DOSE RATE OF THE LANDFILLS OF NORTH-WEST PODILLYA (UKRAINE)

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ABSTRACT

Annually more than 300,000 thousand tons of waste are generated in Ukraine, including about 600 thousand tons of hazardous waste. These include used fluorescent lamps, motor oils, batteries, unsuitable and expired pesticides, pesticide packaging, medical waste and others. According to the State Statistics Service of Ukraine, as of the end of 2018, the total amount of waste accumulated during operation in designated areas or facilities was 12972428.5 thousand tones. Whereas during 2018 the amount of generated waste was 352,333.9 thousand tons, and utilized - 103,658.1 thousand tonnes.

In present research the radioecological investigation of landfills impact on ecosystems is presented.

Environmental monitoring primarily aims to quantify the levels of radioactive substances and ionising radiation resulting from human activities and natural sources in the different compartments of the environment through sampling or by the use of direct detection equipment.

For detailed investigation the territory of the North-West Podillya, covering almost the entire area of Khmelnytsky and Ternopil regions, was selected. Namely four municipal landfills were selected in Malashivtsi, Zboriv district (Ternopil region), near Kremenets (Ternopil region), Khmelnytsky, Dunaivtsi (Khmelnytsky region).

A number of the equivalent dose rate measurements were made on the selected landfills using a certified Soeks ecotester.

Keywords: radiation background, municipal solid waste, landfill, environment, climate changer.

INTRODUCTION

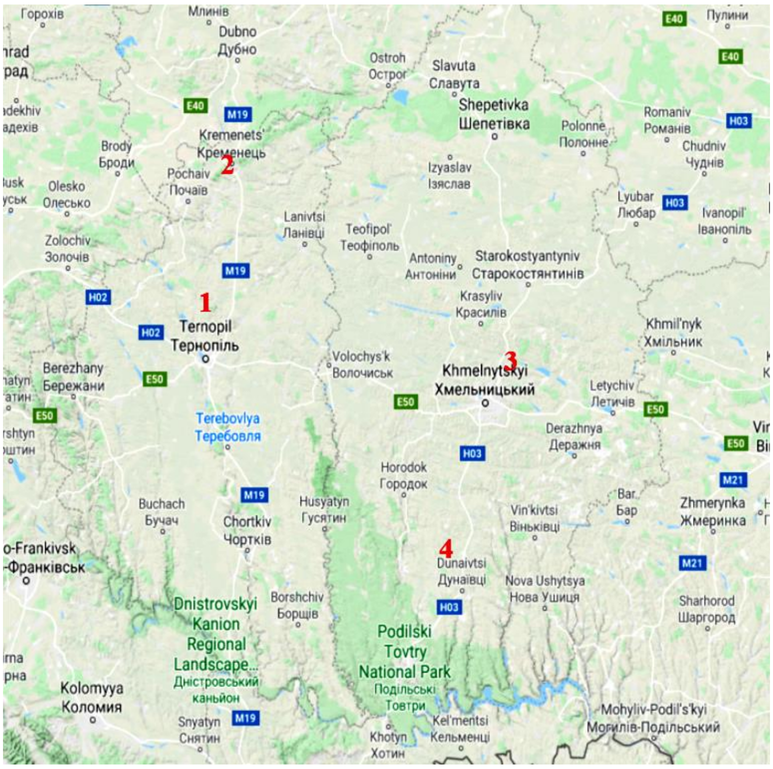
Nowadays the environmental protection is an urgent issue. Therefore, a lot of studies are aimed at identifying factors that have a negative impact on the environment, monitoring their dynamics and finding ways to prevent their effects or eliminate them if necessary. One of the most popular researches in this field is the monitoring of the impact of landfills on the ecosystems, as the problem of landfills is not solved, despite the already known facts of their impact on both humans and the environment [1, 2, 3].

Landfills are objects with increased ecological and technological hazard. A number of scientific studies have defined three main hazardous factors of landfills: biogas generation, waste combustion and leachate drainage. In particular, the research by Vodyanitskii (2016) stresses the fact that municipal solid waste landfill is one of the largest sources of environmental pollution, where leachate percolates through soil, reaches surface and ground waters. Increased dose rate is observed at the landfills (Tulaydan et al., 2017; Popovych et al., 2018; Malovanyy et al., 2018) [4].

This area of research includes detection and investigation of possible environmental impact of ionising radiation of large amounts of waste generated on a daily basis and disposed of in designated areas.

The North-West Podillya is an area of the Western Forest-Steppe, which includes the Ternopil and Khmelnytsky regions without their boundary northern parts. The sites of interest are located in different parts of the selected region (Fig. 1).

Fig.1. The map of the investigated area with the selected sites (1 – Malashivtsi, 2 – Kremenets, 3 – Khmelnitsky, 4 - Dunaivtsi) [5]



Khmelnytsky region is characterized by favorable geographical position, favorable climatic conditions and diversity of landscapes, rich flora and fauna, mineral waters, fertile black soils, a wide network of rivers. By physical and geographical location, the area is in the forest-steppe zone, occupies the central and western parts of the Volyn-Podolsk upland and the western slope of the Ukrainian crystalline shield. The area is located in different natural regions. Agricultural land covers up to 75.9% of its territory, the remaining territories are rivers, forests, swamps, settlements, industrial sites and transport routes. Soils are highly productive. Their matrix is the black soil. The hydrographic network of the region is represented by the basins of three large rivers: the Dnieper, the Southern Bug and the Dniester with their tributaries. Forests cover more than 12% of the territory of the region. The natural-geographical factors, the level of use of natural resources and the environment are significant factors affecting the whole Podilsky region and beyond its borders.

The Ternopil region covers the western part of the Podolsk Upland. The terrain is flat. Due to the location within the Eastern European Platform, sedimentary minerals predominate here, the largest of which is the group of non-metallic minerals (limestones, chalk, marls, gypsum, sands, sandstones, clays, dolomites, etc.). They are the raw material for the production of building materials. Loams and clays (more than 100 deposits), limestones, sandstones are widespread here as well. The climate in the area is temperate-continental: hot summers, mild winters and heavy rainfall. More than 2,400 rivers and streams flow through the territory, there are mineral waters and significant groundwater reserves.

In the Ternopil region, about 800,000 m^3 of solid municipal waste have been formed in recent years. For its land application 740 landfills are functioning, 31 of which are municipal. The total land area occupied by landfills is over 150 ha. The volume of waste generation is increasing every year, namely in 2000 it was 282.0 thous. m^3, 2010 - 659.3 thous. m^3, 2015 - 788.5 thous. m^3, and in 2017 - 784.9 thous. m^3. Now 21430.9 thous. m^3 of waste have been dumped in the landfills of the region. In this regard, the vast majority of landfills operate in overload mode, violating the design target value for waste accumulation. The significant increase in the amount of solid waste is the result of changes in the way of living, namely the unusual spread of disposable items. It is possible to reduce the amount of waste significantly by increasing the shelf life of such things [6].

The largest landfills in the Ternopil region are located in Malashivtsi (Zboriv district), where waste is taken from Ternopil; on the outskirts of Kremenets (district center in the north of the region); Chortkiv and others, most of which are overloaded and do not meet environmental and sanitary requirements.

In 1977, the Ternopil City Council allotted a land plot of mined-out quarry on the territory of Malashivtsi City Council for 10 years for the storage of municipal and industrial waste. The area of the plot is 3.5 ha. However, the city council did not stop using this landfill. In 1997, the Malashiv landfill was banned from exploitation, but municipal waste is still being discharged. In 2009, a garbage line was purchased from the Ternopil Regional Council for the city. According to the State Environmental Inspectorate, over Ternopil to Malashiv landfill is exported more than 100 thous. m^3 of waste per year. The city landfill is located 20 kilometers from Ternopil (Fig. 2).

The landfill is located near agricultural land, partially fenced and planted with shrubbery, but it does not prevent the garbage from escape beyond the landfill, because in some places the height of the accumulated waste heaps reaches 45 m. Vegetation is dominated by weeds and other herbs, and also birch trees and several shrubs.

The landfill is located on the suburb of Kremenets in 1-2 km away from the housing sector and close to the agricultural lands. According to the latest data in compliance with the order of the head of the Kremenetsky district state administration of April 23, 2014, No. 243-od a land plot of 4 hectares was leased for 20 years to the UE Kremenetska Oselya for servicing the landfill outside the settlement in the territory of the Chuhaliv village council (Kremenetsky district, Ternopil region). In October 2019, employees of the UE "Miskvodhosp" of the Kremenets City Council installed a fence around the municipal landfill to improve the environmental situation in the area. First of all the part adjacent to agricultural land was fenced off. Therefore, the possibility of the getting of wind-driven household waste on adjacent territories has decreased. At the entrance there is a barrier and a primitive checkpoint, where a security guard checks the arriving cars with garbage and keeps records, manages the even distribution of waste in the territory of the landfill. Due to the frequent fires, cameras are provided in the area.

Fig. 2. Waste sorting plant in Malashivtsi (photo by Skyba T., 2020.)

In the Khmelnytsky region the landfill sites in Khmelnitsky and Dunaivtsi were investigated.

The landfill is located 2 km from Dunaivtsi, the district center in the south of Khmelnytsky region. The distance from the nearest reservoir is 1 km, from the water intake well - 3 km. It has been in operation since 1952. The area is 5,133 ha. Different types of waste are transported to the landfill: ferrous scrap, municipal mixed waste, technical oils that are not chlorinated emulsions, waste obtained from welding processes, wood chips, used, damaged or contaminated tires etc. The volume of waste disposed for 2013 is 9240 tons. From 2018, a waste sorting line is operating at the landfill, which separates only paper and plastic (Fig. 3).

Fig.3 The waste sorting line on the landfill in Dunaivtsi (photo by Skyba T., 2020)

The Khmelnytsky landfill is located on the suburb of the regional center. It appeared in a clay quarry in 1956 on the place of fly dumping that was uncontrolled until 1987. When the landfill was transferred in account of UE "Spetscomuntrans" the operations for waste storage compliance with the technology began. For this purpose, the landfill was provided with the technical facilities for waste deployment and compaction. The landfill is allowed to accept household waste (except liquid household waste and hazardous waste as a part of household waste) from residential buildings, administrative and public institutions and organizations, trade and public catering establishments, cultural and art establishments, educational and medical establishments and other enterprises, institutions and organizations, regardless of ownership, street and landscape debris and leaves, as well as crushed construction waste and industrial waste of Hazard Categories III and IV, slag and ash from incineration plants. Currently, the existing landfill is municipal property of the territorial community of Khmelnytskyi and transferred to the account of the Khmelnytsky UE "Spetscomuntrans".

On the entrance of the landfill, there is a checkpoint. The responsibility of the inspector is a strict control over the arrival and clearance of incoming vehicles, namely he inspects, receives from the driver the necessary documents (waybill, bill of lading, document for payment of waste disposal services), verifies the data with their own approved documents, weighs and visually assesses the composition of imported waste, makes records. Landfill territory is fenced off, which restricts access by unauthorized dumpers. The area of the Khmelnytsky landfill is impressive in scale and height, seldom plants can be seen, the smell makes it impossible to stay for a long time even for further research. Everywhere you can see the huge number of crows and seagulls that have filled the airspace above the landfill and, accordingly, can be carriers of numerous infections and diseases.

METHODS AND OBJECTS OF THE RESEARCH

During the winter period of 2020 the dose rate on the selected landfills was measured by the Soeks ecotester (Fig. 4).

Fig. 4 Measurement of dose rate at landfill in Malashivtsi (photo by Skyba T., 2020)

The dose rate is evaluated by the ionizing radiation intensity (gamma-ray and beta-particle fluxes based on x-rays). Three measurements were performed at each point for the accuracy of the measurement results. Depending on the location of the waste at the landfills, the access possibility measurements were performed on the principle of points: on each of the four sides - at the foot, at the side and 100 m from the foot. As a comparison measurements were made at a background point that was chosen individually for each landfill according to the wind rose.

RESULTS

The results of the measurements are summarized in Table 1. For convenience of comparison, the average of each group of measurements was calculated. The obtained results are compared with the dose rate limit, which is 0.3 μSv/h. It was carried into the ecotester.

Measurements presented in the table show a tendency of increasing of dose limit from the foot to the top of the dump. Let's consider each landfill individually.

Measurements made on the north side of the landfill in Malashivtsi show the lowest results. It is worth noting that on the north side there are the most overgrown areas of plants of different heights scrub trees, shrubs, weeds, other herbs. This can be a significant factor in further studies to reduce dose rate by planting certain species. In general, there is a concept of increasing the dose rate from the bottom to the top, which depends on the accumulation of the amount of waste with the height, and reducing it from a distance of up to 100 m away from the radiation source. The exception is the west side, where the figures fluctuate: there are higher values at the foot compared to the side, and smaller – compared to the top. But, compared to the background point (0.043 μSv/h), all results exceed its value. This indicates the presence of radiation exposure from the landfill. The highest rates (0.33 μSv/h) were detected at the top of the landfill, where the biggest amount of waste is accumulated.

At the landfill in Kremenets on all sides, except for the north, there is an increasing dynamics from the bottom to the top, and decreasing with the distance by 100-200 m. The dose rate at the top (0.193 μSv/h) do not exceed the allowable rate. The background point is selected at a distance of 1-1.5 km from the landfill, but the measured values indicate that another possible source of ionizing radiation is present, since it is high enough for the forest ecosystem (0.187 μSv/h).

On all sides of the landfill in Dunaivtsi, but the northern one, there is a similar dynamics of increase from the bottom to the top, and mostly - a decrease in the distance by 100-200 m. Background point (0.063 μSv/h). The dose rate at the top is within the normal range, but more than three times higher than the background point.

The situation with the landfill in Khmelnitsky is similar. At all directions but the north, the dynamics of the increase from the foot to the top is detected. The decrease in the distance by 100-200 m, is observed. The dose rate at the top is 0.27 μSv/h do not exceed the allowable rate but exceeds the background value of almost twice.

Table 1. Results of dose rate measurement at landfills of Malashivtsi, Kremenets, Dunaivtsi, Khmelnitsky (presented in mean values)

	Malashivtsi	**Kremenets**	**Dunaivtsi**	**Khmelnitsky**
Top	**0.33**	**0.193**	**0.203**	**0.27**
Northern slope	**0.177**	**0.16**	**0.16**	**0.17**
Foot (from the north	**0.167**	**0.187**	**0.207**	**0.243**

side)				
North (100 m away)	**0.127**	**0.137**	**0.12**	**0.18**
Southern slope	**0.217**	**0.17**	**0.1**	**0.177**
Foot (from the south side)	**0.11**	**0.127**	**0.09**	**0.12**
South (100 m away)	**0.113**	**0.13**	**0.087**	**0.11**
Western slope	**0.1**	**0.17**	**0.15**	**0.12**
Foot (from the west side)	**0.223**	**0.16**	**0.137**	**0.12**
West (100 m away)	**0.16**	**0.24**	**0.12**	**0.1**
Eastern slope	**0.22**	**0.17**	**0.1**	**0.18**
Foot (from the east side)	**0.177**	**0.16**	**0.097**	**0.13**
East (100 m away)	**0.11**	**0.14**	**0.1**	**0.16**
Background point	**0.043**	**0.187**	**0.063**	**0.11**

CONCLUSIONS

The results of radiation-ecological monitoring of four landfills show that the dose rates are within the normal range, except for the measurement at the top of the landfill in Malashevtsi. One of the reasons is the operation of the landfill for 43 years, despite the prohibitions. The landfill contains waste of various types: food waste (bones, skulls), household waste (paper, plastic, glass, packaging), tires, rubber cables etc. The only operation that is done properly is the grading.

In general, there is a dynamic increase in the dose rate from the bottom of the landfill to the top, which is associated with an increase in the amount and density of waste. The dose rate decreases due to the distance from the radiation source (from 100 to 200 m).

At the case of the Malashyvets landfill, it is evident that plants are both an environmental indicator and an ecosystem component that is capable of absorbing harmful and hazardous substances, including radionuclides, from the soil. Therefore, the landfill with the largest accumulation of plants, especially perennials, shows the lowest measurement results. Khmelnitsky landfill, where there are practically no plants, shows the significantly higher dose rates.

The only promising way of preventing the harmful effects of landfills on the environment is to promote the vegetative reclamation processes. Therefore, this scientific area is worth special attention.

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