CASE STUDY

4

RECLAMATION OF AN EXISTING OPEN DUMP FOR SOLID WASTE IN THE LAND OF "ALEKO KONSTANTINOVO" VILLAGE

1. Introduction

After joining the EU, Bulgaria has increased its funding on environment protection and sustainable development, but, some significant challenges remain. Reduction of the amount of waste and preventing the negative environmental impact of the unregulated waste disposal sites are among the major objectives in the "Waste" sector in Bulgaria. Significant progress has been achieved, but waste management continues to be a problem. In respect to this, European and national legislation requires guarantees from the landfill owners for closure and rehabilitation of the open dumps in Bulgaria. This case study describes in detail the strategy developed and further applied during the rehabilitation of a municipal open dump, located in the village of Aleko Konstantinovo, Pazardzhik municipality, Bulgaria.

2. Waste Management in Bulgaria - challenges, investments, and waste management approaches

To reduce the waste amount and to realize a transition to a circular economy, initiatives have been taken in Bulgaria, incl. legislative, aimed at harmonizing national policies with those at the European level. Significant progress has been achieved, but waste management continues to be a challenge (Report on Bulgaria 2020). The generated household waste has a tendency of permanent decrease, which for the period 2008-2018 is about 36% (National Waste Management Plan (NWMP) 2021-2028, unlocking condition). The share of treated municipal waste is increasing (in 2017) 99.7%), and the amount of landfilled waste decreased significantly, but in 2017 (61.8%) remains higher than the EU average (23.5%). The share of the population covered by an organized garbage collection system is 99.8% and includes 4 698 settlements (NSI 2018). The level of recycling of municipal waste for 2017 is still 34.6% far from the values at the EU level (46.5%, Eurostat). Operational Program "Environment" (OPE) is the leading source of funding for public

infrastructure for municipal waste management. During the programming period 2007-2013 are supported investment projects in 20 Regional Waste Management Associations (RWMA), including landfill cells with a total capacity of more than 6 million tons; installations for pre-treatment of mixed household waste with a total capacity of over 350 thousand tons/year; for composting green waste with a common capacity of 200 thousand tons/year; for anaerobic digestion with a total capacity of 20 thousand tons/year and others. OPE 2014-2020 has funded projects for the management of household waste in 24 RWMA, including 19 pre-treatment plants; 43 composting and 3 anaerobic plants, RDF recovery plant with energy production and reclamation of 54 old landfills. These projects contribute to reducing the amount of landfilled waste by more than half a million tonnes - about 28% compared to those deposited in 2012.

The built infrastructure does not have sufficient capacity to achieve the objectives for recycling and utilization of the estimated quantities of household waste in line with the new EU objectives (NWMP 2021-2028). That is why in the period 2021-2027 a priority is given to funding for the development and improvement of municipal waste management systems at the regional level, in particular infrastructure aimed at re-use, recycling, and separate collection for achieving the goals by 2030. Investments in regional infrastructure will be aimed at the RWMS and the municipalities from Annexes № 6, 7, and 8 of the NWMP 2021-2028. More efforts are also needed to raise public awareness and increase the knowledge base as key actions to improve governance of waste by providing grants.

Open dumps reclamation support is aimed at reducing the risk of pollution environment and damage to human health. The predominant part of construction waste has great potential for recycling and recovery, there are recycling technologies available, but there is not enough capacity for their recycling (NWMP 2021-2028). Achieving higher levels of recycling and recovery requires significant investment and effort on the part of Bulgarian companies (Strategy for transition to a circular economy 2021-2027). Investments for the period 2021-2027 focus on interventions, stimulating the transition to a circular economy. Demonstration support projects under OPE 2014-2020 contribute in this direction, including through raising public awareness of the waste management hierarchy, to generate "good practices" and ideas, as well as the opportunity for their subsequent follow-up application on a larger scale. The investments are based on and contribute to the objectives of the NWMP 2021-2028 and the strategy and action plan for the transition to a circular economy 2021-2027. Recommendations on other strategic documents such

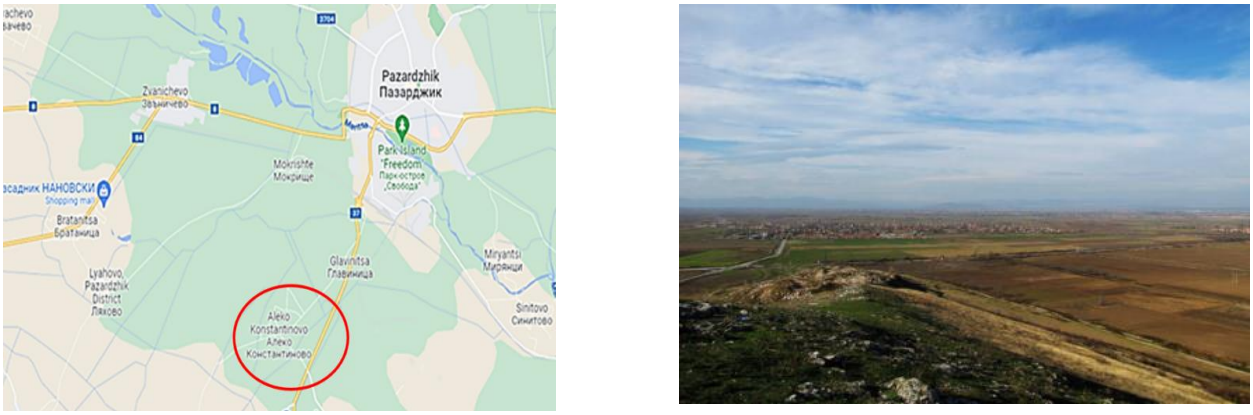
as the Reports on Bulgaria 2019 and 2020, the Early Warning Report for Bulgaria 2018, NDP Bulgaria 2030 and the SME Strategy 2021-2027 has also been taken into account.

3. Project "Closure and Reclamation of an Existing Old Open Dump for Solid Waste in the Land of Aleko Konstantinovo village, Pazardzhik municipality"

This project aims to contribute to the achievement of national goals to reduce the negative impact on the environment from waste treatment and disposal activities. Its implementation includes the reclamation of an old open dump (92 000 m^2), which contained 100 000 m^3 solid wastes, accumulated for the period from 1962 to November 2017. The project is worth over BGN 4.7 million and is funded by the EMEPA (Enterprise for the Management of Environmental Protection Activities), through transfer under the Law on the State Budget of the Republic of Bulgaria for 2019 according to the provisions of Art. 87 of the State Budget Law for 2019. After a public procurement contract was concluded between the Municipality of Pazardzhik and EMEPA for the realization of the project for the 10 months for technical reclamation and 3 years for biological reclamation. The implementation of the project begins in the autumn of 2019. In 2019, activities are carried out mainly for the re-disposal of waste and the construction of a system for polluted water. In 2020 the activities for pre-disposal and shaping of the open dump body were completed and the gas system, the insulation screen, and the technical reclamation were built. The biological reclamation was performed at the end of 2020 - soil preparation of the areas for reclamation and sowing with seeds. Mainly finishing works were carried out during the winter of 2020-2021 - drainage ditches and connection of the gas system. The reclamation process and restoration of the terrains continue until the third year with planned care. The biological reclamation will be implemented during 2021, 2022, and 2023.

The existing old open dump of Pazardzhik municipality is located 12 km south of the town, 1 km SouthEast of the village Aleko Konstantinovo and about 1.8 km south of the village Glavinitsa, "Baira" area (Figure 1). The site can be reached by a fourth-class road to the villages of Kapitan Dimitrievo and Bratsigovo. Over the years, the open dump has created problems for the surrounding villages. With the warming of the weather, the self-ignition of the waste has started. Due to the burning of the waste, the open dump systematically gasses four villages - Kapitan Dimitrievo, Debrashtitsa, Aleko Konstantinovo and roads in the area. The problem with self-ignition is extremely complex, especially because the Pazardzhik open dump is one of the first places in terms of biogas concentration. For more than 30 years, its existence violates all norms

and requirements. It destroys the Natura 2000 protected areas in which it is located, pollutes the agricultural areas that are located next to it. Some of the waste falls directly on the road and is carried by the wind straight to the fields and plantations - paper, plastic bags, and more.



A. **B.**

Figure 1. Location of the open dump in Pazardzhik municipality: **A.** Map of the location of the town of Pazardzhik and Aleko Konstantinovo village. **B.** The land of Aleko Konstantinovo village

The open dump is operated without the construction of a bottom insulation screen, drainage system for filtration water, or other measures limiting the spread of waste or hazardous substances released from the processes of decomposition of waste. The waste is dumped directly on the ground in the used spaces of two quarries for facing materials. The open dump has been operated without any measures for the protection of soils, groundwater, and earth's bowels from pollution due to the disposal of waste on the site, no security ditches have been built, etc.

The open dump, subject to the project "Closure and reclamation of an existing old open dump in Pazardzhik municipality, on the land of the village of Aleko Konstantinovo", is included in the list of open dumps in criminal proceedings for violation № 2012/2082 for non-compliance of the obligations of the Republic of Bulgaria according to Article 14 of Council Directive 1999/31 / EC of 26 April 1999 on landfilling. As a result of data processing and calculations, the existing open dump is classified and included in risk group IV with a risk assessment above 8, open dumps with a very high risk in terms of its impact on soil and groundwater. The closure was planned to be carried out according to Model "C" "*in-situ*" waste disposal, according to the Methodology for risk assessment of old pollutions.

Situation plan of the site before filled

The open dump was not blocked. It has a flat part and a very steep southwestern slope. There are cracks and landslides along the entire slope. This requires mandatory re-mowing and re-depositing to form the necessary slopes. The open dump was used for disposal of household and similar household waste, sludge from wastewater treatment, sludge from production activities, as well as construction waste from excavations, demolition, and reconstruction of buildings. Throughout the year there was smoldering of sludge and waste on the plateau, as well as unpleasant odors. The area with liquid waste deposited in the westernmost part of the dump was filled with fresh waste in 2016-2017, with significant capacity.

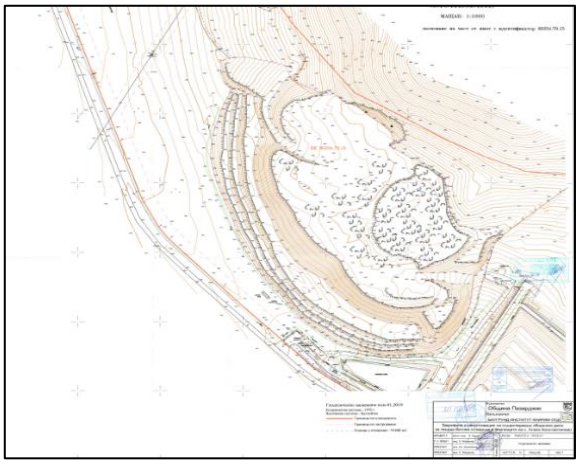
Figure 2. Open dump in the land of Aleko Konstantinovo

(Photos source: https://www.monitor.bg/bg/a/gallery/rekultivirat-staroto-smetishte-v-pazardjik-183241?gallery=0; https://kmeta.bg/smetisteto-kraj-pazardjik-obgazyava-chetiri-sela; https://evromegdan.bg/448

According to the data of the geodetic survey the existing waste disposal site was built on several levels on a slope with southwestern exposure. The used spaces of two marble quarries were initially filled. The way, the top-down waste dumping has been carried out over the years was incorrect, due to which steep slopes have been formed. As a result, in several places landslides

have occurred due to the high height of the steep slope and the disposal of liquid waste. The thickness of the accumulated waste varies from 2.0 to 38.0 m. During the geodetic survey in January 2019 it was found that several soles, with different heights of accumulation, were formed on the reclamation area (92 decares): the main sole of the open dump with the height of waste accumulation between 30-38 meters; low northwestern sole, with deposited liquid waste, with area 12 500 m^2. The old waste disposal site of the municipality of Pazardzhik consists of a flat part (plateau), with a very low slope, on the surface of which in many places there is sedimentation, retention of surface water, and vegetation development. The southwestern main slope of the open dump has slopes of 1/1,1. The decision for vertical planning was made given the allowable slopes for reclamation and given the balance of waste. The project vertical and general plans are presented in Figure 3.

A.



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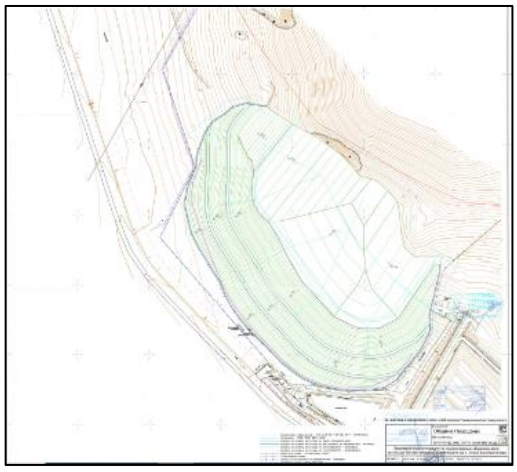

C.

Figure 3. Existing old open dump in the land of Aleko Konstantinovo A. Vertical planning of the site; B. Geodetic survey; C. The general plan of the site is to be reclaimed.

Geological and hydrogeological studies

The old open dump for solid household waste of the town of Pazardzhik is situated in the range of the karst aquifer known in the literature as the Perushtitsa-Ognyanovski karst basin (Antonov and Danchev, 1980). The horizon is formed in karstic marbles and marbled limestones from The Dobrostan marble retinue. The pool is attached to the block-broken thigh of the Northern Rhodope the anticline between the Chepinska and Vacha rivers. As a result of tectonic movements, part of the rock blocks are buried in-depth, and others float to the surface. The open dump is located in the open northwestern part of the basin, in the region of the Bessaparian hills (Figure 4) -horst structures of marble interspersed with gneisses and gneiss-shale. The marble complex is intensely cracked and karst. According to data from the drilling of the geological base at the landfill it was found that the upper part of the incision is made of clays and sandy clays whose thickness varies from 0.3 m to 12-15 m. A rock base of marbles is situated under the clay and in the northeast part of the section - by gneisses and gneiss-shale.

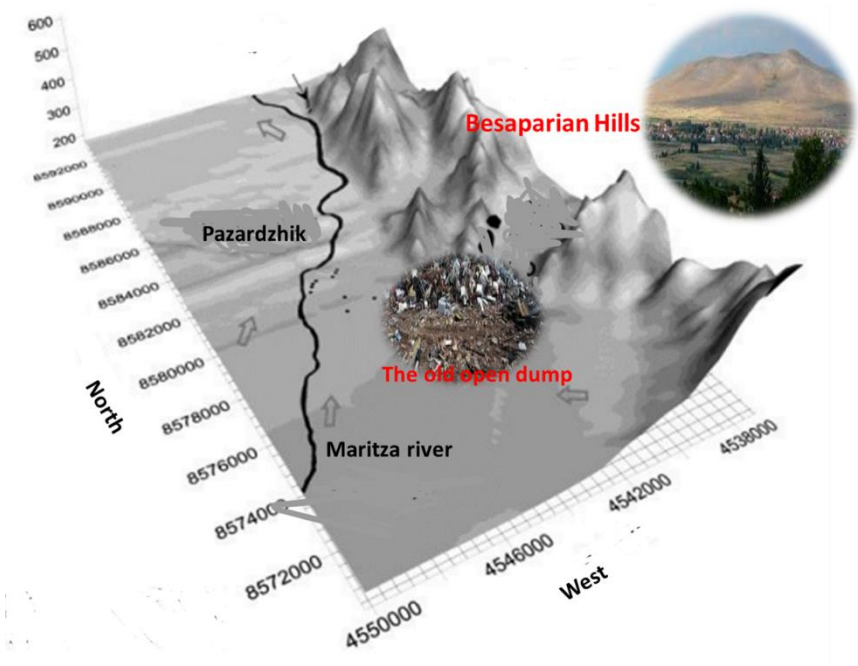

Figure 4. Location of the existing old open dump in the land of Aleko Konstantinovo (Adapted from Stoyanov, Dimovski, 2016).

The waste is deposited in an old marble quarry without laying an insulating layer. This creates favorable conditions for entry into wastewater in-depth and pollution of groundwater. The

operation of this old waste disposal site ends in 2017 and an insulating screen was laid on the open dump area that prevents infiltration of rain and surface waters and decreases sharply the infiltrate produced.

Electric tomographic studies were conducted in the area of the old open dump to investigate the hydrogeological structure and to locate the karst zones. The migration of strong and weak mobile pollutants (for example, Cl and NH_4) in the aeration zone and the water-saturated zone is simulated using mathematical hydrogeological 2D models. An assessment of contamination from the Aleko Konstantinovo open dump, as well as a long-term estimate of migration movements following its rehabilitation, was done. The amount of infiltration flow below the bottom of the open dump is a function of geological permeability and the existence or absence of engineering barriers, according to the results of the model hydrogeological research. The clay-sandy layer, which covers the rock complex, karst marbles, and broken gneiss-shale is the main pollution transport way. The aeration zone's large thickness (about 20-25 m and more) has a vital role in slowing migration. Simulations suggest that toxins from the open dump move to groundwater via a small karst area in the central part of the dump with a width of 50-70 meters. Water does not cross the aeration zone beyond this open dump area. Highly mobile contaminants (Cl) migrate to a depth at a rapid rate, which is proportional to the rate of infiltration flow. For around 25 years after the start of the open dump`s operation, these contaminants reach the underground leads. The percentage of Cl in polluted groundwater is roughly 25% during this time and after the open dump is closed. Low-level pollutants (NH_4) migrate at a considerably slower rate, therefore the contaminated area is significantly smaller. In the closing stages of the old dump's operation, the first "portions" of NH_4 enter groundwater. It will continue to reach the water-saturated zone after closure, although at very low concentrations (about 4-5 %).

4. The reclamation process

Five stages are described in the reclamation process of the open dump. It includes the following activities: preparatory works and temporary construction; re-disposal of waste; construction of a filtration water system; activities for construction of gas capture and exhaust system; construction of insulation layers; construction of a reclamation layer on all planned terrains; construction of a humus layer; biological reclamation; drainage ditches; finishing works; biological reclamation - mowing and hoeing; biological reclamation – fertilization; site monitoring. The process is realized according to the requirements set in the Plan for own monitoring of the old open dump in the

Pazardzhik municipality as well as to the Technical specification regarding the requirements for input materials, waste pre-disposal, construction of top sealing layer, drainage layers, and requirements for synthetic materials.

4.1. Stage 1

Preparatory works include tracing, formation of a temporary road for access to the site, from the road Pazardzhik - Peshtera, over the areas for the installation of pre-treatment and composting waste, construction of surface disposal and infiltration waters facilities (construction of a drainage ditch for collecting filtration waters and completion of a system for their collection and of security ditches for interrupting the inflow of wastewater from neighboring terrains);

4.2. Stage 2

Pre-disposal of waste - compaction of pre-deposited waste and formation of the project - reclamation surface of the open dump.

Excavations and predisposal of waste

The excavations, which are carried out on the site, are mainly for shaping the design surface of the open dump. It was planned to excavate and re-deposit 100 000 m^3 waste. Re-mowing is the excavation of the eyebrow of the slope and pre-disposal of waste on the flat part of the open dump, which forms the design slopes of the open dump body. The most significant are the excavations along the eyebrow of the main slope, as well as in the northwestern part of the open dump- the area where fresh waste was deposited in the period 2016-2017. In these areas, the excavations reach up to 7.0 meters. Re-disposal of waste was carried out mainly along the route of the old operational road of the old open dump - on the east side, as well as on the plateau for alignment and filling and reaching project elevations. The waste is plowed in layers 60 cm high and compacted with a roller during pre-deposition. The subsidence is measured geodetically and a function of subsidence and the number of holes is calculated in the experimental compaction. The leveling and compaction of the residual waste at the open dump's base, as well as the shape of the surface - elevations, transverse and longitudinal slopes - are all part of the project's surface preparation. For each layer, the reference points must be the same. To protect the dump from wastewater from the surrounding terrains, trench excavations were carried out in rocky soils to build ditches. The location of the dump, which is part of the land property with an identifier 00254.70.15 in Aleko Konstantinovo's land, is included in Natura. As a result, the rock excavations

were not done by blasting. Instead, they were done mechanically with a bulldozer and a hammer excavator.

Facilities for capture and treatment of filtration and conditionally clean waters

System for collection of polluted infiltrating water - before the start of the excavation works, it is obligatory to build temporary drainage facilities to ensure the rapid drainage of the surface and running water outside the waste disposal site. The infiltration water collection system of the old dump for solid waste consists of a drainage ditch filled with drainage material and a collection tank for filtration water. The drainage ditch`s material is composed of washed river ballast with a grain size distribution, providing filtration coefficient bigger or equal to 1 x 10^{-3} m/s, which is kept stable during long-term operation of the open dump and carbonate content up to 10 weight %.

System of ditches for conditionally clean water-it consists of surface drainage for conditionally clean water and a system of ditches for catching and draining surface water. As an alternative to a drainage layer of natural materials - gravel, a drainage geocomposite was used. It consists of a structural element that conducts water longitudinally and one or two geotextiles that act as filters. The removal of the waters caught from the drainage is carried out by building peripheral drainage in the heel of the southwestern slope of the reclaimed open dump. It consists of drainage polyethylene pipes wrapped with drainage geocomposite (Figure 5.). The water from the peripheral drainage is drained into polyethylene pipes, laid perpendicular to the peripheral drainage, at least 0.2 meters inwards, and flowing into the terrain. Surface water ditches have also been built, which perform the following functions - protection of the reclaimed surface from wastewater from other terrains, capture and drainage of water from the reclamation surface, and its protection from erosion.

Figure 5. Recultivation surface plan

Gas capture and exhaust system

Municipal solid waste disposal is primarily a biological process in which organic matter is converted to inorganic under the action of anaerobic bacteria. The decomposition process is related to the production of biogas, which mostly consists of methane and carbon dioxide, with minor amounts of other gases. Municipal waste typically contains 120 to 190 kg of carbon per ton of wet waste, with a calorific value of 3.5 to 5.5 kWh/m^3. The ratio C/N is critical for the biological processes of organic matter degradation present in solid household waste. The organic matter content does not properly characterize the degradation processes, since it does not reflect the content of the organic carbon and nitrogen, utilized by the decomposing microorganisms. As a result of the metabolic activity of the present anaerobic microorganisms, gases such as methane, hydrogen sulfide, hydrogen, and others are released. the composition of the open dump gas includes approximately 55 vol % methane (CH_4), 45 vol % carbon dioxide (CO_2), below 1 vol % microelements, as the average ratio methane/carbon dioxide is around 1.2 to 1.5.

The amount of the waste in the open dump is 2,200,000 tons, with a gas potential of 140 m^3/tonne. The total amount of the produced open dump gas depends on the quantity and the morphological content of the waste, type of the waste disposal site, the operation procedures, etc. According to the gas forecast for this open dump, the amount of generated gases is estimated at 500 m^3/hour. The construction of an active gas system is being considered due to the high amount of waste accumulation. It is made up of eight gas wells connected by linear gas drains and an exhaust gas pipeline (88 meters) to the installation for disposal of the captured open dump gases (Figure 6). The gas wells are deep boreholes in the waste, that are filled with drainage material and have a drainage pipe running through the last three meters. They are with a depth of 15 meters. The exploitation of such kind of open dump (old open dump with the passive gas system, which is constructed at the stage of closure and rehabilitation of the dump), show the open dump gas capture system's efficiency, which ranges from 40 to 60 % of the maximum gas potential. For the specific case, 50 % are accepted, and for reduction of pressure losses during the movement of the open dump gas a design speed of 7 m / sec is accepted. During the process of waste pre-disposal to build a vertical layout of the site, the collected and accumulated gases in the volume of the open dump will be partially released into the atmosphere, aerating the waste and changing the phase of the

decomposition process. The amount of gas used will be lowered much more. There are six possible techniques for open dump gas disposal:

- collection and purification of the gas and its use as a transport fuel.
- utilization for energy production on-site
- disposal by waste incineration
- technologies for catalytic, thermal oxidation of methane in the gas
- bio-oxidation (biofilters) and release into the atmosphere
- direct release in the atmosphere

For this open dump, the gas disposal is carried out through incineration in high-temperature combustion facilities, typically up to 1200°C, while allowing a predetermined residence duration in the flue gas combustion chamber.

Figure 6. Gas system plan

4.3. Stage 3

Technical reclamation on the newly formed surface - leveling layer, bentonite waterproofing and tightening layer, laying of reclamation layer, and, the layer of humus soils.

Construction of leveling layer

A leveling layer 0.2 m thick was laid on the open dump surface for reclamation. It contained soils with a maximum grain size of up to 63 mm. For the construction of the leveling layer, contaminated soils from the open dump were used, as well as stabilized and mineralized sludges from wastewater treatment, with a dry matter content of at least 55%. The layer is leveled with a bulldozer to create a base for laying bentonite waterproofing. As an insulating element, a geosynthetic layer of clay (GCL) was used. The bentonite waterproofing contained a minimum of 4.5 kg/m^2 sodium bentonite. The rollers of bentonite waterproofing are 4.50 meters wide to reduce losses and the number of joints. The surface of the leveling layer must be cleaned of residues of building materials, roots of shrubs and trees, stones. The surface must be level with a bulldozer and drained, there must be no retained surface water and it must not be softened. Under the bentonite waterproofing, a 20 cm layer of soil is laid, to provide conditions to prevent the removal of bentonite from the insulation, as well as to tighten and protect the waterproofing from drying out. A layer of mineral material with a thickness of about 20 cm was laid on the bentonite sheets in an unsealed state. This mineral layer protects the material from swelling when wet as well as aging in the environment. To build this tightening layer 19,806 m^3 of soils were used. In the upper insulating screen, the laying of a drainage geocomposite was also provided. It conducts a water volume of 0.2 l/sec/m at a gradient i= 0.1 and loads 20 kPa, including in its construction drainage pipes. The removal of the waters caught from the drainage is carried out through built-in peripheral drainage in the heel of the southwestern slope of the open dump. The water from the peripheral drainage is drained into polyethylene pipes (PE 100 PN 10, DA 110 mm) laid perpendicular to the peripheral drainage at least 0.2 m inwards. On the periphery of the open dump are located drainage pipes at a distance of 25 m.

Reclamation layer

The reclamation layer (0.70 meters) was applied to the tightening layer of the bentonite waterproofing. The necessary soil material was provided partially from the excavations for shaping the sites of the installation for pre-treatment of mixed household waste and the installation for composting of separately collected green and biodegradable waste in the western part of the land property 00254.70.15, the land of Aleko Konstantinovo.

Humus layer

During the construction of the humus layer, humus soil materials from the preparation of the site of the installations for pre-treatment of mixed household waste and composting of separately

collected green biodegradable waste were used. The soil materials used for the construction of the humus layer contained organic carbon of at least 0.6%, respectively humus content equal to or greater than 1%. To protect future vegetation from harmful effects, the earth's mass must not be contaminated with heavy and rare metals and toxic substances.

4.4. Stage 4

Construction of facilities and completion of technical reclamation-security ditches and monitoring points, as well as the construction of facilities for connection of the gas system of the old open dump to the installation for high-temperature combustion of open dump gas at the site of the new Regional landfill 1, Pazardzhik 1, displacement of the fence in this section, placing of turf.

4.5. Stage 5

Biological reclamation with the planned tillage, mineral fertilization and sowing of the seeds, and cultivation care within three years (2019-2021). The goal of the technical and biological reclamation of the old open dump in the land of Aleko Konstantinovo village was to be integrated into the surrounding landscape and the regenerated land to be used as grassland. The object of biological reclamation was the newly formed body of the unregulated open dump. Due to unclear processes that occur in the body of the open dump - subsidence, emission of gases, liquid products, toxic materials that are unfavorable factors for reclamation, it is not expected that the recovered sections of the open dump would be used for agricultural use or afforestation. One of the key goals of the project for reclamation of this open dump, which does not meet the regulatory requirements, is the restoration of the disturbed lands, relief, and landscape of the area. As a result of the reclamation process, the sanitary and hygienic conditions of the area will be improved and the restored lands will be integrated into the environment.

The area for technical and biological reclamation of the newly formed landfill is 95 336 m^2 (as a 2D) or 99 030 m^3 respectively as a sloping surface (as a 3D). A total of 99,030 m^3 soil materials are needed, of which 29,709 m^3 are humus soil (a layer thickness of 0.3 m) and 69,321 m^3 earth masses. These materials are spread gradually and sequentially on the prepared surfaces. The village of Aleko Konstantinovo is situated in the Pazardzhik-Plovdiv agro-ecological region. It covers the western part of the Thracian lowland. The open dump is located on the southern and southwestern slopes at the western end of the Besaparski hills. The altitude of the site is 270 m. The relief is flat and determines mainly accumulative processes, the erosion processes are very

weak. The climate is transitional, with an average annual temperature between 8-9°C in the lowlands and about 5°C in the highlands.

According to Bulgarian geobotanical zoning, the dump is located in the Upper Thracian district of the Macedonian - Thracian province of the European deciduous forest area, between the Plovdiv region and the Rhodope foothills. The modern vegetation on the territory of the site is composed of secondary and derivative-grass and shrub-grass micro-groups. Small populations of medicinal plants participate in plant communities. No local and protected plant species and plant communities have been identified. For this geographic region, the soil cover is diverse, with alluvial-meadow soils, cinnamon-podzolic, resinous, cinnamon forest soils, and saline soils dominating. For the region of the dump, resinous soils are not typical.

Construction of humus layer for biological reclamation

To build the upper root layer for the reclamation of the old open dump are needed 29 709 m^3 humus soils. 14,880 m^3 of this quantity was provided mainly during the preparation on the site of the installations for pre-treatment of mixed household waste (11 320 m^3) and the installation for composting of separately collected green and biodegradable waste (4 560 m^3) within the same land property. As a source for providing the remaining quantities of about 14,829 m^3 of humus soils, the areas of Ovchepoltsi dam (about 60 decares), will be used. The soil materials are characterized in an accredited laboratory complex for testing at the Agricultural University - Plovdiv. They were analyzed for pH, nitrogen, phosphorus, and organic carbon content, as well as for heavy metals and metalloids. The need for additional fertilization has been identified, using mineral fertilizers (single or combined) due to the observed nitrogen deficiency (from 4.61 mg/kg to 14.24 mg/kg dry soil, at a rate of 10-20 mg per 100 g of dry soil for good to very good storage). An alternative is the application of organic fertilizers, which will compensate for the low levels in the sub-humus layers. The thickness of the reclamation layer is 1.0 m of suitable soil masses, of which 0.30 m are humus soils.

The stages in the construction of the reclamation layer were as follows:

- laying 70 cm of the groundmass
- laying 30 cm of humus soils to create a root layer

As the biological reclamation is through grazing, to create favorable conditions for growth, tillage, mineral fertilization, sowing of appropriate and quality seeds, observance of the terms and depth of sowing, and cultivation care of the lawns for 3 years are envisaged.

The tillage activities are very important for the successful germination of seeds and the development of grass vegetation. These include disking, milling, harrowing, and rolling. The seeds must be sown to a depth of 2 cm, as the appropriate sowing dates are in the spring. Anti-erosion overgrowth is not envisaged.

The fertilization was carried out with the universal and applicable for the conditions of the region mineral fertilizers - ammonium nitrate and triple superphosphate, containing respectively 34% N and 45% P_2O_5.

The grass mixtures used for biological reclamation of the dump have a strengthening effect and are resistant to severely deteriorating edaphic conditions. The requirements for grass species are to be drought-resistant and undemanding to the content of nutrients. The choice is made according to the local climate, the created soil conditions, and the purpose of the grassing. For the biological reclamation of the dump the species *Poa patensis* (20 %), *Festuca rubra* (50 %), *Dactylis glomerata* (20 %), and *Bromus inermis* (10 %) were used (Figure 7). These species are drought tolerant, with a deep root system.

Figure 7. Grass species, used in the biologogical reclamation of the Aleko Konstantinovo open dump: A. *Poa patensis*; B. *Festuca rubra; C. Dactylis glomerata; D. Bromus inermis*

The required quantities of grass mixtures for the open dump reclamation amount to 2970.9 kg. Due to the lack of favorable environmental conditions and unguaranteed moisture retention of the reclamation layer, the edges of the slopes are covered with striped strips with a width of 1 m.

Figure 8. View from the recultivated open dump in Aleko Konstantinovo

4.6. Monitoring of the old open dump in the area of Pazardzhik municipality

The plan for control and monitoring of the open dump under Art. 40, paragraph 1, item 1 of Ordinance № 6 / 27.08.2013 is carried out in the process of operation of the open dump and after its closure. It includes the minimum requirements necessary for the monitoring and control of open dumps, including ensuring the protection of environmental components through a lower and upper insulating screen and gas exhaust system. Monitoring includes observations and measurements at a certain number of points, frequency of measurements, and control of certain parameters.

For the open dump in the land of Aleko Konstantinovo village, only the impact of the site on the components of the environment after its closure and reclamation is monitored.

Control of the topography of the reclaimed open dump

The monitoring of the topography of the open dump is to establish the presence or absence of subsidence of the dump. The reasons for the occurrence of deformations can be different - geological, hydrogeological, climatic, etc. In this case, it is important to determine whether there are deformations and within what limits. A total of 5 leveling benchmarks at different elevations are stabilized. The leveling benchmarks are observed from base points outside the zone of probable deformations. For the area of the newly formed and reclaimed open dump a total of 14 benchmarks

were used, located on the plateau (maximum waste capacity) and both berms of the profiled steep slope of the dump.

Monitoring of emissions of harmful substances into the atmosphere

The condition of the air at the site of the old open dump in the Pazardzhik municipality is reported, and two periods are considered: the period before sealing the waste; period after construction of the system for capture, removal, and treatment of the open dump gas and construction of the upper insulation screen. The harmful substances released from stationary sources on the site of the old open dump for solid waste are not subject to continuous own measurements. They are subject to periodic own measurements. The control and monitoring of the volume and composition of the gas emissions (SO_2, NOx, CO_2, O_2) after the closure of the open dump is performed every 6 months. The efficiency of the exhaust system is constantly checked.

Monitoring the amount and composition of filtration water (Sampling point 3)

The project envisages the capture of filtration water from the dump. For this purpose, there is a ditch on its southwestern side and a reservoir for collecting water. No leakage of filtration water was observed. Water composition samples are taken from the filtration water tank (sampling point 3). The filtration waters` composition will be monitored every six months after the closure of the dump. The following parameters are monitored: temperature, color, smell, pH value, electric conductivity, soluble oxygen, absorbable organically bound halogens, Mn, Fe, NO_3, N, SO_4, microbial number, coliforms bacteria, petroleum products, cyanides, polycyclic aromatic hydrocarbons, etc.

Monitoring of the amount and composition of surface water (Sampling point 2)

According to the project, the ditches were constructed to capture and drain the water from the reclamation surface of the dump and protect it from erosion. Sampling point 2 is after the dump before the ditch water flows into the ditch of the Mixed Waste Pre-Treatment and Composting Plant. The monitoring of surface waters is performed by the following indicators: active reaction, electric conductivity, organic nitrogen, NO_3, NO_2, o-phosphates, Fe, Mn, Hg, phenols, Zn, Cr, Ni, Pb, etc. After the closure of the open dump, the monitoring of surface waters is carried out every 6 months.

Monitoring of the amount and composition of groundwater (Sampling point 4)

The chemical status of groundwater is determined depending on the electrical conductivity and concentration of pollutants in groundwater. The indicators to be monitored:

- ✓ substances, ions, or indicators of pollution of natural origin or as a result of human activity – Ar, Cd, Pb, Hg, NH_4, Cl, SO_4
- ✓ parameters showing the attraction of salty or polluted water as a result of human activity– SO_4, Cl, electric conductivity
- ✓ -given the source of potential contamination - pH, permanganate oxidizability, total hardness, phosphates, nitrates, Cu, Zn, etc.

After closure and reclamation of the open dump of Pazardzhik municipality, sampling for control of the chemical status of groundwater is to be performed twice a year – in May and November. The closure of the old open dump near Pazardzhik will have a positive impact on the air, water, landscape, biological diversity, and in general on people and their health. The positive impact is expected to be permanent and irreversible.

References

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Working Project "Closure and reclamation of the existing old open dump for solid waste in the land of Aleko Konstantinovo village, Pazardzhik municipality" (Parts: Technical specifications; Geodetical survey; Gas capture system; Hydrotechnical and technical reclamation; Construction waste management plan; Biological reclamation, Plan for own monitoring); https://pazardzhik.bg/bg/zakrivane-i-rekultivatsiya-na-sashtestvuvashto-staro-depo-za-otpadatsi/.

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