

ENVIRONMENTAL STUDIES

EFFECTS OF SOLID WASTE LANDFILL ON THE TOWN OF SHTIP, R. MACEDONIA

Biserka Dimiskovska, Nikola Dimiskovski

Abstract: *The landfill for solid communal waste is located in Trestena Skala, in the vicinity of Shtip and is characterized by uneven terrain of non-arable land furrowed with smaller and larger ravines, with poor vegetation. The landfill serves for disposal of solid communal waste collected from the households, public areas (parks, cleaning of streets and business streets (commercial and industrial structures) whose waste is similar to the household waste. The town debris and the medical waste are deposited on the city landfill.*

Special transportation means are used for refuse collection (auto cranes, combined vehicles) and vehicles adapted to transportation of waste in containers or vehicles supplied with tarpaulins. The transport of waste by the transportation vehicles is carried out from the town area to the entry into the landfill along asphalt and partially non-asphalt road. For better and more efficient analysis in accordance with the integrated prevention and control of pollution, special consideration will be given to emissions in the atmosphere, surface waters, sewerage, soil, emissions of noise and vibrations as well as sources of emission of non-ionizing radiation.

Based on the performed analyses, an explanation will be given as to whether the landfill for non-hazardous waste "Trestena skala" has an effect upon the environment. If it does have an effect, this will pose a problem as to the development of tourism in the town of Shtip which is known for its cuisine (particularly in the winter period).

Key words: *types of waste, waste emission, landfill, refuse collection transportation vehicles, environment*

1. Introduction

The landfill receives only solid communal waste collected from the households, public areas and business entities whose waste is similar to that of the households. Debris and medical waste is not deposited on the town landfill. So far, there haven't been any precise measurements as to the quantity of waste collected from the town of Shtip and the satellite settlements. The quantity of communal waste is computed based on the volume of transportation vehicles and their daily schedule. In this way, the annual quantity of deposited waste has been computed as shown in (Table 1)

Table 1. Annual quantity of deposited waste

Year	Total quantity of deposited waste m ²
V – XII 2004	54.032
I – XII 2005	78.762
I – XII 2006	93.744
I – XII 2007	78.864
I – XI 2008	72.292
Total	377.604

Further on, (Table 2) shows the monthly and daily quantities of deposited waste.

Table 2. Quantity of deposited waste

Communal waste	Quantity in m3	Quantity of tons (t)
Annual	78.672 - 93.744	21.241 - 25.311
Monthly	6.556 - 7.812	1.770 - 2.109
Daily	218 - 260.4	60 – 70

Special transportation vehicles are used for transport of waste (autocranes, combined) and vehicles adapted for transport of waste in containers or with tarpaulins, Fig. 1 and Fig. 2. For the spreading and compacting of the waste, an earthmover is used, Fig. 3. A cistern with a capacity of 6 tons is used for temporary spraying the landfill and the access road with water. “Trestena Skala” landfill is not arranged for selection and recycling of communal waste and does not have water and power supply. At the landfill, there are two zones of different function:

- Zone for arrival and departure of vehicles.
- Zone for waste disposal.
- The first zone consists from:
 - Access road, namely an asphalt road with a length of 4 km and another 200 m of non-asphalt road;
 - The entry area is anticipated for motion of vehicles. It covers an area of 150 m² where a garage is also located;
 - Trees on one side of the landfill. The created green protective area around the landfill prevents spreading of dust and scattering of light waste (PVC, bags, paper) by the wind;
 - There is also a platform for washing of the waste transportation vehicles after release of waste.



Figure 1. Refuse collection vehicle



Figure. 2. Vehicle adapted to transportation of refuse containers



Figure. 3. Bulldozer for depositing of solid communal waste

The zone for the depositing of the waste consists the body of the landfill, while there are no necessary facilities for collection and dewatering of atmospheric water, drainage system for acceptance and dewatering of filtrated water from the landfill into a septic pit, and a system for regulation of landfill gases. There are also no scale, administrative premises, premises for keeping tools, plateau for temporary disposal of selected waste, sanitary knot – mobile toilet.

2. Method and technological process of operation of the landfill

Non-selected bio-degradable communal waste, pieces of textile from the textile industry, plastic and paper packing, corpses of dead animals are deposited on the landfill. This waste is of a heterogeneous character and may adversely affect the environment and the health of the people if not properly handled. Its properties mainly depend on the morphological composition which is a function of the living standard and the way the people live in a certain area. In accordance with the Law on Waste Management (Official Gazette of R. Macedonia no. 68/2004 and 107/2007), liquid, explosive, corrosive, flammable, medical waste and non-identifiable waste is not deposited on the said landfill.

“Trestena Skala” landfill is not arranged and enabled for selection and recycling of communal waste. However, planned disposal of communal waste is being carried out.

Unloading of the communal waste from the transportation vehicles is done on the anticipated place for disposal of the waste that enables undisturbed motion and maneuvering of the transportation vehicles. Upon unloading, the communal vehicle leaves the landfill.

The deposited waste on the working area of Trestena Skala landfill is mixed, crushed and pushed along the edge of the slope of the

landfill by a bulldozer (earthmover). To provide compactness during the disposal and stability of the landfill body as well as use the area rationally in applying this technology, the waste should be distributed in layers of max. 2 m, as presented in Figure 4.



Figure 4. Technology of waste disposal along edge

While forming the landfill body, care should be taken regarding the stability of the slopes and perform daily coverage with inert material. The waste disposal and its flattening is done during six days of the week.

Daily coverage of deposited communal waste with a layer of inert material and height of 15-30 cm over an established layer of deposited waste with a height of 2 m is necessary, first of all, to prevent spreading of unpleasant smell, fire particularly in the summer period, dispersion of light waste of the type of PVC bags and alike.

The technology of sanitary disposal means planned disposal and compacting of the waste on a certain area by application of the following measures:

- Optimal filling of the landfill (by a compactor);
- Daily coverage of deposited waste with inert material to prevent spreading of unpleasant smell, dispersion of the light fractions of the waste as well as insects and rats;
- Reduction of produced landfill gas to avoid the possibility of creation of air spaces in the landfill body and hence explosions;
- Dewatering of the atmospheric waters to minimize their infiltration into the landfill body;
- Dewatering and control of filtration waters.

With the beginning of the depositing of the communal waste, there starts the process of biological degrading or fermentation of the deposited waste which is carried out in two phases:

- Aerobic (in presence of oxygen), and
- Anaerobic (in absence of oxygen).

These phases correspond to the phases of uncovered waste (working phase) and covered waste (final phase).

During aerobic degradation of waste, i.e., physical-chemical and biological processes of decomposition of waste in the landfill body, the following is produced: disintegrated solid waste, new biomass, landfill gas, filtrate and insignificant amount of heat, as schematically presented in Figure 5.

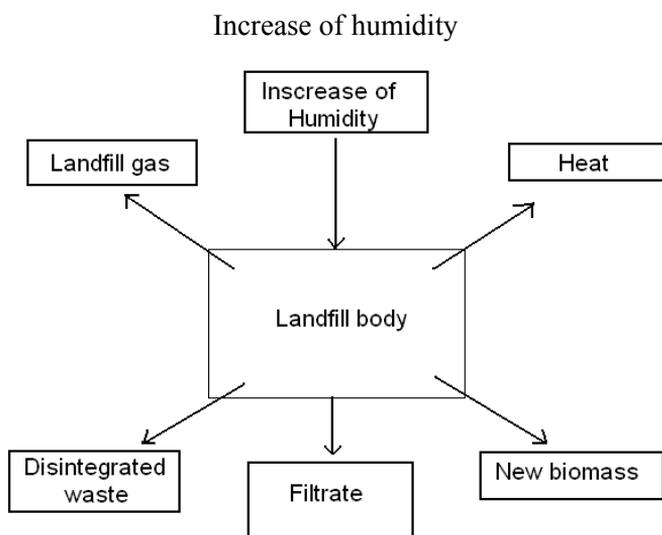


Figure 5. Schematic presentation of the landfill body with degrading products.

According to practical considerations, bio-thermal disintegration of waste in the upper layers of the landfill is carried out more than 10 years, while in the deeper layers, it may last up to 50 years. The processes of separation of gases last 5 – 10 years and sometimes even more years upon closure of the landfill, while the deposited material is settled for 30-50% of its original height in the first five years.

In addition to planned disposal with compaction and flattening of waste and daily coverage carried out on Trestena Skala landfill, the following is necessary to be performed:

- Synchronized establishment of drainage for elimination the landfill gas;
- Dewatering of atmospheric waters in order to minimize their infiltration into the landfill body;
- Dewatering and acceptance of filtering waters.

By compacting the deposited communal waste by a bulldozer with a density that is approximately about 270 kg/m³, an average density of

the waste of 0,4 t/m³ is achieved to prevent creation of cracks and cavities. If the filling and compacting of the waste is done by a compactor, depending on the performances of the compactor, compact densities of 0,6 – 0,8 t/m³ are achieved. The use of the compactor enables achievement of considerably greater effects as is saving of space for disposal, increase of the stability of the landfill body, reduction of problems with sediments, fire outbreak, rats, insects, etc.

3. Handling the materials

Waste management (mode and conditions under which collection, transportation, treatment, storage and removal of waste) is regulated by the Rulebook on Mode and Procedures for Operation, Monitoring and Control of Landfills During Operation, Monitoring and Control in the Phase of Closure and Further Care for the Landfill Upon Closure as well as Mode and Conditions for Further Care for the Landfills once they cease to operate (Official Gazette of RM no. 156/2007), The Rulebook on Criteria for Acceptance of Waste in Landfills of each Class, Preparation Procedures for Acceptance of Waste and General Procedures for Testing and Taking of Specimens of Waste (Official Gazette of RM no. 8/2008), the EU Directives on Landfills, the national and local strategies and plans for regulation of waste management. These are aimed at minimization of quantity of waste, utilization of usable constituents, preservation and protection of the natural resources, protection of environment, life and health of people (MSW Landfill, 2010).

There have been defined three categories of waste: communal, hazardous and inert waste that can appropriately be disposed on landfills if these fulfill the conditions for the stated purpose.

For the Trestena Skala landfill, disposal of only that part of the waste that does not create harmful effects is allowed, namely:

- Waste from the households;
- Waste from the public areas;
- Waste from enterprises of non-industrial character;
- Waste from shops;
- Waste from administrative buildings;
- Ashes
- Non-toxic or slightly toxic waste from industry
- Agricultural waste.

According to the Law on Communal Solid Waste Management (Article 86), disposal of hazardous, toxic waste as well as other waste producing harmful effects is not acceptable on the considered landfill. This includes:

- Liquid waste;

- Waste that is explosive, corrosive, oxidizing, easily flammable or flammable in landfill conditions;
- Medical waste – infectious;
- Waste resulting from scientific research which is new or cannot be identified;
- Used tires;
- Waste mixed with other substances;
- Waste with high percentage of bio-degradable constituents (paper, garden waste, etc.).

Disposed on the Trestena Skala landfill is unselected solid communal waste from 42.652 inhabitants of Shtip, the settlements Tri Cheshmi with 1.065 inhabitants, Bregalichka with 1750 inhabitants and Zeleznichka with 1.198 inhabitants.

Construction debris and medical waste are not deposited on the Trestena skala landfill. Medical waste from exhumation is deposited on the town cemetery. The construction debris is deposited on a separate location – the old town landfill referred to as “Krst”. The old landfill serves as a borrow pit for inert material – fine grained construction debris for daily coverage of deposited waste on Trestena Skala landfill (Masi, 2013).

If, in dry condition, the ashes and, to a certain extent, the slag, may create problems at disposal wherefore such waste should be wetted and then it should be immediately covered with the daily covering layer. If the slag is chemically polluted, it must not be deposited.

The corpses of animals are collected from public surfaces and deposited in holes at the landfill. After the disposal of such waste, the holes are covered with lime.

The refuse collectors do not select the waste wherefore the procedure for beginning with separate collection of plastic that can be re-used is underway. In this way, the problem with unauthorized presence of persons, who collect plastic waste Figure 6 on the landfill will be solved.



Figure 6. Selection of plastic waste.

4. Disposal of waste within the limits of the facility

The “Trestena Skala” landfill represents a constructed structure with a strictly defined purpose and if it is not treated appropriately, it may exert considerable negative effects upon the environment and may also lead to occurrence of landslides, erosion and visual disturbance of the terrain, uncontrolled use of the area, (Xuede, 2012). To prevent the stated effects and exposure of the landfill to different external effects (wind, rain), in addition to planned disposal by an earthmover and daily coverage, the following measures are anticipated to be undertaken:

- Minimization of quantity of waste by selection of components that can be reused;
- Assuring stability of the landfill body by drainage of gas, filtrate and atmospheric waters;
- Planned enclosure and re-cultivation of the landfill to prevent access of unauthorized persons and animals to the landfill.

Selection of the components of communal waste, i.e., separation of large volume objects, plastic, glass, paper, textile, metal objects and composting of bio-degradable waste in the vicinity of the agricultural areas will enable extension of the period of disposal.

The assurance of stability and compactness of the landfill body, in addition to the possibility of using the space of the landfill for other purposes, protection of the environment is enabled by reducing the production of landfill gases, filtered matter, pollution of atmospheric waters and presence of rats.

5. Conditions prevailing at the landfill site and effects

Since there are no emissions from boilers and principal emissions from point sources (there is no system for receipt of landfill gas and an incinerator) at the facility, it can be concluded that there is no emission from the stated sources into the environment.

There are only fugitive emissions from the landfill, i.e., uncontrolled release of gases that are product of combustion of deposited waste which points out the fact that there is contamination of the atmosphere (Raffaello 2013). Particularly noteworthy is the fact that the waste is deposited as unselected with all admixtures of hazardous waste of the type of batteries, toner cartridges and alike that may emit cancerous matters upon combustion. It is important to note that there is no system for safe outlet of gases from the landfill body. So far, no measurements of fugitive emissions have been made. To define the composition and quantity of emissions, it is necessary to perform many-faceted and long-term monitoring.

5.1. Assessment of the Effect upon Recipient – Surface Waters and Sewerage

The negative effect of the filtered material from the landfill is indisputable since it is highly concentrated. However, in this case, it is produced only in conditions of precipitation. The time duration of the filtrate directly depends on the height of the atmospheric water table and also on the deposited waste and in this case it occurs with a duration of several hours upon cease of precipitation or abrupt melting of snow cover. The filtrate does not reach a water recipient but it empties into a dry ravine.

Due to the favourable topography of the terrain, the relatively flat terrain and the distance of 1 km from the recipient, there is no direct emptying into a surface water course. It can be concluded that only in conditions of torrential rains or abrupt melting of a big snow cover, there is a danger that part of the filtrate reaches the surface water course of Bregalnitsa river but in a very diluted form. Since from geological and hydrogeological aspect, the terrain represents a hydrogeological barrier, any contamination of underground waters is not expected (Andreas, 2013).

Since the deposited waste is in a very small quantity (the landfill exists only 4 years) and due to the fact that it often burns, the filtrate occurs very rarely and in a small quantity, i.e., only after heavy precipitation and melting of the snow cover.

5.2. Assessment of the Effect of Emissions on Soil and Underground Waters

The greatest negative effect of the filtrate is exerted upon the soil since it flows along the dry ravine. From geological and hydrogeological aspect, the terrain of the site represents a hydrogeological barrier without conditions for occurrence of underground waters as well infiltration of polluted fluids into underground waters which is due to its geological composition, namely flysch sediments (claystone, sandstone and marlstone), as defined from bore-hole investigations.

In addition to the effect of the filtrate, particular influence upon the soil is exerted by the rats and other rodents that move through the soil of the landfill without any disturbance since rat-catching is not carried out at the landfill. However, other animals can also cause contagious diseases since there is fence only at the entry of the landfill, while the deposited waste is not covered daily. Due to the above stated, insects and birds these can also contribute to the negative effects from the inadequate treatment of the waste.

5.3. Assessment of Effects of Usage of Waste within the Landfill and/or Its Disposal on the Environment

Since there is no primary selection of the waste, it is brought in situ, as a mixed waste. Upon its arrival, it is partially separated (PET wrappings, some types of metals) by people dealing with sale of secondary raw material. The people doing the selection are directly exposed to the negative effects of the waste since they do the job with bare hands and without any additional equipment. Such way of depositing of the waste does not comply with the Law on Waste (“Official Gazette of RM”, no. 68-04) wherefore it is considered that the landfill has negative effects upon the environment and that taking of measures toward improvement of the conditions is necessary.

5.4. Effect of Noise

The results from the measurement of noise in the immediate vicinity of sources of noise lead to the conclusion that noise does not exceed the maximum allowed level of 80 dB.

The measured values of noise in the environment, i.e., within the limits of the facility, in conditions of permanent regime of operation, range between 43 – 66 dB.

Measurements have been done by use of the digital instrument TECTO 815/TECTO 816.

The table shows that, within the circle of the facility, i.e., within its limits, the noise level for $L(A)_{10}$ has the maximum value of 68 dB and since the facility is beyond a populated zone and considering that it covers a larger area, the noise level does not exceed the maximum allowed limit of 70 dB day and night according to Article 4, Table no. II, item VI of the “Resolution on Definition as to What are the Cases and Conditions Considered to Disturb Peace of Citizens due to Harmful Noise”. The results from the performed measurements comply with the instructions in the “Application for Permit for Harmonization with Operative Plan for Facility Performing Activity Pursuant to Appendix 1 of the Decree”.

5.5. Effect of Vibrations

The mechanization used possesses a corresponding equipment for damping of vibrations by which all the negative effects are considered to be removed.

6. Conclusion

The landfill for non-hazardous waste “Trestena Skala” lacks the corresponding mechanisms for reduction of its effects upon the environment. There is neither geo-membrane nor purification of the

filtrate (or its return to the landfill). There is a fence only at the entry part of the landfill. The landfill is permanently burning. No system for collection and use of the landfill gas is installed. The waste is selected and deposited without previous selection. The waste is spread and compacted upon the surface by an earthmover, not a compactor.

A positive characteristic is the temporary re-covering of the deposited waste with inert material preventing: flying of the light weight fractions of the waste (nylon bags, paper), spreading of unpleasant smell, scattering of the deposited waste by animals and birds. Another positive characteristic is the asphalt road for access of the trucks to the landfill itself. A positive characteristic is also the selection of the site beyond a populated area, with favourable meteorological characteristics and good hydrogeological conditions prevailing on the terrain.

However, not the best available techniques of depositing non-hazardous waste are used, namely:

- Selection of fractions of the waste that can be recycled and re-used;
- Compaction of the waste by means of a compactor for the purpose of optimum use of the landfill area;
- Daily coverage of the deposited waste with inert material for the purpose of preventing flying of light-weight fractions of waste (PVC bags, paper, pieces of textile), spreading of unpleasant smell, presence of insects, rats, birds and alike;
- Collection of the produced landfill gas to avoid the possibility of creating air pockets in the landfill body with collected gas that can cause explosion. The gas from the landfill could be possibly used for production of electric or thermal energy;
- Dewatering of the atmospheric waters from the surrounding land for the purpose of minimizing their infiltration into the landfill body;
- Capturing the filtration waters – the filtrate, their purification and return to the landfill body.

It is important to note that protective fence is placed only at the entry into the landfill. It is low, i.e., unauthorized persons and animals can enter the landfill scattering the deposited waste additionally on the landfill itself and in the immediate surrounding. There are no guards to limit the access only to authorized persons which allows the presence of unauthorized persons who perform partial selection of the waste.

For the needs of monitoring the landfills during their operation and after their closure, there has been passed a Rulebook on Mode and Procedure of Work, Monitoring and Control of Landfill During Operation, Monitoring and Control of the Landfill in the Phase of

Closure and Further Care for Landfills after Closure as well as Mode and Conditions for Care of the Landfills Once They Cease to Operate (Official Gazette of RM no. 156/2007). According to the Rulebook, monitoring and control of the landfill means:

- Collection of meteorological data on the Landfill;
- Monitoring and control of parameters of emissions in the air, waters, filtrate and control of gas from the landfill;
- Parameters of change of composition of underground waters, and
- Monitoring of conditions, structure and composition of the location of the landfill.

The stated rulebook reads a precise description of details regarding monitoring of the landfill gas, surface waters, filtrate, underground waters, as well as monitoring of the conditions of the landfill body.

The meteorological data that are monitored include amount of precipitation, temperature, direction and intensity of wind and evaporation, atmospheric humidity.

Monitoring of emissions in the air includes permanent burning (methane, carbon dioxide, oxygen, temperature, carbon monoxide, nitric oxides, sulfur dioxide and suspended particles.

Monitoring of surface waters includes smells, level, diluted oxygen, electric conductivity, non-ionizing ammonium, total ammonium, chlorides, pH, total organic carbon, suspended particles, biological and chemical consumption of oxygen, metals/non-metals, total phosphorus, fecal and coliform bacteria.

Despite the stated inconsistencies, Trestenska Skala landfill is considered a landfill associated with low risk for the environment according to the National Waste Management Plan 2008-2014.

References

- Andreas. L., Dinner. S., Lagerkvist. A., *Steel slag in a landfill top cover – Experiences from a full scale experiment*, Journal of Waste management, Volume 34, Issue 3, march pp. 692-701, 2013.
- Masi. S., Cauani. D., Grieco. E., Lioi. D., Mancini.M., *Assessment of the possible reuse of MSW coming from landfill wining of old open dumpsites*, Journal of Waste management, Volume 34, Issue 3, march , Pages pp. 702-710, 2013.
- MSW Landfill Criteria Technical manual*, national Technical Information Service US Department of Commerce. N^o 1993, 2010.
- Raffello. C., *What type of articles Should be submitted do Waste management*, Journal and building materials, University Padova Italy, pp 736-764, 2013.

Xuede Q., Robert. D., Donald. H., *Geotechnical Aspects of Landfill Design and Construction, books*, 2012.

Notes on the authors

BISERKA DIMISKOVSKA Associate Professor, Ph.D. at the Department of Natural and Technological Hazards & Ecology, Institute of Earthquake Engineering and Engineering Seismology (IZIIS), “Ss. Cyril and Methodius” University, P.O. Box 101, 1000 Skopje, Republic of Macedonia, Tel: +389-71 321 568, E-mail: biserka@pluto.iziis.ukim.edu.mk

Main field: Protection of human environment; analysis of ecological hazards including industrial risks; air pollution due to emission of harmful matter. Water pollution and management, Solid waste management, Investigation of methods for definition of seismic hazard and risk.

NIKOLA DIMISKOVSKI, student, “Ss.Cyril and Methodius” University, Faculty of Economics, Skopje, Republic of Macedonia, Phone: +389-77-642-753, E-mail: Dimiskovski93@gmail.com