CASE STUDY

5

CLOSURE AND REHABILITATION OF AN OPEN DUMP FOR MUNICIPAL WASTE ON THE TERRITORY OF THE MUNICIPALITY OF ELENA, BULGARIA

1. Introduction

This case study is elaborated on the basis of the data of project BG16M1OP002-2.010-0035-C01 "Closure and rehabilitation of an open dump for municipal waste on the territory of the Municipality of Elena", funded under procedure BG16M1OP002-2.010 "Rehabilitation of open dumps for closure, subject to a procedure for violation of EU law in case C-145/14", Priority Axis 2 "Wastes" of the Operational Program "Environment 2014-2020", co-financed by the European Regional Development Fund and the Cohesion Fund of the European Union. The total cost of the project is 807,131.30 EUR (686,061.60 EUR co-financing from ERDF).

It describes the closure and rehabilitation activities realized in the period 06.05.2020 - 27.10.2021 aiming to transform the non-sanitary open dump, that harms the environment, climate and health of citizens of Elena municipality into valuable community asset.

The case study interprets the data of the above-mentioned project in the light of the SMARTEnvi project and contributes to its objectives by revealing good practices at national level in reducing hazards to the environment and human health. It is a good example of the measures and actions undertaken on climate change and environmental protection in the context of COVID 19 national recovery policy.

2. General information, geology, and hydrogeology

2.1. Location

The existing municipal open dump for non-hazardous waste of Elena municipality, Bulgaria is located 450 m northwest of the construction boundaries of the city (Figure 1). The open dump covers an area of 23,488 m^2 within a plot of land № 27190.108.98. Its location can be reached by an existing municipal road. The open dump has stopped operating since 30 September 2016 based

on Order No 551 / 30.09.2016 of the director of the Regional Inspectorate for Environment and Water (RIEW) - Veliko Tarnovo, due to non-conformity with legal requirements. The entire open dump is full of waste. It is neither included in the boundaries of Natura 2000 network as a protected area nor in the boundaries of any protected territory in respect to Bulgarian Protected Areas Act (http://eea.government.bg/bg/legislation/biodiversity/zztan_15.pdf).

Waste is deposited in an area of 24,221 m^2. The area assigned for rehabilitation is 23,488 m^2 - sufficient to allocate the waste step-wise in compliance with the Ordinance № 6 and the instructions for conducting technical and biological rehabilitation (MEW, 2013).

Figure 1. Elena Municipality open dump location. Source: http://zop.elena.bg/wp-content-location

2.2. Open dump status before rehabilitation

Elena Municipality open dump was opened in the last century. The waste deposited in it comprised household, non-hazardous production, and construction waste. However, it was heterogeneous, unsorted, and self-compacted area. The open dump area was marked with an announcement sign. There wasn't any fence or entrance portal; the entrance was inaccessible. There was no electric power and water supply. No input control and weighing of incoming waste (by type and quantity) were executed. There wasn't lower insulating screen and equipment for compaction of the deposited waste. Biogas was not management at the open dump. There was no system for collecting and removing the surface water and the infiltration.

Waste deposited comprised the one collected as a result of organized waste collection in the city of Elena, as well as incidentally delivered bulks by individuals and/or production settings, for which no control of their non-hazardous nature had been carried out.

The open dump neighboured in its northwest (about 150 m) a gully with a variable runoff after rain. In addition, no surface water and infiltrates were drained from it and there were no gears for collecting and treating the rainwater. There was neither a system for biogas collection/control (Figure 2).


Figure 2. Elena Municipality open dump general overview. Source: http://zop.elena.bg/wp-content-location

Environmental and emission hazards imposed by the open dump can be summarized as follows:

1. Smoke and toxic emissions when waste is self-ignited;
2. Soil contamination due to the prolonged exploitation of the open dump without adequate measures for the soil basis protection;
3. Pollution of surface and groundwater from waste deposition and infiltrate formation;
4. Waste distribution and spreading of infections by the wind and the animals;
5. Deterioration of the flora and fauna status in the area.

2.3. Geological characteristics of the area

Stratigraphy

The open dump area is made up of rocks dated from the lower Jurassic period.

Physical-geological processes and phenomena

Erosion-accumulation, gravitational and karst processes and phenomena are typical for the area. The erosion-accumulation processes and phenomena resulted in the modern mountain relief of the area. The karst processes and phenomena resulted in mostly small karst forms - kari, karst rushed

cracks, voids of varying excavation. The gravitational processes and phenomena include screens, collapses and landslides, that are not located near the open dump.

Seismicity

Seismic danger in Bulgaria, including Elena Municipality, is mainly determined by seismic sources identified on the territory of the country. Relatively weaker is the influence of seismic sources of Marmara Sea (Turkey) and Xanthi (Greece). The strongest earthquakes near Elena Municipality were registered during the period January 1908 - March 1942 with magnitude 7.0. According to Bulgarian national regulations, the territory of the open dump is classified into a seismic area of VII seismic degree, and the design of buildings, communications and other constructions is carried out with seismic coefficients of Kv and Kh = 0.10 (Bonchev et al., 1982).

2.4. Hydrogeological conditions

Hydrogeological conditions of Elena Municipality are determined by the karst groundwater, detached in an underground water body (normal pressure) "Karst-water in the Central Balkan", code BG1G0000TJK045. It is fuelled by rainstorm and surface waters from the surrounding mountain slopes and drained on the slopes by variable flow springs. Aquifers are represented by sandy, alunite and dolomitized limestone, dolomite and carbonate flesh. The natural resources of the groundwater body are 10,246 L/s, and the permitted water quantities are 78 L/s. The chemical status of the groundwater body and the protection zones are poor, while the quantitative parameters are good.

There are no mineral waters on the territory of Elena Municipality. The surface water from the Yovkovtsi dam and water abstraction of groundwater are used to satisfy the drinking and household water needs of Elena and the other settlements in the municipality and the water for manufacturing, agricultural, and other purposes. There are not any water intakes near the open dump.

3. Technical rehabilitation

3.1. Vertical planning, cleaning of household waste from outside of the landfill borders and re-mowing

The geodesic survey performed in 2017 indicated that the waste was scattered on a territory of about 23.3 Dka. It was collected on 23,940 m^2 (3D) and compacted up to 23,924 m^2. A total of

1460 m^3 waste was re-deposited outside the boundaries of the open dump and 57 716 m^3 were re-deposited for re-shaping the slopes of the open dump (Investment project – technical recultivation). The technology for laying and building the rehabilitated open dump body includes the following steps:

1. Delivering of the waste for re-depositing and spreading with a bulldozer to the specified Municipal Solid Waste (MSW) level;
2. Minding a maximum deviation from the surface level in both directions ± 5cm at a distance of 50 m;
3. Shaping a slope 1:2.5 without a deviation from the slope angle;
4. After laying, aligning the area to the design elevation;
5. Laying down a layer of 20 cm earth mass as an equalizer;
6. Inspection of the surface integrity and correction (if needed) before applying the insulating screen; deviations greater than 5 cm for 50 m length in both directions are not allowed.

The upper isolating screen is shaped in compliance with Ordinance No. 6 of Ministry of Environment and Water (MEW) from 2013 (MEW, 2013) and consists of the following elements:

1. Gas drainage;
2. Sealing layer;
3. Drainage system for surface waters;
4. Recultivation layer.

The vertical planning project was made by the AutoCAD Civil 3D programme. A digital 3D model of the rehabilitated open dump body was created. It outlined the projected rehabilitated open dump after waste disposal and before applying the sealing layers. The model outlined as well the equalization soil layer (0.20 m), the sealing layers, and 0.75 m earth soils and 0.25 m humus soils. The total geometric volume of the planned waste without the layers of earth masses for technical recultivation was about 106,200 m^3. The earth masses required for the one-dimensional recultivation layer were 22,638 m^3, of which for the 0.75 m lower recultivation soil layer – 16,956 m^3 and for the upper 0.25 m recultivation soil layer with increased humus content – 5,682 m^3 (Investment project – technical recultivation).

3.2. Compacting the waste

Compaction of the waste in the open dump body was done after the waste outside the open dump

borders had been cleaned and the vertical planning had been carried out.

3.3. Drainage of surface water

Since the only surface waters were the rainstorms, their drainage was arranged through the following facilities (Investment project – technical recultivation):

1. For the slope waters: two drainage channels (335 m total length) were built that gather the slope waters and mainstream them into a safety transport channel. The channels were constructed by pre-casted (70/30/100 cm) concrete elements after hydraulic sizing in respect to the minimal conductivity corresponding to the minimum slope of the water route. The safety transport channel (191 m total length) was built on the east - northeast side of the rehabilitated open dump to mainstream the slope surface waters in its lower part, next to the body border. The channel was constructed by pre-casted (53/50/200 cm) concrete elements. Additionally, a third drainage channel (161 m total length) was built in the gully to capture the gully waters (when available) as well as part of the rehabilitated open dump waters from its north-west side. Alongside the 3rd channel, a gabion wall (1/1 m; 161 m total length) was built, and the waters of both the safety and the 3rd channel were discharged in the gully. The hydraulic sizing, like for the two drainage channels, was done in respect to the minimal conductivity corresponding to the minimum slope of the water route.

2. For the infiltrated rainwater: the surface water infiltrated through the soil layer of the rehabilitated open dump were taken away by a drainage system that prevents their penetration in the rehabilitated open dump body and avoids the destruction of the recultivation layer. Drainage geocomposite material was used for area drainage of the rehabilitated open dump, bilaterally cashed with non-woven polypropylene geotextile. The removal of the surface water infiltrated through the soil layer was carried out by means of perforated two-layer HDPE (high density polyethylene) pipes (Ø 160 mm). The water from the pipes was taken away to the lowest point of the terrain.

3.4. Gas discharge system

Gas emissions from the open dump

The decomposition of the waste organic components is a long-term process that has continued for decades for the open dump of the city of Elena. One of the end products of the biological

degradation of the organic matter in the solid waste is landfill gas. Its quantity and composition depend on many factors such as the waste composition, structure (organic/inorganic mass ratio), origin (type and composition) of the organic matter, type of the microbiological processes (anaerobic or aerobic), meteorological processes - air temperature, atmospheric pressure, precipitation, coating layers.

It is well known that the biogas quantity and composition change over time. During the initial period of aerobic decomposition of the organic matter in the waste, the biogas is composed by carbon dioxide, ammonia, and small quantities of some other pollutants; the methane amount is negligible. Upon initiation of the anaerobic processes, the amount of methane increases in the open dump, and the biogas composition is changed to methane - 55 vol. %, Carbon dioxide – 45 vol. % and other ingredients – about 1 vol. % (Dada and Mbohwa, 2017).

Before rehabilitation, the open dump gas formed during the aerobic and anaerobic decomposition of the waste was not managed through a gas discharge system. It was freely emitted into the atmosphere. The landfill gas composition and quantity were not measured. However, the experts' opinion was that the biogas was negligible due to the following reasons:

1. The waste composition in the open dump has not been subjected to long-term monitoring and therefore, the percentage of the different non-hazardous waste components can be determined only approximately. However, the relative share of the nondegradable (mainly plastics) waste is the largest one.
2. Generally, the gas emitting is most intense during the first 10 years of the open dump operation; then it gradually fades. It is anticipated that the open dump of the city of Elena is not an exception.
3. Regardless of the lack of data, the annual waste quantity imported in the open dump was not large.
4. The open dump did not meet the required conditions for the above-mentioned processes for gas generation to take place.
5. The structure of the deposited waste is not constant, resulting in a non-consistent biogas composition.
6. The type and composition of the organic mass has also changed over time and depending on the season (greater in the summer months and minor in the winter ones).
7. The microbiological processes in the open dump are spontaneous and not subjected to external regulation.

8. The rainfalls and the air temperature cannot be defined quite precisely.

That is why, the amount of landfill gas, emitted from the rehabilitated open dump of Elena municipality is insignificant and its increase is not expected.

The need for a gas discharge system

Following the good practices of the state of art, a gas discharge system is recommended when the annual landfill of waste exceeds 5,000 tons (Dada and Mbohwa, 2017). The values for the Elena Municipality open dump area were within this range. Therefore, a gas discharge system was built, but collected landfill gas is not used for incineration or to produce energy at present.

Construction of a gas discharge system

For the gas removal from the horizontal part of the rehabilitated open dump body, drainage geocomposite material was used. It is applied on the entire surface, anchored at 1 m. The drainage geocomposite represents a drainage cover consisting of two geotextile layers and a watertight HDPE core, which technical characteristics fit EN ISO standards. Its projected life span is 120 years. During the recultivation, a gas collection well (perforated HDPE pipe, Ø315 + nonperforated one at the surface of the upper sealing screen) is built whose above-ground surface is secured with a shaft made up of a standard reinforced concrete tube Ø1200, closed with a steel cover Ø1220 / 10 mm.

3.5. Structure of the upper insulating screen

The upper insulating screen is composed of:

Gas drainage:

- ✓ A drain layer on the upper surface of the rehabilitated open dump body with a drainage geocomposite (see 5.3.4);
- ✓ A gas collection well.

Sealing layer:

The mineral sealing layer is made of bentonite geomembrane GSL (Geosynthetic Clay Liner). It provides protection against leakage and diffusion of harmful substances. It is waterproof, leaching resistant, and able to retain heavy metals. The bentonite geomembrane consists of two layers of

geotextile and powdered bentonite encapsulated between them. The qualitative characteristics of the bentonite waterproofed membrane of the upper insulating screen meet the EN ISO (https://www.iso.org/standards.html) and ASTM standards (https://www.astm.org/products-services/standards-and-publications.html).

Drainage system for surface water:

The drainage system comprises geocomposite material consisting of two geotextile layers and a waterproofed core of HDPE.

Recultivation layer:

The recultivation coating is 1.0 m thick. It consists of two layers:

- ✓ Soil materials with a thickness of 0.75 m (3 x 25 cm);
- ✓ Humus layer with a thickness of 0.25 m.

The sources of earthly masses are located in the "Faraki" area, about 4.2 km away of the open dump.

3.6. Management of the landfill infiltration

Inspection of the open dump showed that the facility operation was suspended; the horizontal area is obscured with a compacted soil layer; and there was a wild vegetation forming a stable turf. The open dump body failures were in a steady state, no slices or downgrades. After sealing the open dump and disconnecting the access of the waters to the facility body, the quantities of the infiltrate decreased sharply.

3.7. Roads

There is a road to be used in the recultivation.

4. Biological recultivation

4.1 Objectives of the biological recultivation

The recultivation of any damaged terrain, including the open dumps, encompasses a set of engineering, meliorative, farming, forestry, landscape architectural and other activities aimed at restoring these terrains in accordance with the environmental conditions and landscape. The

recultivation requirements for land related to sanitary and hygiene areas include the choice of conservation means that correspond to the condition, composition and properties of substrates, the climate conditions, and technical economic indicators. In Bulgaria, all recultivation activities have to be coordinated with the responsible experts in the Ministry of Environment and Water.

The biological recultivation of the rehabilitated open dump of Elena Municipality is performed in accordance with the following regulatory documents (MEW, Waste):

1. Ordinance No. 26 / 2.10.1996 on recultivation of damaged terrains, improvement of low-productive lands, removal and utilization of the humus layer;
2. Ordinance № 6 / 27.08.2013 on the conditions and requirements for the construction and operation of landfills and other facilities and waste disposal installations;
3. Ordinance No. 4 / 21.05.2001 on the scope and content of investment projects.

The objectives of the biological recultivation are:

1. Strengthening the earth cover from the upper insulation screen of the technically rehabilitated open dump for non-hazardous waste and achieving its long-term sustainability;
2. Maximal isolation of the waste;
3. Fitting of the rehabilitated open dump to the surrounding landscape;
4. Creation of environmentally-sustainable economic use of the recultivated area.

The recultivation project was elaborated based on documents, provided by Elena Municipality and reference data about the environmental conditions, economic and demographic status of the area (Municipality of Elena Development Plan 2014-2020; Geography of Bulgaria, 1997). It provided for profiling, alignment and sealing of waste, positioning of the insulating screen and laying of a recultivation or soil layer. The biological recultivation envisaged the following activities: grassing with appropriate mixtures of grass species and planting of shrub species. In this way, grass and mixed grass-shrub subareas were defined, the shrub vegetation playing an anti-erosion and landscape-building role (Investment project – biological recultivation).

4.2. Site characteristics:

Elena Municipality occupies the southernmost parts of the Veliko Tarnovo region, the high parts of the pre-Balkan and the Balkan area. The municipality is situated on an area of 671,390 m^2, at altitude between 100 and 1,536 m, predominantly by 300-600 m and slopes 20 - 30°.

The relief of the area is diversified: from typical mountain one in the southern part, very steep, highly intersected by deep cuts and streams, to typically hilly-prependon in the northern part.
The municipality is characterized by a dispersed settlement network of many small villages, and neighbourhoods (124) that are depopulated. The total population of the municipality is 8,358 people (NSI, 2020), about 60% of which live on the territory of the city of Elena.

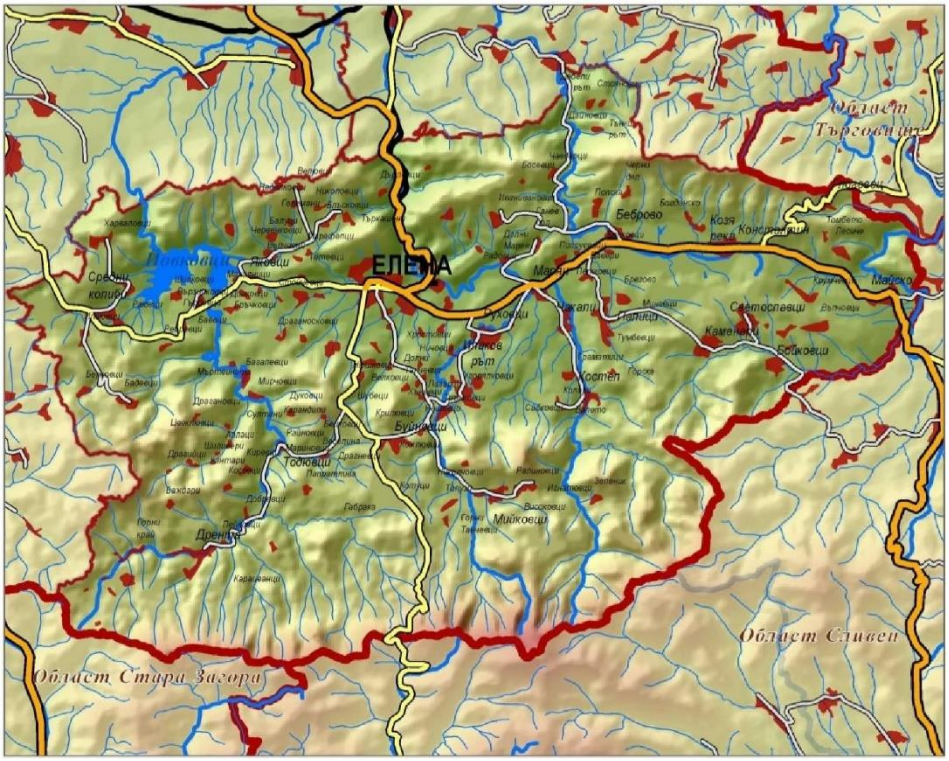

Figure 3. Elena municipality location; source: Municipality of Elena Development Plan 2014-2020 https://www.strategy.bg/StrategicDocuments/View.aspx?lang=bg-BG&Id=1128

4.3. Weather conditions:

According to the climate zoning of Bulgaria (Velev, St., 1997) Elena municipality is situated in a moderate continental zone (Pre Balkan), encompassing four climatic areas. These climatic conditions determined the development of rich and varied vegetation.

4.4. Geological, hydrological and hydrogeological conditions

Elena Municipality is situated on the northern slopes of the eastern share of the Middle Stara Planina, formed during the Mesozoic and Neozoic periods. The sedimentary rocks - sandstones, marls, and limestones predominate. At some eroded locations, limestone layers from the Jurassic period can be detected. The marls predominate, while the participation of the limestones, sandstones and conglomerates is insignificant (Velev, 1997).

The territory of the municipality falls into the water catchment of the Stara Reka River - right tributary of the Yantra River. Part of the municipality falls into the catchment of Vesselina, which together the Rivers Bebrowska and Zlatarishka drain over 90% of the territory of the municipality. Veselina river extended in the big dam "Yovkovtsi", the waters of which are mainly used for urban water supply. Another eight micro-dams have been built on the territory of the municipality, used primarily for irrigation and fish breeding for amateur fishing.

The rivers flowing through Elena Municipality, have good oxygen regime and indicators that meet the Threshold Limit Values (TLVs) for the biological recultivation project category. As an exception, some increase in the TLV have been registered for undissolved substances, ammonium nitrogen and nitrite nitrogen. There is an underground water body BG1G0000TJK045 - karst waters in the Central Balkan, with a good chemical status of quality standards reported during the last monitoring. Here, nitrate operational monitoring is organized as well.

4.5 Soils

The soil cover in the municipality is not very diverse (ESDAC). The soils are meadow-*Chernozems, Luvisols*, light *Luvisols, Leptosols* and *Cambisols*. L*uvisols, Leptosols* and *Cambisols* are the majority.

4.6 Vegetation

According to the scheme of the forestry registration of Bulgaria, the territory of Elena falls into a Misian forest area – sub-area Northern Bulgaria occupying a sector of altitude 400 to 1,500 m. The shrub species were successfully used in the biological recultivation of the open dump.

4.7. Biological recultivation: grassing, planting of bush vegetation

<u>Grassing</u>

In the biological recultivation part of the rehabilitation project, the greater part of the technically rehabilitated open dump area, which is mostly flat or with small slopes, was grassed. The total grassing area was 18,311 m^2.

Along the grassing process, the following requirements about the grass species were minded:

1. The grass species have to belong to the rhizome-tuft type that are able to form an even, dense and sustainable sward. The grass species have to be tolerant to the soil conditions in terms of moisture and nutrients, and more precisely - to be drought-resistant;
2. The grass species have to be unattractive for grazing and not to require frequent mowing;
3. Upon mowing, the grass species have to be able to recover in short periods of time;
4. The grass species have to be resistant to diseases, environmentally friendly and adaptable to extreme conditions;
5. The grass species have to exert a long-standing environmental effect.

The grass species were sown in the autumn to avoid damages by the early spring droughts, although the terrain is semi-mountainous with natural high moisture. According to this schedule, the moisture and the heat were sufficient seeds to germinate and rapidly develop.

Technology for lawns establishment:

Since the earth masses for the recultivation purposes, as well as the adjacent soils, were poor in organic substance, nitrogen, and phosphorus but with enough amount of calcium, they were subjected to full nitrogen, phosphorus and potassium fertilization. In respect to the climate conditions and rainfalls in the area, nitrogen fertilizers were supplied twice, after which the lawns were watered during vegetation to have a longer lasting effect.

During the first year, watering is planned to be provided twice a month with a monthly norm of 30 - 40 l/m^2. The recommended nitrogen fertilizers are of combined type - ammonium and nitrate forms with 33-35% nitrogen content in the form of granules. Physiologically, this fertilizer acts as a mild acid fertilizer and does not change the soil reaction. The fertilization will increase the plants resistance to unfavourable environmental conditions on the surface of the rehabilitated open dump. The nitrogen fertilization in the spring of the first year is planned for 100 kg pure substance/ha. Generally, the grasses are tolerant to phosphorus that stimulates the faster rooting of plants and supports their overall growth and development. That is why, it is recommended in autumn a single introduction of triple superphosphate with 48% phosphorus content at a rate of 100 kg phosphorus

(pure)/ha for 3 years to be done along the humus laying. In fact, phosphorus fertilization has an effect of retaining fertilization as it is a slow-acting one.

Because the area is relatively well-stocked with potassium -containing substrates, it is needed in minimal quantities, since N and P stimulate more intensive use of soil potassium.

Thus, the fertilization norm (per pure substance) is: $N_{100}P_{100}K_{50}$ kg/ha, corresponding to ammonium nitrate - 28kg / da, triple superphosphate - 20 kg/da, and potassium chloride - 10 kg/da/ The fertilization process is organized as follows:

1. The N fertilizer is applied three times - in autumn together with the sowing of the grasses, with the phosphorus fertilizer, and in May - 10 and 18 kg/da respectively. Over the next two years - at the end of April - 14 kg/da and in the beginning of June -14 kg/da;
2. The P fertilizer is applied once per year, for three years, along with the laying of the humus layer and before sowing the seeds - 20 kg/da, and in autumn over the next two years at 20 kg/da;
3. The K fertilizer is applied once, during the first year with the P fertilizer, in the autumn and the next one - in early spring, at 10 kg/da, with the first N introduction.

Technological performance of the grassing process

The technological performance of the grassing process is presented in Table 1:

Table 1. Technological performance of the grassing process.

Year	Procedure
I year (autumn to autumn)	1. Preparation of the grass bed - milling, alignment with a paddle; 2. Supply of the mineral fertilizers (P, K, and part of N); 3. Sowing the grass mix; 4. Supply of the rest of the fertilizers - in April and June; 5. Mowing - twice or more often depending on the grass growth; the high grasses accelerate the water flow and can cause erosion; 6. Watering - after fertilization and upon severe drought (May – September).
II and III Year	1. Fertilization – April: 14 kg/da N and 10 kg/da K fertilizer 2. Fertilization – June: 14 kg/da N fertilizer 3. Fertilization - October (superphosphate)

	4.	Mowing - three times
	5.	Watering - after fertilization

Planting of shrub vegetation

Following the requirement of the Enterprise for Management of Environmental Protection Activities, the biological recultivation of the open dumps envisages planting of shrub vegetation at the peripherals and the slopes to allow protection against erosion. For the rehabilitated open dump of Elena Municipality, an area of 4,556 m^2 was planted with 11,758 pcs. of shrubs - most deciduous and one coniferous (*Juniperus sabina* L.) species. Besides, its anti-erosion function, this vegetation protects the grassy surface from other damages like grazing, unauthorized mowing, etc. For this reason, a large part of the bushes is prickly to interfere the people and animals to damage the grassland.

The marking of planting sites and planting is carried out in early spring. Only standard saplings with a well-developed root system were used for planting. They were produced from local plant material. Three times trenching of the young shrubs is envisaged.

During the second year, up to 20% replacement of dead saplings and two-fold trenching during the vegetation period is planned.

During the third year, up to 10% replacement of dead saplings and one-time trenching and during the vegetation period is planned.

Fertilization is integrated along with the grassland one.

Planting and cultivation technology

The technological scheme for planting and melioration is presented in Table 2.

Table 2. Technological scheme for planting and melioration.

Year	Procedure	
I year (autumn to autumn)	1.	Supply of P and N fertilizer (in the autumn, with the grass species)
	2.	Marking of the seedlings and planting the saplings (in the spring)
	3.	Supply of mineral fertilizers (in the spring, with the grass species)
	4.	Trenching of young saplings - 3 times

	5.	Supply of mineral fertilizers (in autumn - P)
II year (autumn	6.	Replenishing the dead saplings
to autumn)	7.	Fertilizing with mineral fertilizers (in autumn and spring)
	8.	Trenching - twice during the vegetation season
III Year	1.	Fertilizing (in autumn) with P
	2.	Replenishing the dead saplings
	3.	Fertilizing with mineral fertilizers (in spring)
	4.	Trenching - once during the vegetation season

5. Conclusion

The official opening of the rehabilitated open dump of Elena Municipality was held on 27.10.2021 (see the photo below) by the Mayor of Elena Municipality, representatives of the contractor of the construction and installation works and the construction supervision.

In the next three years, the biological recultivation will continue, comprising complex of forest/technical, agrochemical and meliorative events. Upon completion of these activities, the rehabilitated open dump will be put into operation under the Territory Development Act.

As a result of the performed activities:

1. Technical rehabilitation of Elena municipality open dump has been performed;
2. Biological recultivation has started and will continue for 3 years;
3. The complex rehabilitation will contribute to the reduction of the adverse environmental impact by limiting emissions from the rehabilitated open dump body;
4. The polluted water is removed and treated;

5. The rehabilitated open dump will be used as a green area.

Figure 4. Official opening of the rehabilitated Elena Municipality open dump.

References

Agrolesproekt, 1994. Forestry project of State forestry Elena, https://dgselena.scdp.bg/za-nas-branch last accessed 29.01.22

ASTM standards https://www.astm.org/products-services/standards-and-publications.html last accessed 29.01.2022

Boncev, E., Bune, V. I., Christoskov, L., Karagjuleva, J., Kostadinov, V., Reisner, G. I., Rizhikova, S., Shebalin, N. V., Sholpo, V. N., Sokerova, D. 1982. A method for compilation of seismic zoning prognosticmaps for the territory of Bulgaria. Geologica Balcanica, 12, 2, 3-48.

EN ISO https://www.iso.org/standards.html last accessed 29.01.2022

ESDAC https://esdac.jrc.ec.europa.eu/content/soil-map-bulgaria last accessed 29.01.2022

Investment project – technical recultivation http://zop.elena.bg/wp-content-technical

Investment project – biological recultivation http://zop.elena.bg/wp-content-biological

Mbohwa, C., Dada, O. 2017. Biogas Upgrade to Biomethane from Landfill Wastes: A Review. Procedia Manufacturing, 7, 333-338.

Municipality of Elena Development Plan 2014-2020, Operative programme "Administrative Capacity 2007-2013", May, 2014 https://www.strategy.bg/StrategicDocuments/View.aspx?lang=bg-BG&Id=1128 last accessed 29.01.2022

Ministry of Environment and Water, Republic of Bulgaria, 2013. Ordinance No 6 https://www.moew.government.bg/static/media/ups/tiny/%D0%A3%D0%9E%D0%9E%D0%9F/maredba6.pdf last accessed 29.01.22

Ministry of Environment and Water; Waste https://www.moew.government.bg/en/waste/ last accessed 29.01.2022

National Statistical Institute (NSI), Republc of Bulgaria, 2020. https://www.nsi.bg/nrnm/show9.php?sid=1811&ezik=en last accessed 29.01.2022

Protected Areas Act http://eea.government.bg/bg/legislation/biodiversity/zztan_15.pdf last accessed 29.01.2022

Velev, S. 1997. Climate division. In: Yordanova, M., Donchev, D. (Eds). Geography of Bulgaria.

Physical geography. Socio-economic geography. Publishing House of the Bulgarian Academy of Sciences, Sofia, 127-130 (in Bulgarian with English summary).