Chemical analysis of landfills leachate in the context of investigation its influence for hydrological ecosystems

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SUMMARY

The results of hydrochemical research of leachate sample from the Landfill No 5 for the municipal solid waste disposal are highlighted. It is located in Kyiv Oblast, Ukraine, approximately 11 km south of the residential and industrial development in the southern part of Kyiv City. Results are confirmed extraordinarily high toxicness of the leachate. The sample has high values of dry residue, total alkalinity, and the contents of chlorides, nitrates, and magnesium compounds. The content of chlorides exceeds the maximum allowable concentrations for surface waters more than 17 times, nitrates – more than 3 times, Mg2+ compounds – almost 2 times, dry residue – more than 21 times. Since the leachate is vastly wastewater with a high content of organic pollutants.

Keywords: landfill, leachate, hydrochemical analysis, hydrological ecosystems.
Introduction

Landfill sites and dumps for disposal of municipal solid waste (MSW) belong to environmentally hazardous facilities. Their exploitation leads to pollution of almost all components of the environment – soils, surface and underground waters, atmospheric air, vegetation, etc. (Antoshkina et al., 2003; Mor et al., 2006; Øygard and Gjengedal, 2009; Bondar et al., 2013; Azimov et al., 2019, 2020; Shevchuk et al., 2021; et al.).

Also, landfill sites and dumps are the sources of negative impact on the health of the population living in settlements situated near them. The facts of relatively higher incidence of various diseases among the local population have been revealed (Delehan-Kokaiko et al., 2020; Ojekunle et al., 2022; et al.).

Thus, the studies have documented the carcinogens in landfill leachate, for example, uranium-containing compounds (Øygard and Gjengedal, 2009; et al.). Therefore, it is currently relevant to study the ecological and geochemical state of the environmental components of the areas affected by solid waste disposal facilities.

In Ukraine, both within landfill sites and dumps, as well as in the adjacent areas, the significant technogenic changes occur in soil sediments, surface water, shallow groundwater, and also the plant communities are often radically changed (Antoshkina et al., 2003; Bondar et al., 2013; Azimov et al., 2019, 2020; Shevchuk et al., 2021; et al.). At the same time, in such territories, the physical and chemical processes of pollution of the environmental objects vital to humans have not been fully studied. Among the products that arise as a result of the operation of landfill sites and waste disposal dumps, landfill leachate is very dangerous in the geoeological context, and the study of its hydrochemical properties is the main task of this work.

Subject of research

Therefore, we will focus our main attention on the leachate of disposal sites and MSW landfills as the subject of research. The leachate is a chemically complex liquid with a pronounced unpleasant smell of biogas. It is formed from wastewater resulting from the infiltration of atmospheric precipitation into the "body" of the garbage dump itself, and then concentrates in its base. At the same time, passing through the layers of waste, the leachate is enriched with the various toxic substances included in their composition, or is saturated with their decomposition products.

Within the limits of landfills laid without following the rules of environmental protection (for example, those that do not have anti-filtration screens, leachate removal and purification systems, etc.), the leachate usually flows freely along the terrain in the direction of lowered areas, and, as a result, gets into the soil and its underlying sedimentary formations, surface waters of the hydrographic network, bottom sediments, soil water and underground ones.

Description of the study area and methods

The above is also typical for the MSW Landfill site No 5, which is located approximately 11 km south of the residential and industrial development in the southern part of Kyiv City (Figure 1). After over 36 years of the landfill activity its facilities are insufficient and for this period the body of Landfill has accumulated the leachate due to atmospheric precipitation.

Since 2006 the matter concerns the complete closure of the Landfill No 5 area due to its critical ecological conditions primarily connected with the leachate seepage into the soil and as a result the polluting environment and above all groundwater aquifers (Figure 2).

Therefore, for the purposes of the impact assessment of the leachate, which penetrates into geological surroundings from the Landfill No 5 the field surveying multiple studies have been performed in November 2018 with the following laboratorial and desk studies of sample.
The leachate sample at the volume of 1.5 l were collected in accordance with the requirements of GOST R 51592-2000 (Water..., 2000) from the main collection pond of the Landfill (Figures 3, 4). This leachate sample has black colour with strong, pungent unpleasant odour of decaying organic matter.

The ecological and geochemical study of heavy metals contents in the leachate sample is carried out using the physical-chemical methods of analyses, in particular, the mass spectroscopy with Inductive Couple Plasma (ICP-MS analysis).

Results

Table 1 shows the results of the hydrogeochemical analysis of the leachate sample. They testify that the leachate sample has high values of dry residue, total alkalinity, and the contents of chlorides, nitrates, and magnesium compounds.
Table 1 Results of chemical analysis of the leachate sample collected

<table>
<thead>
<tr>
<th>Hydrochemical indicator</th>
<th>Measurement units</th>
<th>Contents</th>
<th>MAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mg^{2+}</td>
<td>mg/dm³</td>
<td>152*</td>
<td>80</td>
</tr>
<tr>
<td>Cl⁻</td>
<td>mg/dm³</td>
<td>4260*</td>
<td>250</td>
</tr>
<tr>
<td>SO₄^{2-}</td>
<td>mg/dm³</td>
<td>480</td>
<td>500</td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>mg/dm³</td>
<td>155*</td>
<td>45</td>
</tr>
<tr>
<td>Dry residue</td>
<td>g/l</td>
<td>21.12*</td>
<td>1.0</td>
</tr>
<tr>
<td>Hardness</td>
<td>mg-eq/dm³</td>
<td>12.5*</td>
<td>7</td>
</tr>
<tr>
<td>Total alkalinity</td>
<td>mg-eq/dm³</td>
<td>235</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: * indicates the values exceeding MAC (Nikitin et al., 1990).

Thus, the content of chlorides exceeds the maximum allowable concentrations (MAC) for surface waters, according to (Nikitin et al., 1990), more than 17 times, nitrates – more than 3 times, Mg^{2+} compounds – almost 2 times, dry residue – more than 21 times. And that’s understandable. Since the leachate is vastly wastewater with a high content of organic pollutants. The latter, most likely, belong to humic and other organic acids.

Given the above, to obtain the more correct indicators of chemical composition for water of such type as sewage, which is characterized by a high content of organic pollutants, it is necessary their preliminary treatment by the special technology.

Since the dry residue of surface water samples taken at the observation site No 5 from a pond of the Landfill No 5 recorded the significant deviations in the content of some of them from the norm (Azimov et al., 2019), in the future it would also be advisable to examine the landfill leachate for such chemical elements as Mn, Ni, Ti, V, Cu, Zn.

Conclusions and prospects for the further studies

Therefore, the results of hydrogeochemical studies confirmed the extremely high toxicity of the leachate formed at the garbage sites of the Landfill No 5. The leachate sample has high dry residue, total alkalinity, contents of chlorides, nitrates, magnesium compounds.

Consequently, it is necessary to regularly carry out an appropriate analysis of the liquid that remains as a result of the processing (cleaning) of the leachate by the ROCHEM equipment and after that enters the surface waters of the environment, in particular, beyond the boundaries of the Landfill. Therefore, surface water bodies adjacent to it also need monitoring studies

Appropriate knowledge will be able to reduce socio-ecological and socio-economic risks in the case of the dangerous releases of toxicants to the hydrological ecosystems of the area.

References


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