

**MODELING AND FORECASTING OF THE STATE  
OF THE ENVIRONMENT IN THE WASTE MANAGEMENT  
AND MANAGEMENT SYSTEM CONSUMPTION OF KREMENCHUK URBAN  
TERRITORIAL COMMUNITY IN WARTIM**

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**Abstract.** We consider waste management and management as an area of ecological safety. As a result of the study, the ecological aspects of this branch of activity were analyzed on the example of the operation of the operating MSW landfill in the city of Kremenchuk. The prospective direction of the field of waste management in the region, as well as the state of its financing, are taken into account. Such dangerous factors in the operation of the municipal landfill for the environment as: pollution of groundwater and open dumps of the landfill have been identified. The chemical composition of the leachate formed in the body of the landfill was evaluated and the concentrations of pollutants were compared with the permissible values in wastewater discharged to the city sewer. Priority measures for landfill reclamation were proposed. We analyzed solid household waste landfills from the point of view of resource-energy saving, as an alternative source of energy thanks to the use of generated biogas, as well as extracted secondary resources.

**Keywords:** modeling, forecasting, management, handling, waste, leachate, open landfill dumps, reclamation, resource and energy saving, environmental aspects, industry activity.

## 1. Introduction

Removal of waste to landfills is the most widespread way of removing waste from the places of its generation. Exploitation of landfills leads to environmental pollution (Shmandiy et al, 2022). The Association Agreement between Ukraine and the

European Union, signed in 2014, requires each region of Ukraine to take practical steps to implement European standards in the field of waste management and management.

According to the National Strategy for Waste Management in Ukraine until 2030 (Order Kabinetu Ministriv Ukrainy, 2017), waste management measures should be carried out in accordance with the established hierarchy and sequence adopted in the EU:

1. Prevention of waste generation.
2. Reparation for reuse.
3. Processing.
4. Ther types of waste utilization, including energy utilization, use of waste as secondary energy resources.
5. Removal of waste – burying it in specially equipped places/objects and destruction (disposal) at facilities that comply with environmental regulations, only in the case of the inability to perform the previous stages of the hierarchy.

The national strategy envisages special measures in the field of household waste management, which include:

1. Creation of specialized communal waste collection points for different fractions (dangerous, organic, secondary raw materials, large-sized, etc.).

2. Creation of a network of collection points for the reuse of furniture, household appliances, clothes and other goods that were in use.

3. Increasing the level of waste processing.

4. Ensuring the construction of a network of regional landfills, termination of operation, closure and reclamation of landfills and landfills that do not meet ecological safety requirements.

5. Construction of a network of garbage transfer stations, etc. measures in the field of waste management, as well as a number of changes in the current legislation, such as the improvement of the legal framework for the organization of separate collection of all types of waste and their processing and disposal, the development of bills on waste management, on waste disposal, on household waste, waste packaging, etc.

One of the conditions for the implementation of the National Strategy is the creation of a network of regional landfills, which must be defined in regional and local waste management plans.

Both in the city of Kremenchuk and in the Poltava region in general, the technical equipment of landfills does not meet either European or domestic standards, modern technologies for sorting and extraction of resource-valuable components are poorly developed, composting and the process of anaerobic digestion are not widely used. The main direction of solid waste management remains their burial in landfills and removal to special places and facilities (Regional program, 2022).

The economic downturn of 2020, caused by the pandemic crisis of COVID-19, had a negative impact, in particular, on the field of waste management. The planned measures for the arrangement of landfills and waste disposal infrastructure were not carried out. At the same time, the amount of household waste increased. As a result of the production and use of personal protective equipment, the amount of plastic waste and medical waste has increased.

Russia's large-scale invasion of Ukraine and hostilities on its territory starting in 2022 had an even greater negative impact on the field of waste management, as it led to an increase in the volume of specific waste, including construction waste containing asbestos and heavy metals. Often, construction waste generated as a result of hostilities, saturated with toxic particles of gunpowder, electronics and batteries, contains deformed plastic. Population migration has added an additional burden to local landfills in more favorable regions.

On the other hand, in connection with the forced change of the state's priorities in the direction of defense, the lack of satisfactory financing in the field of waste management, work on the arrangement of modern landfills and reclamation of existing landfills almost does not take place.

In July 2023, the Law of Ukraine "On Waste Management" entered into force, which prohibits from January 1, 2030 the operation of waste disposal sites (landfills, landfills) without equipping with biogas and leachate extraction and disposal systems, systems for monitoring emissions into the atmosphere and monitoring soil pollution and underground waters. However, the requirements of this article do not apply if the business entity that manages the waste disposal site develops and implements certain measures to bring the existing waste disposal site into compliance with the requirements of the law.

In the conditions of war, assessing the financial component of the sphere of waste management and the existing infrastructure in Ukraine, it is currently impossible to provide waste disposal sites with all the necessary environmental protection systems. At the same time, to ensure the sanitary and epidemiological well-being of the population, as well as to exclude the possibility of the formation of spontaneous landfills in the regions, landfills must function.

Based on the above, we consider it expedient to consider the risks that may lead to negative consequences in the event of further operation of an undeveloped landfill, as well as to propose the main priority measures to minimize the negative impact of landfills on the environment. At the same time, landfills will continue to perform the irfunction until the moment of obtaining the necessary investments for carrying out capital construction works.

## **2. Research results and their interpretation**

### **2.1. Negative impact of the landfill**

#### **2.1.1. Prospects of waste management in the region**

Let's consider the environmental condition of landfills in the Poltava region. At the end of 2021, there were: 709 landfills and solid waste landfills in the region, of which:

1. Landfills that remain in temporary operation as necessary infrastructure facilities, it will be decommissioned after the implementation of regional waste treatment facilities in the territories of the respective clusters – 56 facilities.

2. Landfills that do not meet sanitary and ecological requirements and are subject to priority 274 objects were closed.

3. Landfills planned to be decommissioned in 2025–2030 – 354 objects.

4. Landfills that have already been closed and liquidated or are being prepared for liquidation – 18 objects.

5. Landfills and landfills that remain in operation for the period until 2030, for further reconstruction or expansion – 7 objects (including the landfill of Kremenchuk).

In 2020, by merging the Kremenchug City Council (Kremenchuk) and the Potokiv Village Council (the villages of Potoky, Prydniprianske, Mala Kohnivka and Sosnivka), the Kremenchug Urban Territorial Community was formed with the administrative center in the city of Kremenchuk. Collection of solid household waste in the city is carried out according to the container scheme. Waste is collected according to the following components: polymer waste, paper waste, glass and other mixed garbage. Collection of solid household waste according to the container scheme has not been implemented in the villages.

There are 2 official solid waste disposal sites on the territory of the community (Fig. 1). Solid waste dump in the village. Streams covers an area of 1 hectare, intended for waste from activities of public catering establishments, maintenance and repair of equipment, devices and products, other communal and similar non-specific industrial waste, others. As of January 1, 2018, the total amount of waste received was 2.569.95 thousand tons. The landfill is not equipped with protective structures and does not meet sanitary and environmental standards. Waste disposal is carried out in an open area with periodic compaction and soil spillage with the help of a loader.

The solid waste landfill is located in the right-bank part of the city of Kremenchuk on Deivska Gora. It covers an area of 28 hectares. The landfill accepts household and industrial waste. At present, more than half of the territory of the landfill is filled and is subject to reclamation. About 10 hectares remain for future exploitation. The total mass of accumulated waste is 9 million tons. The landfill is equipped with a biogas collection and utilization system, but it is not equipped with engineering facilities for groundwater protection, extraction and utilization of leachate.

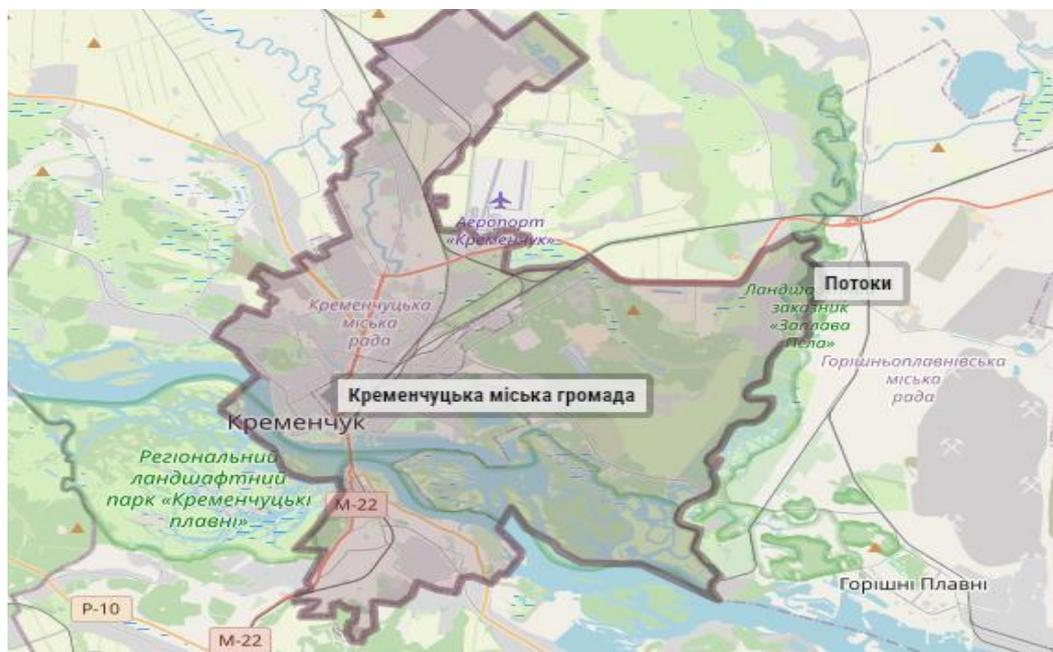


Fig. 1. Solid waste disposal sites in the Kremenchuk urban territorial community

From July 2023, all waste generated on the territory of the entire Kremenchuk MTG will be sent for disposal to the Kremenchuk MSW landfill. Of course, this is a positive step on the way to the organized collection of waste, its accumulation in one specially designated place. In the future, the landfill in

the village will be rehabilitated. Streams that will have a positive impact on the environment. However, currently there is a load on the operating landfill of the city of Kremenchuk. Therefore, it is necessary to develop and implement priority urgent measures to minimize the impact of the operating landfill on the environment.

### 2.1.2. Groundwater protection measures

The landfill in Kremenchuk is located 1000 m from residential buildings. Groundwater quality control is carried out from the source of water supply at the quarry and drinking wells located on private residential plots, below the municipal solid waste landfill. The geological structure of the landfill site is relatively homogeneous and is represented by a thickness of Neogene sands and loams. The aquifer belongs to Neogene sands. The depth of the groundwater level is 55–67 m from the surface of the earth. Waste is brought to the landfill by special transport, which undergoes weighing and radiological control, after which the waste enters the working map, where it is unloaded. Discharged waste must be leveled and compacted. Disposal of solid waste is carried out by layer-by-layer storage with clay layers and layers of inert industrial waste, which are rammed with a bulldozer.

According to the monitoring data of the state of groundwater in the territory of residential buildings within the influence of the landfill, exceeding the normative indicators for nitrates were periodically recorded.

Since the territory of the landfill is heterogeneous and some of its parts belong to III, IV, V zones in terms

of the degree of protection of groundwater, this indicates that the leachate is capable of entering and contaminating the groundwater of the adjacent territory. The technogenic aquifer is represented by leachate, which is formed in the waste body as a result of infiltration of atmospheric precipitation. The filtrate contains compounds released from the waste in dissolved and colloidal form. We recommend using traditional methods of cleaning household and industrial wastewater, as well as their combinations, for the disposal of leachate utilization. We consider it appropriate to determine the method of leachate disposal and disposal individually in each specific case based on the characteristics of the leachate and requirements for the quality of purified water.

There are no leachate lakes on the territory of the Kremenchug solid waste landfill and beyond, there are only isolated cases of leachate seepage through the waste layer. Such leaks most often dry up or are absorbed back into the garbage. But, taking into account the planned increase in the volume of waste at the landfill, the situation may become more complicated. The results of the analysis of the chemical composition of the leachate that leaked in the central part of the landfill are given in Table 1.

Table 1

#### Results of the analysis of the chemical composition of the leachate taken from the solid waste landfill

| No. | Indicator                 | Unit of measurement | Permissible concentrations of pollutants in wastewater discharged to the city sewer | Measurement results |
|-----|---------------------------|---------------------|---|---------------------|
| 1   | Color                     | description         | –   | black               |
| 2   | Transparency              | sm                  | –   | 0.5                 |
| 3   | pH                        | unit of pH          | 6.5–9.0   | 8.43±0.10           |
| 4   | Ammonium ions             | mg/dm <sup>3</sup>  | 15.0  | 1595.±143.0         |
| 5   | Common iron               | mg/dm <sup>3</sup>  | 1.5   | 11.9±1.4            |
| 6   | Suspended substances      | mg/dm <sup>3</sup>  | 150.0   | 180.0±18.0          |
| 7   | Chemical oxygen demand    | mgO/dm <sup>3</sup> | 450.0   | 3760.0±53.0         |
| 8   | Chlorides                 | mg/dm <sup>3</sup>  | 100.0   | 2690.0±190.0        |
| 9   | Sulfates                  | mg/dm <sup>3</sup>  | 80.0  | 497.0±45.0          |
| 10  | Dry residue               | mg/dm <sup>3</sup>  | 700.0   | 11980±600.0         |
| 11  | Fats                      | mg/dm <sup>3</sup>  | 30.0  | 2.5±0.8             |
| 12  | Oil products              | mg/dm <sup>3</sup>  | 0.5   | 0.189±0.066         |
| 13  | Copper                    | mg/dm <sup>3</sup>  | 0.05  | 0.01                |
| 14  | Zinc                      | mg/dm <sup>3</sup>  | 1.0   | 0.950±0.228         |
| 15  | Nickel                    | mg/dm <sup>3</sup>  | 0.059   | 0.354±0.064         |
| 16  | Surface-active substances | mg/dm <sup>3</sup>  | 2.0   | 1.60±0.38           |
| 17  | Nitrates                  | mg/dm <sup>3</sup>  | 45.0  | 20.5±5.1            |
| 18  | BSK <sub>5</sub>          | mgO/dm <sup>3</sup> | 180.0   | 455.0±91.0          |
| 19  | t <sup>0</sup> C          | degrees             | 40  | 9.9±0.2             |

The obtained data indicate that most of the indicators do not meet the established standards for acceptance at the city treatment facilities for additional treatment, therefore it is necessary to collect and dispose of the leachate on the territory of the landfill using a combination of methods of cleaning domestic and industrial wastewater. In the conditions of limited funding, we offer the simplest structure for collecting leachate – the arrangement of drainage channels and the construction of a storage tank at the foot of the active part of the solid waste landfill. Collecting the leachate will avoid the flow of liquid into the environment, and in the future, it will be possible to further process and clean it using modern technologies.

### **2.1.3. Justification of partial reclamation measures**

The resource of most of the Kremenchuk landfill is almost exhausted. The slopes of the landfill have reached the normative value, and two of the four waste disposal maps are no longer in use. There is a need for reclamation of closed waste disposal maps

and the opening of new maps. Usually, reclamation of landfills is carried out in two stages: technical (technological screen (loam), gas drainage, geotextile, waterproofing) and biological (drainage, mineral soil, fertile soil).

One of the dangers at the landfill is open dumps prone to fire outbreaks, which creates additional threats to the environment and human health. Also, open landfills attract insects and rodents that can carry diseases (Fig. 2). They can become a source of atmospheric air pollution, releasing harmful substances, contaminating the soil and groundwater, the natural landscape.

A slope without proper leveling can cause soil erosion by water and wind. Erosion can lead to the destruction of part of the landfill and the spread of waste and contaminated materials over considerable distances. An incorrect slope angle can cause landslides and oscillations in the body of the landfill. Landslides and collapses of the landfill cause not only negative consequences for the environment, but also threaten the safety of the personnel who maintain the landfill.



**Fig. 2.** The open slope of the household waste landfill

In the conditions of martial law, taking into account the lack of sufficient funding, to solve the problem of reclamation of the active part of the landfill, we consider it expedient to allocate several priority mandatory stages of technical reclamation. These measures will significantly reduce the danger of operating the landfill, while they will not require significant financial costs. Below are the 3 stages of work:

1. Reducing the angle of inclination of the slopes of the landfill using inert waste and clay.
2. Reinforcement of landfill slopes with inert waste.
3. Planning the entire area of the landfill with inert materials that have a dense structure, while filling cracks as much as possible and leveling the entire surface (Titova et al 2021; Titova et al, 2022).

Although this method is not a complete stage of technical reclamation, but, in our opinion, the implementation of even these primary measures can significantly reduce the danger during further operation of the landfill. Leveled slopes and the surface of the landfill will help to contain the waste in the body of the landfill and reduce the likelihood of its scattering and spreading outside the boundaries of the landfill. In this way, the risk of landfill collapse will be reduced, atmospheric air pollution will be reduced, and the aesthetic appearance of the facility will improve.

Due to the regular observance of waste layering technology, the risk of spontaneous combustion will decrease, which will have a positive effect on the formation of biogas in the body of the landfill. In turn, extraction of biogas from the municipal solid waste landfill by an operating plant, as well as its use as an alternative fuel for the production of electricity, will allow to save and rationally use energy, contributing to the efficient use of resources. This will have a positive impact on energy savings at the local level, especially in wartime (Titova, 2023).

### 3. Conclusions

Based on the results of research, it was confirmed that the operation of the Kremenchuk solid waste landfill has a negative impact on the environment. Based on the fact that the sufficient number of specially designated places for storing waste, including production waste, on the territory of the Kremenchuk

MTG is limited, there is no alternative for placing a new solid waste landfill. Forecasting of the development of the situation was carried out and it was proved that the only way to solve the issue of waste management and handling is the reclamation of the landfill in the village. Flows and reconstruction of the municipal solid waste landfill with the development of engineering protection of its territory, as well as reclamation of used waste disposal maps.

It is advisable to use inert waste in the initial emergency measures for reclamation of the landfill. It is predicted that the implementation of this solution will provide an opportunity to reuse industrial waste, as well as reduce its amount by disposing of it in an environmentally friendly way. This will make it possible to effectively plan waste disposal areas, prevent possible landslides, stabilize closed maps of the landfill, and prevent waste dispersion.

A chemical analysis of the filtrate was carried out. A comparison with the permissible concentrations of pollutants in wastewater, which is discharged to the city sewer, indicates the contamination of the leachate. The necessity of building a system for collection and disposal or filtration of leachate with subsequent transportation to treatment facilities is substantiated. Due to the high concentrations of pollutants in the liquid and, accordingly, the recorded excesses of nitrate concentrations in the groundwater, construction must be started in the near future.

It is predicted that failure to implement the above-mentioned measures may lead to further contamination of groundwater, leakage of leachate, landslide of the landfill and clogging of adjacent territories with waste.

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