CASE STUDY

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REHABILITAION OF AN OPEN DUMPS IN BULDAN DENİZLİ

1. Project scope and purpose

In less developed and developing countries, solid waste is generally removed from residential districts by being piled up indiscriminately in open areas that are away from these residential districts. This method has been used for the removal of solid waste in Turkey for many years. On the one hand, increased migration from rural to urban areas increased the amount of solid trash in migratory cities; on the other hand, due to unplanned urbanization, garbage dump sites remained within settlement zones.

Environmental Protection, Prevention of Environmental Pollution, and Maintenance of Waste Management are specified in the Environmental Law No. 2872 published in the Official Gazette dated 11.08.1983 and numbered 18132, the Waste Management Regulation published in the Official Gazette dated 02.04.2015 and numbered 29314 and other relevant legal regulations. In this context, the open dump, which was started to be used in 2007 in the Buldan District of Denizli Province, is required to be closed.

The goal of the project is to rehabilitate the open dump in line with applicable rules and technical requirements.

2. General information about the dump site

Buldan, 42 km away from the center of Denizli, is located in the interior of the Aegean Region and is adjacent to the Güney District to the east, Kuyucak to the west, Sarıgöl to the north, and Sarayköy and Buharkent to the south. The entire land is above sea level. The Buldan plateau descends and reaches Sarayköy. Other areas of the district are covered with mountains and plateaus. In the west of the district center, there is Süleymanlı lake at an altitude of 1500 m, on the plain inside the mountain. It is known that this lake irrigated the green gardens of Buldan with an arc system a long time ago. Towards the east of Buldan, the height of the land gradually decreases. This region, where approximately one third of the district's lands are located, is gradually increasing its productivity with the waters of Adıgüzel Dam. It plays an important role in the

weaving (textile) in our country and Buldan cloth, which is unique to the district, is a world-famous weaving type. The geographical location of Buldan District is shown in Figure 1.

Operation of the open dump, which started to be used in the Buldan district in 2007, was transferred to the Metropolitan Municipality in 2014, pursuant to the Metropolitan Municipality Law No. 5216. Figure 2 shows the satellite image of the Buldan open dump area. Open dumping was carried out in the field until that time, but since 2020, the wastes collected in the district by Buldan Municipality have been brought to the Solid Waste Transfer Station established in Bozalan town and transported to the Kumkısık Landfill. Until 2020, an average of 31.2 tons/day of waste was dumped into the open dump. The use of the open dump was terminated by planning with the establishment of the Transfer Station in 2020.

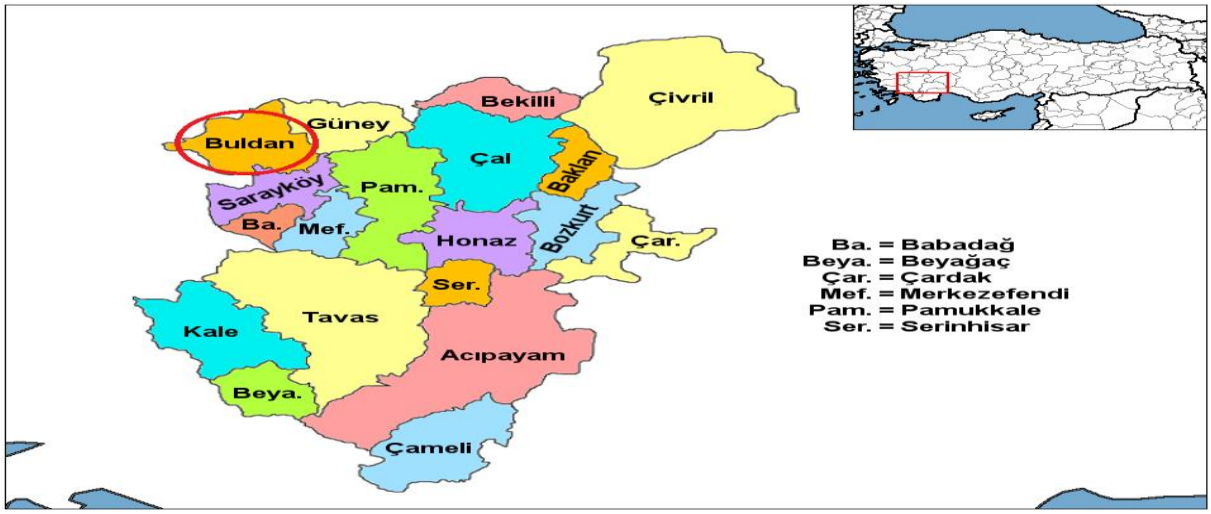

Figure 1. Geographical location of Denizli and Buldan district

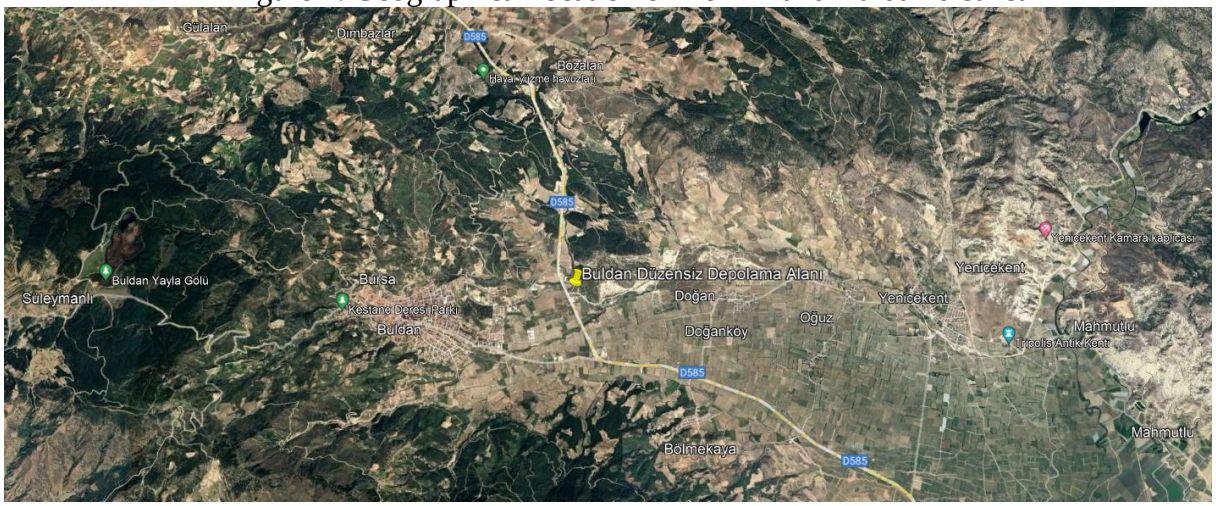

Figure 2. Satellite image of the open dump area in Buldan

3. Observations on the open dump area before rehabilitation

There was a dense mass of garbage in the area of 2.6 hectares before rehabilitation. No activities related to landfill gas management were carried out in the open dump prior to rehabilitation. Landfill gas formed in the open dump can neither be completely removed from the garbage mass, nor be completely isolated within the mass. Due to the location of the disposal site, it causes visual pollution and odor on the Denizli-Salihli road. The dense smoke from active and passive combustion in the open dump affects the residential areas and the highway. Images before rehabilitation of the Buldan open dump area are given in Figures 3 and 4.

(a)

(b)

Figure 3. Photos of Buldan open dump area before rehabilitation

(a)

(b)

Figure 4. Fire images in the open dump before rehabilitation

4. Population and waste amount calculations

4.1. Population

The past census results from Buldan District are given in the Table 1. The values for the previous years have been obtained from the Turkish Statistical Institute (TUIK). The open dump area was used beginning from 2007. Until the open dump were closed, it served 45 villages of Buldan District. The average population value between 2007 and 2020 was found to be 27,380 as shown in Table 1 below.

Table 1. TUIK Population Data of Buldan

Year	Population
2007	27.380
2008	27.194
2009	27.430
2010	27.092
2011	27.135
2012	27.484
2013	27.558
2014	27.455
2015	27.359
2016	27.335
2017	27.248
2018	27.241
2019	27.179
2020	27.223
Total	**382.313**

4.2. Current amount of waste

Two different methods are used to estimate the amount of waste present in dump sites. The first method is to determine the waste amounts of the past years with the help of retrospective population projections and unit waste amounts. Second one is to determine the estimated current amount of waste in the field by making 3D modeling using the maps obtained as a result of the current map acquisition. However, because of the results of the factors that cause the decrease in the waste volume, such as degradation, burning, and settlement in the dump sites, the retrospective waste amounts for the period when the site was in operation were calculated based on the population.

The following formula is used to determine the retrospective waste amount:

$W = N \times f \times w$

W: Waste amount (ton/year)

N: Population (person)

w: The amount of waste produced per person in ***t*** time (kg/person/day)

f: Unit conversion factor (365 days/year x 10^{-3} ton/kg)

is defined. According to this statement, population and daily waste generation play an important role in determining the amount of waste. The average amount of waste per capita (kg/person-day) was obtained from the data announced by TUIK every two years, and its average is shown in Table 2.

Table 2. TUIK average amount of waste per capita

Year	**Average amount of waste per person (kg/person-day)**
2008	1,15
2010	1,14
2012	1,12
2014	1,08
2016	1,17
2018	1,16
2020	1,13
Average	**1,14**

According to the average values taken from Table 1 and Table 2;

N: 382.313 person

w(t): 1,14 (kg/person/day)

W= 382.313-person x 1.14 kg/person/day x 365 days/year x 10^{-3} tons/kg

f: (365 day/year x 10^{-3} ton/kg)

W= **159.080 ton/year** (Total waste)

Waste density was taken as 0.7 ton/m³. So, a total of **227.257 m³** of waste was rehabilitated in Buldan open dump.

5. Rehabilitation of open dump

Approximately 227.257 m^3 of house of wastes belong to Buldan were stored in the open dump has 9 m depth and 2.6 hectares area. Slope arrangement and embankment formation, top cover system set up, surface water drainage and gas management system were carried out in this area.

5.1. Slope arrangement and embankment construction

The slope arrangement and embankment construction ensure that the sored area is statically safe against slipping. As a result of the slope arrangement, final cover layers can be safely place. The

steep slopes, especially in the northern part of the open dump, where active solid waste dumping is made, have been moderated to 1/3 rate by filling approximately 20.000 m^3. It was given 3% of slope on the top of the area to ensure surface drainage. The embankment is designed to surround the garbage mass. The planar section width of the embankment is 4m. The embankment was formed from the marl material obtained during the excavations in the region and was compacted in 30 cm layers. The drainage channel, which will provide the surface water drainage of the waste mass and the whole side, was built on the outside of the embankment. Photos of the open dump during the rehabilitation study are given in Figure 5.

5.2. Top cover system

After completion of the rehabilitation study of the Buldan Open Dump, the rehabilitated site was covered. The main purposes of the top cover impermeability system are summarized below.

- To prevent the waste from coming into contact with the surrounding areas,
- To prevent rainwater from penetrating the waste and to reduce the amount of leachate,
- To prevent erosion,
- To minimize greenhouse gas emissions into the atmosphere,
- To minimize emissions that have negative effects on the environment.

The top cover system to be established within the scope of the rehabilitation of the Buldan Open Dump area consists of the following layers from bottom to top;

- Leveling Layer, 50 cm,
- Clay Layer, 50 cm,
- Drainage Layer, 30 cm,
- Vegetative Soil, 50 cm.

(a)

(b)

Figure 5. Photos of open dump area during rehabilitation

5.2.1. Levelling layer

The leveling and capillarity prevent layers are in contact with the upper surface of the waste mass. This layer consists of 30 cm thick highly permeable soil material compressed with a vibrating roller.

5.2.2. Mineral impermeability layer

The mineral impermeability layer is made of natural clay material. The thickness of this layer is 50 cm and the impermeability coefficient is $k \leq 1x10^{-9}$ m/s. The natural clay material was obtained

from the quarries used for the Kumkısık Landfill. A sufficient amount of clay is available in these quarries. The photos of the top cover formation of the rehabilitated site are given in Figure 6.

Figure 6. View of the open dump site during top cover formation

5.2.3. Drainage layer

16-32 mm diameter gravel material was used to form 30 cm thick drainage layer. Gravel must be free of lime or have a lime level of less than 20%. Hard, round grain materials are used in the drainage layer that has a permeability of $k = 1 \times 10^{-4}$ m/s.

5.2.4. Soil layer

A soil layer is sited at the top to protect all the layers in the last cover as well as to carry out planting operations in the last cover. The minimum soil layer must be 0.50 m. This layer helps to avoid erosion and improve the quality of the landscape. To establish the vegetation, short-rooted and self-propagating species that can thrive in poorly conditioned and contaminated soil must be chosen from among the local species.

5.3. Surface water drainage plan

The dry stream bed that runs parallel to the field performs natural precipitation drainage. The 3% slope given in the surface leveling ensures the flow of precipitation falling on the surface to this dry stream bed. Trapezoidal rainwater collection channels were created outside the bank surrounding the site to collect the precipitation falling into these basins. Thus, the precipitation waters that made their way to the waste mass from the stream bed were drained by circulating the site. Open channels with trapezoidal sections mostly aim to remove the water directed at the waste

mass from outside. The cross-section of the surface water channel is given in Figure 7. In addition, the drainage channel has been covered with 10 cm of concrete.

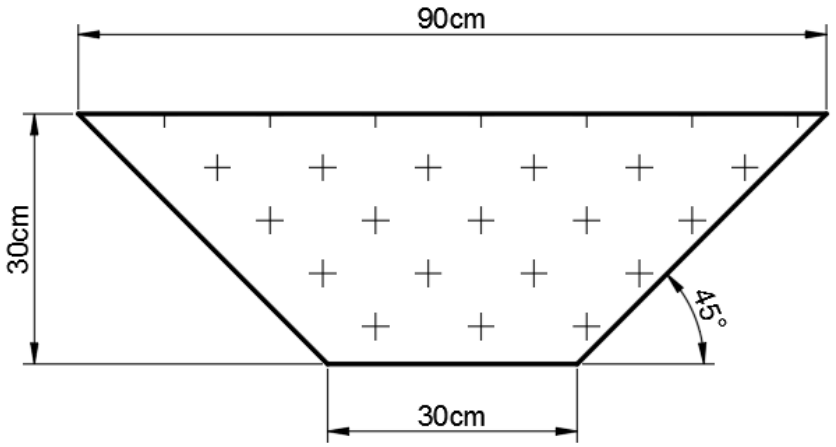

Figure 7. Surface water channel section

5.4 Gas management system

A vertical landfill gas collection system will be used in the open dump. The gas collection system consists of gas collection wells filled with gravel material placed at appropriate intervals and perforated pipes placed inside. The radius of influence of gas collection wells in landfills is approximately 50-60 meters. A total of 12 vertical wells were created in the Buldan Open Dump. The gas collection wells have an approximate diameter of 800 mm and a height of 9m. High-density polyethylene (HDPE) pipe with an inner diameter of 100 mm, resistant to the corrosive effects of leachate is used in the gas collection wells. As a filter material between the wall of the well and the collection pipe, carbonate-free gravel with a particle distribution of 16/32 mm or 32/64 mm was used. This material has a steel mesh on the outside. The creation of the gas chimney is shown in Figure 8.

(a)

(b)

Figure 8. Installation of gas chimney

5.5. Landscape arrangement

It is aimed at making the most appropriate arrangement within the technical, economic, and aesthetic conditions in the field. It was foreseen that the plants of the project area would not be taken into care of other than periodic maintenance and the landscape work was chosen accordingly. In planning:

• The area is considered as an mono-block.

• Certain plants and a system have been established in the project area to make it easier for the implementer to execute his/her job.

• A design has been made that will allow for changes and additions that may occur over time.

• The materials used are easy to find and applicable and have been chosen in line with the regional characteristics.

• The climate and soil characteristics of the region were also taken into consideration as important factors in plant selection.

5.6. Maintenance and monitoring activities after closure

Existing open dump should be rehabilitated and closed in a way that has the least impact on the environment. Post-closure maintenance of the rehabilitated open dumps will be carried out in accordance with the recommendations listed in the "Open Dumps Rehabilitation Guide" dated 12 December 2009 and as shown in Table 4. In the rehabilitated unsanitary landfill, it is foreseen that the maintenance and control work will continue for 30 years after the rehabilitation process.

Table 4. Maintenance and control periods of rehabilitated open dumps

Component	Check Frequency	Potential Problems
Top Cover	Once a year and after heavy rain	Erosion, abrasion on the soil surface
Surface Water Drainage	Four times a year and after heavy rain	Soil accumulation in the surface drainage layer, control of drain pipes
Landfill Gas	Regular	Odor, broken gas chimneys, compressor and flare equipment
Flora	Four times a year	Vitality level
Ground-water	Twice a year	Groundwater pollution

6. Cost calculation

Various engineering studies were carried out for the rehabilitation of Buldan Open Dump. The cost analysis for these above-mentioned engineering studies is shown in Table 5. As can be seen from the table, a total of **162.175,65** Euros was spent for the rehabilitation of the Buldan open dump area.

Table 5. Cost analysis of rehabilitation process

Approximate Cost Table				
Process	**Unit**	**Amount**	**Unit Price (Euro)**	**Total (Euro)**
Machinery Excavation, Transport, Laying and Compaction of Waste in Buldan Open Dump	m^3	26.000	0,94	24480,00
For the Site: Filling Works (From Excavation Material)	m^3	5.150	0,81	4151,69
Road Construction	m^2	2.642	2,86	7547,99
Final Cover System: Natural Clay Material Supply and Formation	m^3	13.000	6,58	85560,00
Final Cover System: Gravel Material Supply and Laying	m^3	8.642,40	1,89	16300,90
Final Cover System: Top Cover Soil Construction	m^3	13.000	1,04	13460,00
0.3x0.3x0.9 Surface Water Drainage Channel Formation	m	660	8,27	5457,69
H=9m Ø 1000 mm HDPE Chimney Construction	piece	12	141,54	1698,46
Turf	da	26	126,44	3287,32
Irrigation of park areas	ar	260	0,89	231,60
Total amount			0,00	**162.175,65**

As a result of this study, the negative environmental effects of the Buldan open dump area were minimized. The risk of gas compression and explosion has been eliminated, the strength of the field has been ensured, and the formation of leachate that may occur due to rain water has been minimized.