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WAYS TO MINIMIZE ENVIRONMENTAL HAZARDS FROM POLLUTION OF THE ENVIRONMENT IN THE ZONE OF INFLUENCE OF THE HRYBOVYCHI LANDFILL

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Abstract. The article analyzes the environmental risks of existing landfills in Ukraine (on the example of Hrybovytske landfill). The possible treatment technologies of the accumulated infiltrates were analysed and the successful application of infiltrates biological treatment technology in aerobic lagoons was confirmed. It was shown that the problem of introducing innovative technologies for solid waste management could be solved only by a complex approach: creating the conditions for technical and biological remediation of existing landfills and providing a system of measures with the aim of preventing environmental pollution.

Key words: environmental risks, landfills, infiltrates, aerobic lagoons, remediation, environmental.

Statement of the problem. Analysis of recent researches and publications. Existing landfills in Ukraine, a genesis of creation and functioning of which is extremely similar to all objects, today have become powerful environmental hazards. To analyze this risk and suggest a strategy of its minimization with passing to innovative technologies of behavior with hard domestic wastes (HDW), the dynamics of changes in environmental conditions of Hrybovychi landfill was examined, where trash of Lviv had been collected until recently.

Hrybovytske landfill is located at a distance of 3 km from the northern border of Lviv city, nearby the villages of Velyki Hrybovychi, Zbyranka and Malekhiv. The landfill has functioned since the 60s of the last century and it covers an area of 33.6 hectares (Fig. 1).

The thickness of the garbage layer in the south-east part of dump reaches 50 m, in the northwest it ranges from 1–3 to 10 m [1]. In spite of the fact, that in a number of normative documents, articles in mass media and in official statements the object is often named “landfill of HDW”, the name is wrongful, because landfills of HDW are nature protection engineering structures equipped with a protective anti-filtration screen, system of collection and utilization of infiltrates and landfill gas with a planned system of physical and biological recultivation of waste-filled cards, collection and removal system of conditionally clean atmospheric waters. All this is absent at Hrybovychi landfill. Since the landfill has exhausted its resources, the only correct solution is to close it. The necessary condition of technical remediation according to [2] is to create the slope angle, the normative value of which is set depending on the further target use (a maximal value is normalized for planting forests, shrubs and trees - less than 18°), that nowadays exceeds the norm greatly. To achieve the required angle for reclamation of the landfill slopes, general alignment of slopes by filing up the adjoining territory with hard material (wastes, earth, clay, etc.) is necessary. But, as at present the backfill place is occupied by the infiltrates lakes, which have been accumulated according to different estimations, 100–150 thousand m^3, the priority task is clearing and the removal of these infiltrates that would enable to start work on the general alignment of the landfill slopes.

There is also industrial waste of sour Goudron accumulated in local areas of the landfill. But this situation is not typical of all landfills of Ukraine, and so in this article, the ways of optimal strategy of their utilization (which require detailed research) are not given.

In our opinion in solving the problem of elimination of environmental hazards, caused by Hrybovychi landfill infiltrates, it is necessary to single out 2 stages:

1 – purification of the accumulated infiltration for the purpose of the landfill recultivation;

2 – clearing of the infiltrates, which constantly for decades, will be formed in the body of the landfill as the result of the occurrence of biological processes of decomposition of the organic component of the waste.

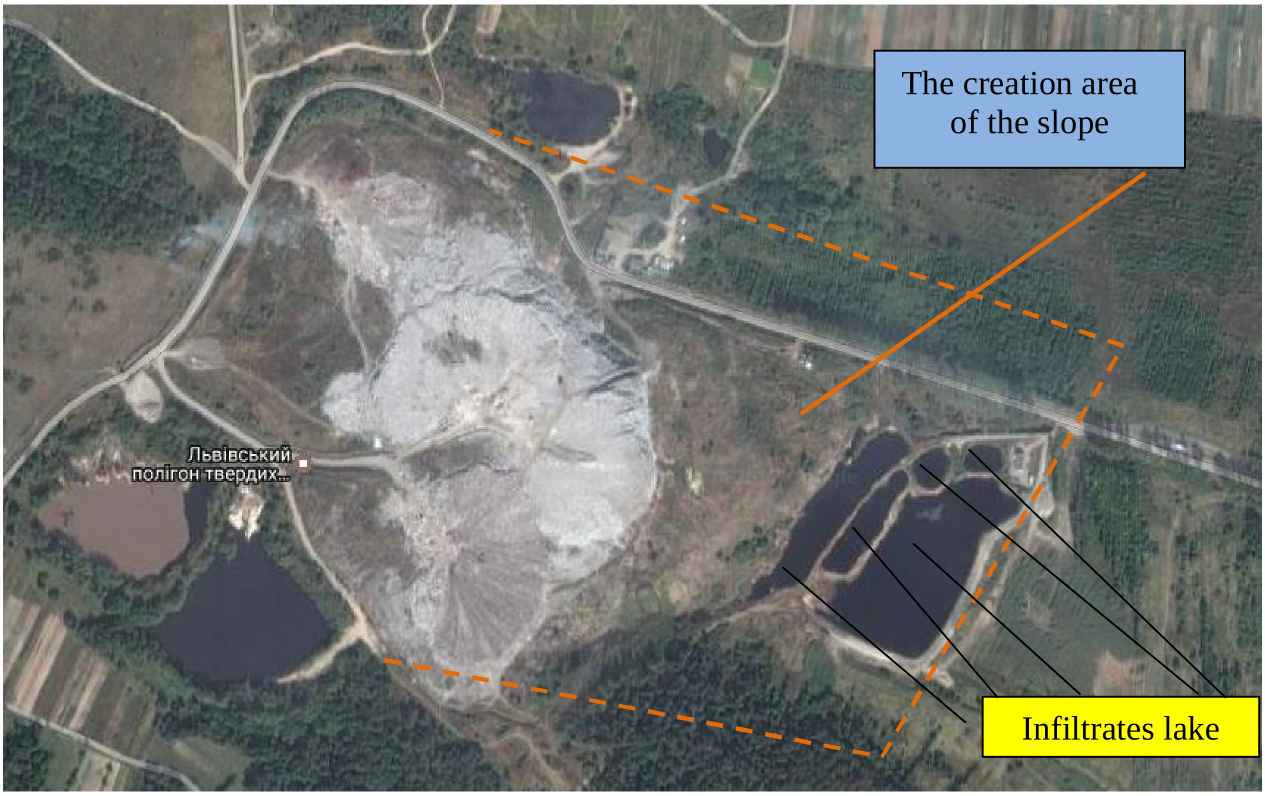

Fig. 1. Type of Hrybovytske landfill HDW from space

Tthese stages are fundamentally different in terms of infiltrates, received for processing, their physico-chemical characteristics and the time of implementation of each of the stages. In our opinion, one technology is inefficient to provide for the implementation of these two stages from a technological (the inability to ensure full loading and efficient operation of the equipment) and financial positions (significant cost overruns).

To select the optimal strategy of infiltrates cleaning we will conduct a review of known technologies for infiltration landfills treatment.

The most widely recommended in Ukraine [3] are the following technologies:

– reverse osmosis technology;
– technology of chemical and biological oxidation;
– technology of the electro-plasma purification of infiltration;
– technology of evaporation and drying;
– technology of infiltration linking;
– technology of biological treatment in anaerobic and aerobic environment.

Reverse osmosis technology is used by more than 350 landfills of the world [4]. Modern reverse osmosis systems allow achieving high purity and allocate up to 10 % of the concentrate, which must be returned into the body of the landfill. Since the cost of capital and operating costs for the treatment technology accumulated on the Grybovychi infiltrates dump is significant, the use of the device for the implementation of the tasks of stage 2 will be ineffective.

Technology of chemical and biological oxidation usually comprises the steps [4] of reagent-adsorption purification, biological treatment of oxide-anoxic ventilation unit of gravity separation of waste sludge, chemical or ultraviolet disinfection of treated effluents. The technology is not tested for the conditions of cleaning large expenditure flows of landfills infiltrates.

Technology of electro-plasma cleaning of infiltration [4] has been known since the 90-ies of the previous century, but despite the attractiveness of cost and the depth of treatment, it is not widely applied and proposals as for industrial installations of electrical plasma cleaning of infiltrates are limited.

Technology of evaporation, drying and binding of infiltration is unacceptable for such huge quantities of infiltration, in which are accumulated in storage ponds of Grybovychi landfill, that is the reason they were not considered as promising ones for the treatment of infiltrates.

The technology of anaerobic treatment of infiltration is attractive; however, for its successful industrial implementation there must be strict adherence to the parameters of the implementation, which is difficult in terms of variable qualitative composition of infiltration.

Our attention was attracted to the purification technology in an aerobic environment in the conditions of aerobic lagoon [5-7], the practice of which involves the prospects for its use as one of the stages of Grybovychi landfill infiltrates pre-treatment technology with sending them for further refining at the appropriate dilution to municipal wastewater treatment plants.

The aim of the article. Analysis of environmental risk of existing landfills (for example Grybovychi landfill) and development of strategies for its minimization with the transition to innovative technologies of solid industrial waste (SIW).

Presentation of the basic material

Thus, as shown above, the collection and purification of infiltrates is the priority problem of Gryboviychi landfill at present. Since at the stage of the landfill construction little attention was paid to the creation of a geological barrier and filtration system, the problem of groundwater contamination is significant. According to the conclusion of the city sanitary-epidemiological service, water from wells in the surrounding villages is unfit for consumption.

Inadmissibility of infiltration entering into groundwater is based on two aspects – the construction of the system of infiltrates collection and the decrease in groundwater level.

The system of collecting infiltrates from the landfill is based on the system of canals built around the landfill, where contaminated infiltrates are accumulated and wherefrom due to their own stream they come into filtration ponds. According to the project of recultivation and active degassing of Lviv solid waste landfill, carried out by LLC "Gafsa", the existing system of infiltration collection has to be improved with the construction of 15 filtration wells and system of transporting of filtrate into the storage ponds. However, this task was not completed. In our opinion, the activity, which was conducted by LLC "Gafsa" concerning the degassing of the landfill was definitely a needed and progressive step and would remain so if degassing continued until decomposition of organic waste. But, on condition of termination of degassing, the intensification of gas release in the processes of decomposition of organic part of waste (which was caused by degassing – the intensification of the reaction products withdrawal) has led to filling the porous structure of the dumps body with the combustible gases, and later, to spontaneous combustion and famous tragedy.

In the construction of filtration system an important task is to prevent mixing of atmospheric precipitation (which are conventionally clean) with infiltrates, which are formed in the body of waste as a result of anaerobic decomposition. Collection of atmospheric precipitation should be carried out with the help of bypass channels, and the possibility of partial use of existing communications should be considered. At the stage of completion of recultivation, the predicted composition of the collected in this way atmospheric precipitation will not allow to throw down such water into the water bodies without any treatment, however, after the completion of the recultivation it will significantly reduce the costs of remediation of infiltration due to the decrease in their volume.

We have conducted studies of aerobic infiltration of Hrybovychi landfill in a laboratory setting, working volume of which was 4 liters. Through the laboratory aerator to the bottom of the flask, the air was supplied with an expense of 4.2×10^{-5} м^3/p. Initial parameters of infiltration were as follows: the concentration of dissolved oxygen – (C_{DO}) – 1.87 mg/dm^3; pH – 8,64; the concentration of ammonium ions – 900 ml/l; chemical oxygen demand – 11 000 mg/L. Aeration was carried out in a continuous mode at a constant research temperature 20 °C. After a certain period of time samples were taken, in which the above mentioned parameters were determined.

Two stage of aerobic purification of infiltration were investigated: a static mode when the volume of the filtrate in the flask was not changed and a dynamic one when after some period of time a certain amount of infiltration was taken from the bulb, adding the same portion of fresh infiltration instead. At the stage of a static mode, the maximum degree of infiltration purification was set that can be achieved in the process of aerobic biological oxidation in conditions of the experiment realization. A dynamic mode modeled purification in real conditions, when aerobic lagoon is constantly supplied with new infiltration and is purified to the next stage of technology of preliminary cleaning. In the described research, infiltration was refilled and accordingly taken in amounts 250, 350, 400 and 500 ml/day.

Analysis of the results of studies of aerobic biological treatment in a static mode in an experimental plant shows that over the period of 16-day cycle it was possible to achieve the reduction of COD almost 2 times and decrease in the concentration of ammonium ions more than 3 times. Microbiological analysis defined the composition of the infiltrate, which was purified, broad range of microbiological aerobic culture, which is different from the culture of activated sludge of municipal wastewater treatment plants. Analysis of the results of studies of aerobic biological treatment in a dynamic mode indicates the optimum delay time of infiltration in aerobic lagoon for 8–10 days.

Study of the effect of infiltration on biological treatment process at the wastewater treatment facilities of the city of Lviv was conducted at the pilot installation that simulated the wastewater treatment plant. Purification of the mixture of wastewater with infiltration in continuous mode occurred in the experimental aerating installation in a plastic housing with a diameter D =1.2 m. On the bottom of the tank. a tubular aerator was installed for oxygenation and to ensure the stirring of water-sludge mixture. Air supply was carried out from the compressor station. The concentration of dissolved oxygen was maintained at the same level as in full-scale aeration tank, and monitored by a portable oxygen meter. Based on the results of the researches it was established that, on condition of dilution of infiltration of urban runoff in the ratio 1: 500 the deterioration of the quality parameters of treatment and the negative impact on the purification technology is not revealed.

In connection with no alternative condition for the treatment of Grybovychi landfill (closing and recultivation), it is necessary to develop a transition strategy and different technology of waste management. The options in the new technology are:

• a new landfill that is designed and operated in accordance with the Ukrainian norms [2] and EU directives [8] and allows to remove wastes energy in the form of biogas;

• recycling plant where the garbage that comes from the collection system passes the preliminary stage of separation, where valuable components are extracted, and then according to the designed option, is either sent for further anaerobic decomposition, or is incinerated or stored in the landfill. Another possible option is to use various methods of treatment for different waste fractions;

• incineration plant, where all the garbage that comes from the collection system, is burned and solid residue and dust, caught by the system of exhaust gasses purification is stored on the landfill appropriate to the class of hazard waste. It is worth noting that the choice of the incinerator does not exclude pre-separation and recycling of valuable waste components at the level of the collection system. Since waste undergoes thermal processing, the incineration plant by definition is the waste recycling plant as well, therefore, just this term will be used henceforth.

Regardless of the selected option, a new HDW landfill should be one of the links in recycling, where residues or the entire mass of waste without processing will be stored.

Taking into account the impact of Grybovychi landfill on the environment, as well as the resonance of the public outcry regarding this influence, an important task is to develop strategies for closure and recultivation of the landfill and turning it into an object safe for the environment. A necessary step in minimizing the environmental hazard caused by Grybovychi landfill is technical reclamation of such layers in accordance with the norms [2]:

• protective mineral layer of permeability 10–9 m/s and a layer thickness of 1 m;

• synthetic waterproofing layer with a minimum thickness of 3 mm resistant to chemical and biological aggression and to damage by rodents;

• drainage layer with thickness of 0.5 m, which is necessary for removal of atmospheric water from the surface of the landfill;

• recultivation layer of not less than 1 m thickness, which has a layer of fertile soil thickness of 30–50 cm.

It should be noted that standards for technical recultivation [2] are similar to the norms of the directive [8], except that the layer of synthetic waterproofing is not required in the EC directive, as well as the fact that the top recultivating layer fertility is not standardized in EC directive. According to [8] the geological barrier should be covered with synthetic waterproof material and a drain layer in which perforated pipes are installed to collect infiltration. According to [2] synthetic coating is not required. It should be noted that the position of the developers [2] is unclear. Synthetic material allows better protection against ingress of infiltration, formed during the anaerobic decomposition of waste, into the groundwater. But the synthetic surface is required as a protective layer for the upper floors of the landfill and it is placed at a depth of 1.5 m from the surface. Therefore, greater importance is given to protection from falling precipitation into the body of the landfill than from the ingress of toxic infiltration into the groundwater. One of the options for biological restoration is planting bushes and trees that may have roots deep down, and thereby damage the synthetic surface and reduce its efficiency.

The next step should be biological recultivation, which should be carried out based on variable ecological succession using the determined by a number of researchers [9–11] species composition and structure of phytocenosis-ameliorants.

Conclusions

It was found that landfills of Ukraine pose a significant environmental hazard in their area of influence due to the lack of a protective impervious screen of the system of collection and disposal of infiltration and landfill gas, planned system of physical and biological recultivation of filled with garbage cards, the system of collection and removal of relatively clean rainwater. The analysis of possible technologies for accumulated infiltrates treatment is made; promising applications of the technology of biological treatment of infiltrates in the aerobic lagoons are presented. It is shown that the solution to the problem of introduction of innovative technologies of solid waste management is possible only in case of comprehensive approach: creating conditions for technical and biological recultivation of existing landfills and the operation of the system of measures for prevention of environmental pollution, construction of landfills which comply with indicators of Ukrainian normative documents and EU directives, the establishment of effective recycling systems with the use of existing advanced technologies.

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