or into the main water collectors.

Figure 3 Cross-section of the landfill with a view of all layers and service road

After the material dumping by truck, planning of materials is done by bulldozer. During this, the care is taken that the planned base is 1%. Plateau is divided into sections of 80 m, Figure 4.

Each section has the view, shown in Figure 4, which presents the slopes of this layer. In this way, it enables the proper functioning of the drainage system. All collected water goes into formed “channel”, and from there the water is collected with drainage pipe $\varnothing 160$ mm. This water is lowered by canalettos into the main

channel that is constructed between the service road and this layer.

For drainage system functioning, it is necessary to form the first layer (marl) with a slight decline of 1%. In addition to the general decline, this layer is formed to have another decline towards “inside”. As it is shown in Figure 4, the distance of 80 m to which the pipes will be placed, will be divided in half, wherein these halves will form a decline towards “inside” and thus all water will interflow to the pipes.

Figure 4 View of the final layer segments

5 BIOLOGICAL PHASE OF OPTIMUM RECLAMATION

After the completion of formation of the first layer, the formation of the second layer starts - the so-called drainage layer (Figure 3). The material that will be used for construction of this layer consists of gravel, size 5-25 mm. Transported material is disposed in piles along the newly-formed layer as bulldozer could easily and quickly manipulate with it. For continuous operation of mechanization along the slopes of the newly-formed layers of 1 m, a road will be temporarily constructed in the cut that after completion of the work will be turned back to the proper state. Planning the deposited material is also done by bulldozers. Layer thickness is about 0.5 m.

The final layer is formed of humus. In the vicinity of the landfill, temporary landfills of humus are formed topsoil, where the required amount of humus will be transported to the landfill plateau. Thickness of the layer is about 1 m. Works on planning and leveling of the final layer will be made by mechanization - bulldozer.

Biological phase of optimum reclamation involves the application of phytoameliorative measures on the substrate in order to establish and survival of vegetation for forming a stable ecosystem. For the success of biological cultivation, the preliminary works of technical reclamation are important as well as implementation the measures of care and protection of some cultures at all stages of their development. The selected culture - acacia fits into the existing landscape and will contribute to more beautiful appearance of micro location.

5.1 Working Technology in Afforestation of Flat Surfaces

On flat surfaces of the landfill, after technical reclamation, the pits seedlings are dug by articulated multifunctional combined machine (backhoe) of rectangular section, depth 40 cm (bucket width is 30 cm and length 40 cm) (Figure 5). Seedlings are planted by hand on a square pat

tern as 2000 seedlings/ha. Each seedling after planting is added, at a certain distance around the seedling, 0.2 kg NPK per plant.

Figure 5 shows a schematic view of a pit digging by ZMKM backhoe, from one position to 3 pits are dug in one row.

Figure 5 Scheme of digging pits by backhoe for seedlings at the final plate

CONCLUSION

Afforestation of degraded areas in the first place is aimed to preserve the environment, fertilizing the landscape, apiculture development and profit of acacia wood. The root system of acacia is deep and binds the substrate binds and stimulates the development of pedological processes (3). Acacia belongs to the bioameliorate - improves the soil properties and enables preparation for more economical species in the future period (3).

The effects of reclamation the ash and slag landfill are in:

- Forest plantations provide better soil bonding, stimulate the development of ground flora, activate the pedological processes in the substrate of root system, prevent insolation and drying of the soil, blowing strong winds and dust rising.
- Afforestation of degraded areas on the ash and slag landfill contributes to the environmental protection, improving the microclimate and aesthetic appearance of the landscape.

Total degraded area of the landfill is 400 628 m².

Total costs of reclamation for **40.06** ha are: $T_t = 4\ 527\ 253.9$ € (work dynamics of 2 years).

Total cost of reclamation per hectare is:

113 011.9 €/ha

Total cost of reclamation per m² is:

11,30119 €/m²

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REKULTIVACIJA DEPONIJ PEPELA I ŠLJAKE GACKO - B i H**

Izvod

Tehnološki proces sagorevanja uglja u termoelektranama proizvodi određene količine pepela i šljake koje treba transportovati i odložiti na izabranoj lokaciji – deponiji. Deponovanje pepela i šljake iz TE Gacko u Gacku, B i H vršilo se u kaseti II formiranoj u otkopnom prostoru površinskog kopa Gračanica. Sa potrebom novog prostora za deponovanje pepela i šljake nađeno je rešenje u formiranju kasete III u nastavku postojeće kasete II. Nakon završetka eksploatacije i dostizanja projektovane kote od 940 mnv vrši se rekultivacija svih kaseti, čime se trajno eliminiše bilo kakav negativni uticaj pepela iz deponije na okolni životni prostor i vazduh.

Ključne reči: rekultivacija, deponija, pepeo i šljaka

UVOD

Termoelektrana Gacko od 1995. g. odlaganje pepela vrši na deponiji pepela - prva faza, kaseti I u otkopnom prostoru površinskog kopa Gračanica na delu eksploatacionog polja A. Nakon zapunjavanja kasete I, nastavak odlaganja pepela i šljake se vršilo u kaseti II, u otkopnom prostoru površinskog kopa Gračanica, koja je formirana u nastavku kasete I. Nakon dugogodišnjeg odlaganja pepela i šljake u kaseti II, došlo je do smanjenja odlagališnog prostora pa je bilo neophodno obezbediti novi

prostor za deponovanje pepela i šljake i time obezbediti kontinualni rad TE Gacko. Adekvatno rešenje je nađeno u formiranju deponije u kaseti III, u otkopnom prostoru površinskog kopa Gračanica. Kaseti III je formirana u nastavku kasete II do južne završne kosine kopa (slika 1). Lokacija deponije i pepela u kaseti III je izabrano kao najpovoljnije tehno-ekonomsko rešenje za odlaganje pepela i šljake iz TE Gacko s obzirom na lokaciju naselja Gacko, razvijene infrastrukture, raspoloživosti prostora, itd.

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Sl. 1. Prostor predviđen za kasetu III

Procesom eksploatacije uglja na površinskom kopu Gračanica došlo je do narušavanja životne sredine tj. došlo je do degradiranja velikih površina zemljišta kao i poremećaja režima površinskih i podzemnih voda. Izgradnjom termoelektrane TE Gacko kvalitet životne sredine se još više narušavao. Veliki uticaj na to su imale deponije pepela i šljake.

Leteći pepeo predstavlja najfiniju frakciju koja zaostaje nakon sagorevanja uglja u termalnim postrojenjima. [1]. Leteći pepeo je heterogena mešavina čestica različitih fizičkih, hemijskih, mineraloških i morfoloških osobina, koja nastaje sagorevanjem uglja u termoelektranama i čije su karakteristike određene kvalitetom izgorelog uglja, tehnologijom sagorevanja i uslovima sagorevanja. [1]. Fine frakcije pepela mogu imati jak degradirajući uticaj na životnu

sredinu i okolinu, posebno u periodu jakih vetrova, kada se raznose po okolini, što može dovesti do velikih ekoloških problema, a pre svega narušavanja zdravlja stanovništva, imajući u vidu da je ova sirovina kategorisana kao opasan otpad. [2]

Međutim, aerozagadenje je eliminisano jer se tehnogena sirovina transportuje na deponiju u vidu hidromešavine tj. u okvašenom, odnosno potopljenom stanju. Naime, elektrofilterski pepeo iz TE Gacko pripada tipu karbonatnih pepela (visok sadržaj CaO), što znači da poseduje cementaciona svojstva i u kontaktu sa vodom gradi kompaktan materijal određene mehaničke čvrstoće. Na taj način sprečena je emisija finih čestica pepela u vazduh.

Izrada deponije će se odvijati u dve faze. Početna situacija za formiranje deponije je formirana deponija na kasetama I i II do

završne kote K+940m, i pripremljena podloga faze 1 kasete III. Početna površina deponije od 141.750 m² formirana je izgradnjom masivnog inicijalnog nasipa od vodonepropusnog materijala sa tri strane i kosinom terena ka kaseti I. Dno novoprojektovane deponije, biće presvučeno plastičnom folijom za zaštitu zemljišta i pod-

zemnih voda, od procednih voda. Ispod plastične folije biće postavljena drenaža za evakuaciju podzemnih voda, koje se odводе u pumpnu stanicu procedne i drenažne vode. Početna situacija u fazi 2 je praktično završni izgled deponije na kraju faze 1. Konačan izgled deponije pepela i šljake u fazi 2 je dat na slici 2.

Sl. 2. Konačni izgled deponije pepela i šljake u fazi 2 kasete III u programu Gemcom 6.2

Ponovno kultivisanje i revitalizaciju degradiranih površina nastalih eksploatacijom uglja na površinskom kopu Gračanica, a kasnije deponovanjem pepela i šljake u otkopani prostor površinskog kopa podrazumeva rekultivaciju.

Za revitalizaciju degradiranih površina na deponiji pepela i šljake primeniće se optimalna rekultivacija sa fazama: tehničke i biološke rekultivacije.

Prema fizičko hemijskim osobinama tla, geomorfologiji deponije, eksponiranost povr-

šina jugu, klimatskim uslovima i prirodnoj vegetaciji u okruženju u obzir dolazi biološka faza optimalne rekultivacije i to na završnim ravnama deponije pepela i šljake gde će se vršiti pošumljavanje bagremom.

2. DEGRADIRANE POVRŠINE ZA REKULTIVACIJU

Rekultivacija degradiranih površina planirana je na platoima i kosinama deponije. Površine za rekultivaciju prikazane su u tabeli 1 i 2.

Tabela 1. Površine u Fazi 1 za rekultivaciju

Lokacija	Faza	Ravne površine-etažne ravni	Površina m ²	Metoda rekultivacije	Kose površine -kosine etažnih ravni	Površina m ²	Metoda rekultivacije
Deponija	1	plato - 940	101 552	pošumljavanje	E940/E937	4 558	zasipavanje
		937	5 375	zasipavanje	E937/E934	4 660	zasipavanje
		934	5 380	zasipavanje	E934/E931	4 600	zasipavanje
		931	5 390	zasipavanje	E931/E928	4 560	zasipavanje
		928	5 490	zasipavanje	E928/E925	3 898	zasipavanje
		925	3 535	zasipavanje	E925/E922	2 860	zasipavanje
		922	2 945	zasipavanje	E922/E919	2 580	zasipavanje
		919	2 500	zasipavanje	E919/E916	2 390	zasipavanje
		917	2 450	zasipavanje	E916/E913	2 247	zasipavanje
		913	2 240	zasipavanje	E913/E910	1 990	zasipavanje
		910	2 030	zasipavanje	E910/E907	1 800	zasipavanje
		907	1 880	zasipavanje	E907/E904	1 071	zasipavanje
		904	520	zasipavanje			
Ukupno		141 287			37 214		

Tabela 2. Površine u Fazi 2 za rekultivaciju

Lokacija	Faza	Ravne površine-etažne ravni	Površina m ²	Metoda rekultivacije	Kose površine –kosine etažnih ravni	Površina m ²	Metoda rekultivacije
Deponija	1	plato - 940	176 518	pošumljavanje	E940/E937	5 571	zasipavanje
		937	5 730	zasipavanje	E937/E934	5 112	zasipavanje
		934	6 530	zasipavanje	E934/E931	3 875	zasipavanje
		931	4 265	zasipavanje	E931/E928	2 628	zasipavanje
		928	2 875	zasipavanje	E928/E925	2 250	zasipavanje
		925	2 300	zasipavanje	E925/E922	4 473	zasipavanje
		Ukupno		198 218			23 909

3. PEDOLOŠKE OSOBINE PRIRODNOG ZEMLJIŠTA

Sloj tla pilikom otkrivanja ležišta (investiciona raskrivka) je skinut i odlagan na pozajmištu humusa odakle će se koristiti za nasipavanje platoa deponije.

Za određivanje pogodnosti prirodnog zemljišta za rekultivaciju degradiranih površina na deponiji izvršene su agrohemijske analize uzetih uzoraka D1 i D2 u laboratoriji Instituta za rudarstvo i metalurgiju Bor. Rezultati agrohemijske analize su za uzorak D1: pH= 7,55, CaO =3,85; P₂O₅=0,15;

K₂O=2,20, a za uzorak D2: pH= 7,69, CaO =5,46; P₂O₅=0,16; K₂O=1,33.

Podaci analize uzoraka D1 i D2 u ovom slučaju poslužili su za definisanje tipa prirodnog zemljišta i njegovih svojstava. Prirodno zemljište sa pozajmišta prema klasifikaciji pripada rendzinama i to rendzinama na laporu i laporovitom krečnjaku.

Zemljište je neutralne reakcije, slabo obezbeđeno fosforom i treba uneti NPK 10:20:30. u količini 400 kg/ha.

4. TEHNIČKA REKULTIVACIJA

Tehnička rekultivacija deponije pepela i šljake na prostoru površinskog kopa Gračanica vrši se osnovu Evropske Uredbe o odlaganju otpada na deponije (DIREKTIVA VIJEĆA 1999/31/EC od 26. travnja 1999. o odlagalištu otpada - u daljem tekstu Direktiva).

Na osnovu preporuke Direktive posle završetka odlaganja pepela i šljake (kota 940 m), na celokupnoj površini deponije postavljaju se tri završna sloja, koja imaju ulogu zaštite, kao i pripremu za biološku rekultivaciju.

Prvi sloj se formira odlaganjem odloženog materijala sa postojećeg odlagališta. Ovaj materijal na osnovu geoloških podataka pripada laporovitim krečnjacima. Procenjeno je da debljina ovog materijala treba da iznosi oko 1 m. Nakon formiranja prvog sloja vrši se formiranje drugog sloja koji predstavlja drenažni sloj. Ovaj sloj se sastoji od rizle i peskovitog materijala. Visina sloja iznosi 0,5 m. Završni sloj predstavlja sloj humusa, što bi bila garancija da se na ovakvoj podlozi može vršiti biološka rekultivacija. Procenjeno je da debljina završnog-trećeg sloja od humusa treba da iznosi 1 m. Humus se transportuje i odlaže sa formiranih humusnih odlagališta koji su u blizini deponije. Završni izgled deponije pepela i šljake će biti formiran sa nagibima oko 1% prema objektima odvodnjavanja u cilju rešenja odvodnjavanja putem gravitacije.

Tehnička rekultivacija obuhvata sledeće radove:

- utovara materijala za izradu servisnog puta i zasipavanje kosina,
- utovara materijala za izradu slojeva – laporac, drenažni materijal, humus,
- transporta materijala,
- rad buldozera na ravnjanju i nivelaciji servisnog puta,
- rad buldozera na ravnjanju kosine deponije,

- rad buldozera na ravnjanju slojeva na platou deponije,
- postavljanje drenažnih cevi i kanaleta,
- povezivanje svih segmenata drenažnog sistema.

4.1. Radovi na izgradnji servisnog puta

Radovi u ovoj fazi tehničke rekultivacije bi obuhvatali izradu servisnog puta na platou deponije, i uspostavljanje veze sa mrežom pristupnih puteva ka deponiji. Mreža puteva van deponije je izrađena, i kako je u stalnoj upotrebi, održava se redovno, tako da je put u dobrom stanju. S obzirom na buduće radove na deponiji izradiće se servisni putevi na istoj, koji će se nadovezati na postojeću mrežu.

Servisni put će biti širok 5 m. Sama izrada se sastoji od utovara i transporta materijala sa odlagališta laporca, a zatim nasipavanja materijala - laporca na plato deponije, a zatim ravnjanja - nivelacije buldozerom.

4.2. Opis radova za rekultivaciju kosina deponije

S obzirom da su kosine deponije pod velikim nagibom, nepohodno je izvršiti rekultivaciju istih kako bi se stabilizovao teren i sprečili eventualni prodori voda. Tehnička rekultivacija kosina obuhvata zasipavanje kosina kako bi se ublažio pad i pri čemu se formira ugao generalne kosine od 18,3° (ili odnos 1:3).

Sa formiranih odlagališta laporca koji se nalaze u blizini deponije uzima se materijal za nasipavanje kosina tj. postavljanje sloja. Vršiti se utovar i transport ovog materijala na plato deponije. Materijal se istovaruje na gomile na više mesta kako bi buldozer brže i kvalitetnije radio. Zatim se vrši preguravanje materijala po kosini deponije. Visina materijala, tj. završnog sloja preko kosina treba

Sl. 4. Prikaz segmenta završnog sloja

Nakon završetka formiranja prvog sloja počinje se sa radom na formiranju drugog sloja – tzv. drenažnog sloja (slika 3). Materijal koji će se primeniti za izradu ovog sloja sastoji se od šljunka veličine 5-25 mm. Transportovani materijal se odlaže na gomile po novo formiranom sloju kako bi buldozer mogao da lakše i brže manipuliše sa njim. Da bi mehanizacija funkcionisala kontinualno po kosinama novoformiranog sloja od 1 m, će se privremeno napraviti put u useku koji će se nakon završetka radova vratiti u odgovarajuće stanje. Planiranje deponovanog materijala se takođe vrši buldozerima. Debljina sloja iznosi oko 0,5 m.

Završni sloj se formira od humusa. U blizini deponije su formirana privremena odlagališta humusa, odakle će se potrebna količina humusa transportovati do platoa deponije. Debljina sloja iznosi oko 1 m. Radovi na planiranju i nivelisanju završnog sloja će se vršiti mehanizacijom – buldozerom.

5. BIOLOŠKA FAZA OPTIMALNE REKULTIVACIJE

Biološka faze optimalne rekultivacije podrazumeva primenu fitomeliorativnih

mera na supstratu u cilju uspostavljanja i opstanka vegetacije radi formiranja stabilnog ekosistema. Za uspeh biološke rekultivacije važni su prethodni radovi tehničke rekultivacije kao i sprovođenje mera nege i zaštite podignutih kultura u svim fazama njihovog razvoja. Izabrane kulture – bagrem se uklapaju u postojeći pejzaž i doprinosiće lepšem izgledu mikrolokacije.

5.1. Tehnologija rada pri pošumljavanju ravnih površina

Na ravnim površinama deponije posle tehničke rekultivacije kopaju se jame sadnica zglobnom multifunkcionalnom kombinovanom mašinom (rovokopačem) pravougaonog preseka dubine 40 cm (širina kašike iznosi 30 cm, a dužina 40 cm) (slika 5). Sadnice se sade ručno po kvadratnoj šemi i to 2000 sadnica/ha. Svako jama sadnje se dodaje na određenom rastojanju oko sadnice 0,2 kg NPK po sadnici.

Na slici 5 dat je šematski prikaz kopanja jama ZMKM - rovokopačem, iz jednog položaja mašine kopaju se 3 jame u jednom redu.

Sl. 5. Šema rada rovokopača na kopanju jama za sadnice na završnoj ravni

ZAKLJUČAK

Pošumljavanje degradiranih površina na prvom mestu ima za cilj očuvanje životne okoline, oplemenjivanje pejzaža, razvoj pčelarstva i dobit od bagremove šume. Korenov sistem bagrema se duboko zakorenjuje i vezuje supstrat i podstiče razvijanje pedoloških procesa.(3) Bagrem pripada biomeliorativnoj vrsti - popravlja svojstvo zemljišta i omogućava pripremu sredine za ekonomičniju vrstu u budućem periodu.(3)

Efekti rekultivacije deponije pepela i šljake ogledaju se u tome da:

- Šumski zasadi omogućavaju bolje vezivanje zemljišta, stimulišu razvoj prizemne flore, aktiviraju pedološke procese u supstratu korenovim sistemom, sprečavaju insolaciju i sušenje tla, duvanje jakih vetrova i podizanje prašine.
- Pošumljavanjem degradiranih površina na deponiji pepela i šljake doprinosi se zaštiti životne sredine, poboljšavanju mikroklimе i estetskom izgledu okoline.

Ukupne degradirane površine na odlagalištima iznosi 400.628 m².

Ukupni troškovi rekultivacije za **40,06** ha iznose: $T_u = 4.527.253,9$ €(dinamika rada 2 godine).

Ukupna cena rekultivacije po jednom hektaru iznosi: **113.011,9 €/ha**

Ukupna cena eurekultivacije po jednom m² iznosi: **11,30119 €/m²**

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