ENVIRONMENTAL SAFETY ANALYSIS OF THE PROJECTED MUNICIPAL LANDFILL AREA IN A SMALL CITY IN UKRAINE

Alla CHOBAN[1], *Igor WINKLER[1], Myron ROGOZYNSKYI [2]

[1]Yu. Fedkovych National University of Chernivts, Ukraine, igorw@ukrpost.ua
[2]National Technical University "KhPI", Chernivtsi Faculty, Ukraine, rmyron@ukr.net
*Corresponding author
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Abstract: *The influence of a relatively small dump area on the environment is analyzed on an example of a new project of the landfill in Storozhinets, Ukraine. The results of the analysis prove that the landfill is not expected to cause excessive contamination of the environment. However, some additional measures can lower a predicted level of contamination and allow better collection and utilization of the landfill biogas. Efficiency of these measures is also discussed and simulation of the expected emission of the environment pollution agents is shown.*

Keywords: *solid municipal waste; utilization and reuse; landfill areas; environmental safety; small communities*

1. Introduction

Environment-friendly and rational reuse, utilization and/or disposal of the waste materials is an acute problem in many countries worldwide. Solid municipal waste (SMW) is a relatively small part of the total amount of waste materials formed by mankind but effective SMW management is often problematic because of a wide variety of the components found in SMW, which complicates their effective processing. Land areas required for new dumps are often deficient or even unavailable. As a result, this problem is quite persistent and hard-to-resolve in many communities and countries [1-3].

Daily formation of SMW in the developed countries is 1-3 kg per capita, which makes 300-1000 kg of the wastes per year. Complete reuse/utilization of SMW is either impossible or unprofitable causing ~10 % growth in the total volume of the waste materials collected in the landfills in the USA annually [4]. The content of the harmful and environmentally dangerous components in SMW is also growing.

These and other related problems cause active development and implementation of new waste management technologies involving waste sorting, burning, composting and others. For instance, many of these solutions have been put into practice in France, where numerous waste-burning factories operate even in small communities. The majority of waste materials undergo preliminary sorting and a lot of waste composting facilities are engaged in the process of SMW utilization, which produce vineyard fertilizers or raw materials for the biogas. Deep level of reuse/recycling of SMW is achieved in Japan, Germany and some other EU members.

On the other hand, 2/3 of SMW are still disposed at the landfills [5]. It should be understood, that this way of wastes disposal is a 'timebomb' since landfills extend constant and growing negative influence on the environment. Waste materials cause contamination of the soils and groundwater, emit noxious smell and promote growth of population of rodent and other vermin species while often self-ignitions result in massive air contamination release. As a result, the waste-related legislation of many countries is a subject of thorough attention and legal requirements in this area are becoming more and more severe. Establishing new landfill areas in many countries is quite complicated or even illegal at the moment.

This paper deals with analysis of the current state of art in the field of operation of the landfill areas in small communities in Ukraine. This issue is often shadowed by more acute problems of operation and expansion of the landfills related to big cities. That is why environmental influence of small landfills remains beyond attention, although these areas also contribute into environmental pollution processes.

2. General description of the landfill area and analysis of its environmental influence

Storozhynets is a typical small city (population 14500) located in the Western part of Ukraine (see Fig. 1). Local waste materials are currently disposed to an old landfill area in the city outskirt. This area has been put into regular exploitation in the 90^s and has neither water proof perimeter nor any stormwater filtration equipment. As a result, it causes serious contamination of the groundwater and local authorities have made a decision to develop a new landfill and put it into regular operation.

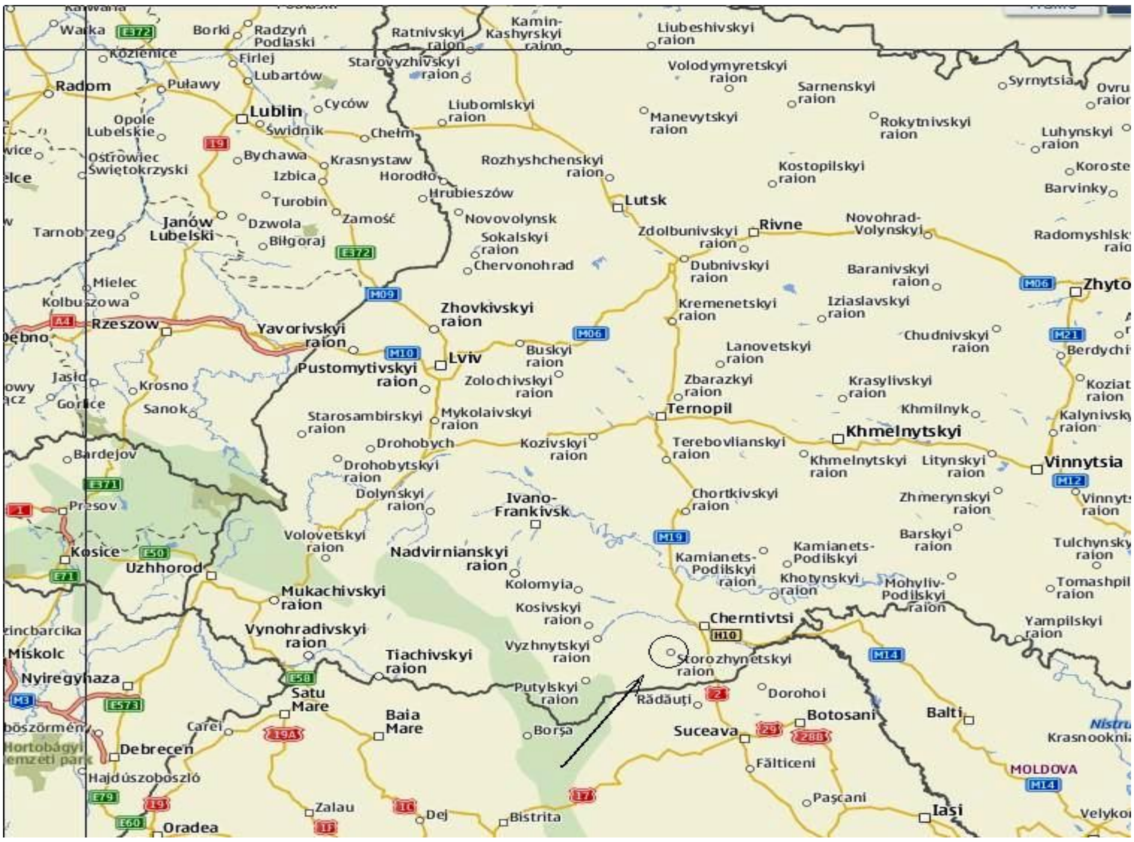

Figure 1. Location of Storozhynets (arrowed and encircled) on the map of the Western Ukraine.

The new landfill is expected to substitute the old one and to decrease the negative environmental impact it causes. In this paper we report results of the general analysis of the influence of the projected landfill on the local environment.

The new landfill (NL) is projected to collect, thicken and store the solid municipal wastes. No reuse or another utilization of the wastes is planned. NL is supposed to collect the municipal, commercial and some industrial or construction waste materials without any toxic or radioactive agents. No chemically or epidemically unsafe materials can be disposed at the landfill.

Total land area of the landfill is 10 ha and projected capacity of NL is 97389 m^3 of thickened wastes, which is equivalent to 263000 m^3 of raw materials. With average 14.5 thousand m^3 of the wastes collected in the city per year this landfill is expected to stay in service for at least 18-20 years. Two trenches are projected as places for the wastes disposal. Both trenches should be dug in the loamy soils with filtration coefficient $1.6 \cdot 10^{-5}$ sm/s. Projected thickness of the waste layers is under 0.3 m.

Technically, collection of the wastes can be performed through either “pushing in” or “pushing off” methods. The first method assumes formation of 12-20 thickened waste layers from bottom to top. A slightly sloping bank formed therefore can be up to 2 m higher than the dust-cart discharge level and then new waste collecting bank should be started nearby by pushing in new materials over the old ones. This method ensures effective natural thickening of the wastes by their own weight.

The “push off” method assumes that the dust-cart discharges at the upper area with further pushing of waste materials by bulldozer down the slope. Its height difference should be kept under 2.3 m. The upper edge of the slope gradually moves horizontally with every new portion of the wastes discharged until the working area limit is reached. Then the newly formed waste band should be covered with at least 0.25 m of soil and the next working band can be started along the previous one. Construction wastes, slag or thickened snow can be used as a temporal cover in the winter if the soil is frozen and can not be collected for the regular cover. However, no new band can be laid over this temporal cover until it is substituted with normal soil.

This way the complete area of NL will be gradually filled with wastes until the total area is covered with new soil and then reclaimed agriculturally. Natural anaerobic biodegradation is expected as the main way of the wastes decomposition. This process will result in formation of some amounts of gases, filtrate and insignificant heat emission.

3. Environment protection measures and the efficiency analysis

A special filtrate-collecting pit is projected to keep the landfill filtrate inside the working area while stormwater around it should be captured in a by-pass channel and then discharged to a nearby pond. Another 2.5 m high ground bank is planned along the channel as an additional environment protection line.

It is necessary to provide strict monitoring of the groundwater quality near such an environmentally dangerous object. A groundwater control well will be established 100 m away from the landfill. The well should be drilled down to 16 m as it corresponds to the groundwater depth in the area, which is 14-18 m.

The landfill area is bordered on east, west and north by bushes/woodland and on south – by a small stream. Protective area around such objects extends for 1 km (this is also a distance to the nearest settlement).

An influence of the newly planned landfill area can be analyzed by taking into account the technology of the wastes treatment, the location and the planning of the new area. In Table 1 we summarize all groups of environmental risks related to this object.

Table 1
Estimation of possible environmental risks related to the projected landfill area

Threatened component	Expected environmental risk	Expected area under threat
Air	Emission of CH_4, NH_3, H_2S, CO_2 into the near-surface atmosphere	Within protective area (1 km)
Water	Contamination of groundwater with filtrate; Pollution of the pond with the surface run-offs from the landfill	Within the landfill perimeter Pond
Soil	Contamination of the landfill bedding soils with filtrate	Within the landfill perimeter
Forest	Cuttings within the new woodland (required because of fire safety)	A 50 m wide area along one side of the landfill.

Table 2
Expected emission of the air pollution agents from the landfill

Contamination agent	Expected emission		
	g/s	kg/hour	t/year
CH_4	22.0	76.2	681.564
H_2S	0.9	3.24	28.398
NH_3	0.4	1.44	11.359

Data of Table 1 prove that the projected area will cause additional contamination of all components of the environment. Biogas (50-65 % methane, 30-45 % CO_2, small amounts of hydrogen sulfide, mercaptans, ammonia, aldehydes, amines, etc.) is expected to become the most massive pollution agent. Average emission of biogas is estimated for one ton of wastes according to [5] as 60-180 m^3/ton. The results of assessment of the atmosphere contamination from the projected landfill are shown in Table 2.

Calculated emissions of the contamination agents are insufficient to cause excessive air pollution in the area and no excessive contents of the pollution agents are expected outside the landfill sanitary protection perimeter.

However, some extra measures can be taken to lower emission of the biogas. In this context some preliminary thickening of the wastes layers can result in reduced emission of the biogas.

Other measures are planned to protect ground waters from contamination with filtrate. Some predicted parameters of the filtrate are following: BOD_5 – up to 4300 mg/l; COD – up to 51000 mg/l; content of detergents – up to 50 mg/l [5]. So this substance is extremely contaminated and environmentally dangerous. An average annual amount of the filtrate is estimated as ~ 117 m^3/year.

A special filtration/drainage system with a 10 m^3 filtrate collecting pit is planned to collect this substance and protect the local groundwater. The filtrate should be collected and then pumped out for decontamination once a month. An additional anti-filtration clay screen should also be constructed for extra protection against filtrate leakage.

It seems that the landfill project has been designed according to rather outdated environment protection requirements of the 80's-90's [6]. Some new materials, which were quite rare in 80's-90's but can be found in modern wastes (new polymer materials and packaging, massive amounts of carton boxes and packaging, new materials for the detergents selling, personal care materials etc.) were not taken into consideration. Since no preliminary wastes sorting is currently employed and won't be used at the new landfill, the specific influence of these wastes components becomes more important.

Moreover, since realization of the project has not been started yet, it can be updated and a waste sorting stage can be added to the technological scheme of waste collecting and processing. This stage would allow to separate and retrieve some secondary resources (paper, plastics, metals, glass), which can result in the decrease of the total amount of the waste materials and pay back some expenses for wastes collecting and processing. It should also be emphasized that biogas formation in the low-polymer containing waste is more effective.

Another remark is aimed onto possible utilization of biogas. There is a well-known technology of establishing the vertical drillings network to collect the waste-originating biogas at landfills. Then it can be burnt in electricity generators or used for heating.

No surface water decontamination equipment is planned at the new landfill and this is another shortcoming of the project. As we mentioned above, new components are present in the municipal wastes today and this can cause significant chemical contamination of the stormwater run-offs which will be collected and then discharged into a local stream without any treatment. We propose to establish an additional settler and the sand-gravel filter to ensure at least some primary decontamination of the stormwater run-offs.

4. Conclusion

A modification of the landfill project, planning of waste sorting and grinding stage, construction of the biogas collection and utilization system can be proposed. Installation of the stormwater cleaning equipment should also be considered. These steps can ensure better environmental safety of the landfill and addressing today's wastes management trends.

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