

Monitoring of Municipal Solid Waste Landfill Impact on Environment in Poltava Region, Ukraine

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ABSTRACT

Municipal solid waste landfills are mostly bordering on rural areas and may to cause the environmental degradation. Therefore, the issue of monitoring and assessment of negative landfill impact on bordering areas, including agricultural land, is relevant. The aim of the study is monitoring and assessment of landfill impact on air pollution, soil contamination, pollutants content of leachate from landfills. Monitoring of air pollution was measured on the soil sites situated at the landfill, at the border between landfill and agricultural areas, at the distance of 200 m from the landfill. The following pollutants were investigated: CO₂, NO₂, NH₃, H₂S, C₇H₈, C₈H₁₀, dust. Monitoring of soil contamination was measured at the border between landfill and agricultural areas; at the distance of 50, 100, 200 and 500 m from the landfill. The following pollutants were investigated: Pb, Hg, Cu, Zn, petroleum products. Monitoring of leachate pollution was conducted by following pollutants: NO₂⁻, NO₃⁻, NH₄⁺, SO₄²⁻, Cl⁻, Fe, Cu, Pb, Zn, Ni, PO₄³⁻, petroleum products, surface active substance. Sampling of the leachate was carried out at the territory of the landfill. The results of our study show that 90% of studied landfills are in close proximity to agricultural land and have technogenic impact on the bordering areas. The assessment of landfill impact on atmospheric air established the exceeding of MPC of all investigated pollutants at the border between landfill and agricultural land. Exceeding of the MPC of pollutants in atmospheric air at a distance of 200 m and more have not been established. The assessment of landfill impact on soil contamination established the exceeding of MPC of heavy metals and petroleum products at the border between landfill and agricultural land and at a distance of 50 m and 100 m from landfills. Exceeding of the MPC of heavy metals and petroleum products in the soil at a distance of 200 m and more has not been established. The results of the assessment of leachate from landfill sites show the exceeding of MPC of investigated pollutants for 60% studied areas. This creates an additional chemical load on groundwater, soils and can lead to decreasing the quality of agricultural products which grown in technogenic pressured areas. Thus, our research confirmed the existence of a threat to environmental and food security on areas, bordering on the landfills.

Keywords: municipal solid waste landfills, monitoring, air pollution, soil contamination, leachate pollution, agricultural land.

INTRODUCTION

Today, the attention of all world community is focused on the sustainable development of society. According to the results of the Conference in Rio de Janeiro in 2012 year, one of the main issues of sustainable development, that require special attention, was the reduction of soil quality and fertility, changes in soil properties due to technogenic pollution [Resolution of UN, 2012].

The impact of technogenic factors on land resources leads to a violation of the natural properties of ecosystems and functions of soil restoring [Dalemo et al., 2008].

In Ukraine, landfills are mostly bordered by rural areas and may be the main cause of deteriorating ecotoxicological indexes of soil quality, surface and groundwater quality and agricultural products. Therefore, the main problem is not only landfills, as lands withdrawn from

the economic circulation of the region, but also contaminated areas around landfills. However, according to scientists [Pysarenko et al., 2021; Snitynskyi et al., 2014; Semenenko et al., 2011], the scope of pollution and damage from pollution are assessed differently.

Scientific works of Astel et al. (2011), Yermeev et al. (2015), Kumar et al. (2017), Petruk et al. (2012), Pantini et al. (2013), Fysho (2004), Nekos et al. (2014) describe the methods, principles and criteria for assessing the quality of the environment in the zone of landfill influence, assessing the impact of waste. According to this researches and Report of the International Finance Corporation (IFC, World Bank Group), the main indicators used in assessing the level of danger of landfills are engineering and technical indicators: solid waste disposal, years of exploitation, filling level and other. Some studies [Mor et al., 2016; Popovych, 2016] use indicators of chemical and toxicological analysis of landfills, but the assessment of the actual impact of landfills on rural areas, including agricultural land, is not sufficiently studied.

Therefore, the aim of this work was to conduct an environmental monitoring of landfill impact on bordering rural areas, in particular agroecosystems, taking into account the spatial distance from the source of pollution.

MATERIALS AND METHODS

One of the most important issue of reducing the negative impact of municipal solid waste landfills on rural areas and agricultural lands is the organization of competent control of landfill exploitation and environmental monitoring of landfill impact on bordering areas. The object of the study is technogenic disturbed lands under municipal solid waste landfill sites and bordering rural areas, in particular agricultural lands, in Poltava region, Ukraine. The results of these studies can be applied to any other region or area.

The aim of the study is assessment of municipal solid waste landfills impact on air pollution, soil contamination, leachate pollution from landfills.

Monitoring of air pollution was measured on the soil sites situated at the landfill; at the border between landfill and agricultural areas; at the distance of 200 m from the landfill. The following pollutants were investigated: CO₂, NO₂, NH₃,

H₂S, C₇H₈, C₈H₁₀, dust. Atmospheric air sampling and analysis was performed in accordance with RD 52.04.186-89 in five times frequency. Measurements were carried out on agricultural lands in all directions of the landfill. The highest value of measurement was taken for further research analyze. For sampling were used electroaspirator AE-1A, gas analyzers OKSI 5M-5H and DOZOR-C, Testo 405-V1, filter cartridge, a set of tips and filters, APA-10, Richter absorbers. The analysis of atmospheric air samples was carried out in accordance with methods RD 52.04.186-89, DSTU ISO 17621: 2016, MVV № 081 / 12-0161-05, in the laboratory of agroecological monitoring of Poltava State Agrarian University.

Monitoring of soil contamination was conducted at the border between landfill and agricultural areas; at the distance of 50, 100, 200 and 500 m from the landfill. The following pollutants were investigated: Pb, Hg, Cu, Zn, petroleum products. Soil sampling was performed according with DSTU 4287:2004, preparation for soil analysis – according with the requirements of DSTU ISO 11464-2007. Samples were taken in three-time frequency. Determination of Pb, Hg, Cu, Zn content of was performed by atomic absorption method using a spectrophotometer atomic absorption C-115 U according to DSTU 4770.9:2007; DSTU ISO 16772:2005; DSTU 4770.6:2007; DSTU 4770.2:2007. Determination of petroleum products content was performed according with DSTU B V.2.1-16:2009.

Monitoring of leachate pollution was conducted by following pollutants: NO₂⁻, NO₃⁻, NH₄⁺, SO₄²⁻, Cl⁻, Fe, Cu, Pb, Zn, Ni, PO₄³⁻, petroleum products, surface active substance. Sampling of the leachate was carried out at the territory of the landfill in accordance with DSTU ISO 5667-11: 2005. Determination of NO₂⁻ content was performed according with DSTU ISO 6777:2003; NO₃⁻ content – according with DSTU 4078-2001; N content – according with DSTU ISO 5664:2007; SO₄²⁻ content – MBB № 081/12-0177-05; Cl⁻ content – according with DSTU ISO 9297:2007; Pb content – according with DSTU ISO 11885:2005; Zn content – DSTU ISO 11885:2005; Fe content – according with DSTU ISO 6332:2003; Cu content – GOST 4388-72; Ni content – according with DSTU 7150:2010; PO₄³⁻ content – according with DSTU ISO 6878:2008; surface active substance content – DSTU ISO 2871-1:2015; petroleum products content – according with DSTU ISO 9377-2:2015. The analysis of soil and

leachate samples was carried out in the laboratory of agroecological monitoring of Poltava State Agrarian University. Statistical data analysis was performed by Microsoft Office Excel 2010.

RESULTS AND DISCUSSION

According to the results of technogenic pressure assessment in the Poltava region 30 biggest municipal solid waste landfills were identified, which consist 70% of all technogenic from pressure of Poltava Region. The area of one landfill is more than 2 hectares, the degree of filling is more than 50%, the volume is 2000 m³, the level of danger is estimated as extremely dangerous [Sereda 2021]. The average service time of studied landfills is 37 years (standard is 20 years), 11 landfills have been in operation for more than 40 years. 26% of studied landfills are more than 100% full (overcrowded). This all aspects create a great danger for the bordering areas.

The total amount of waste from studied landfills (from the start of their exploitation) is 8199.51 million tons. Only in 2020 year 736,895,000 tons of waste were accumulated [Ecological passport of Poltava region]. Studied landfills accept not only municipal solid waste. Most of them (67%) contain industrial waste, and 4 studied landfills contain industrial hazardous waste (more than 20% of the total amount).

The total area of the studied landfills is 171.58 ha (6 landfills have an area of more than 10 ha). These are: lands which exclude from economic circulation; objects of negative impact on the environment; contaminated agricultural lands, which lead to loss of profit in the Poltava region.

Assessment of municipal solid waste landfill sites impact on atmospheric air

Municipal solid waste landfills, which located in close proximity to agricultural land are particularly dangerous (90% of studied landfill). Research results of landfills assessment establishes that only three of the studied landfills have distance to agricultural lands more than 200 m; nine landfills have distance to agricultural lands less than 100 m; two landfills have distance to agricultural lands less than 50 m (Figure 1).

Research results of air pollution assessment at the territory of landfills show that CO value exceed MPC in 1.02–2.12 times; NO₂ value exceed MPC in 1.01–1.35 times; NH₃ value exceed MPC in 1.15–1.4 times; H₂S value exceed MPC in 2.2 times; C₇H₈ value exceed MPC in 1.7–2.05 times; C₈H₁₀ value exceed MPC in 1.05 times; dust value exceed MPC in 1.02–1.5 times (Figure 2).

Research results of air pollution assessment at the border between landfill and agricultural land show that only CO, NO₂, C₇H₈ and dust values exceed MPC in 1.0–1.1 times (Figure 2).

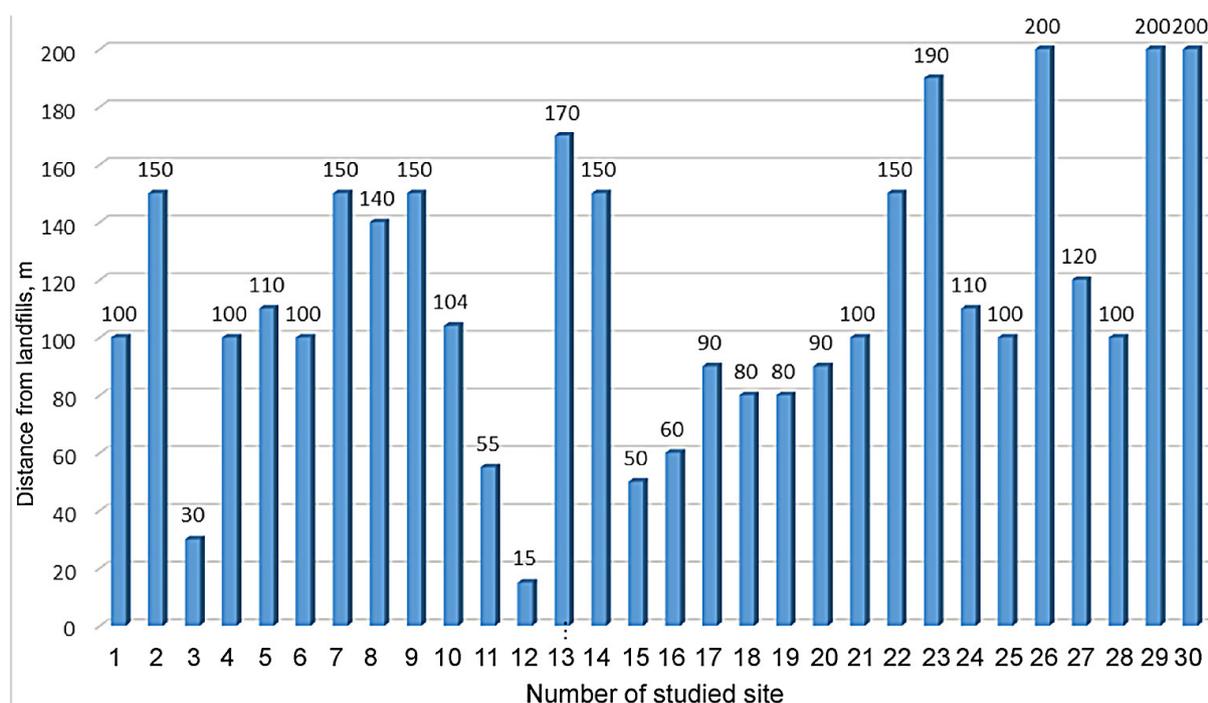


Figure 1. Distance from municipal solid waste landfills sites to agricultural land, m

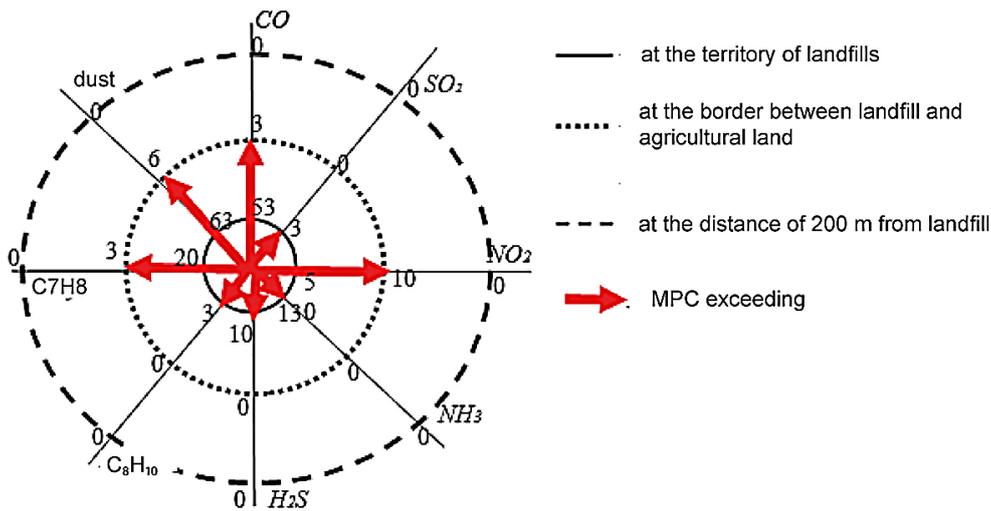


Figure 2. Amount of municipal solid waste landfills where pollutants values exceed MPC in the atmospheric air, %

Research results of air pollution assessment at the distance of 200 m from landfill show that all studied contaminants values not exceed MPC. Thus, it is confirmed that at a distance of 200 m from landfill the negative impact on atmospheric air is absent (Figure 2).

Assessment of municipal solid waste landfill sites impact on soil contamination

Research results of soil contamination by Pb on the border between landfill and agricultural land show that Pb value exceed MPC in 47% of studied landfills. For 38% of landfills Pb value exceed MPC in 1.1–1.3 times, in some landfills

Pb value exceed MPC in 3.7–5.4 times. On the distance 50 m from landfill Pb value exceed MPC in 1.1–4.3 times (13% of studied landfills). On the distance 100 m from landfill Pb value exceed MPC in 1.7–2.5 times (7% of studied landfills). On the distance 200 and 500 m from landfill Pb value not exceed MPC (Figure 3).

According to research [Sereda 2021], agricultural lands are located at a distance less than 100 m in 54% of the studied landfills, therefore soil contamination by Pb are dangerous for environment and food security of the neighboring areas.

Research results of soil contamination by Hg at the border between landfill and agricultural land show that Hg value exceed MPC in 25%

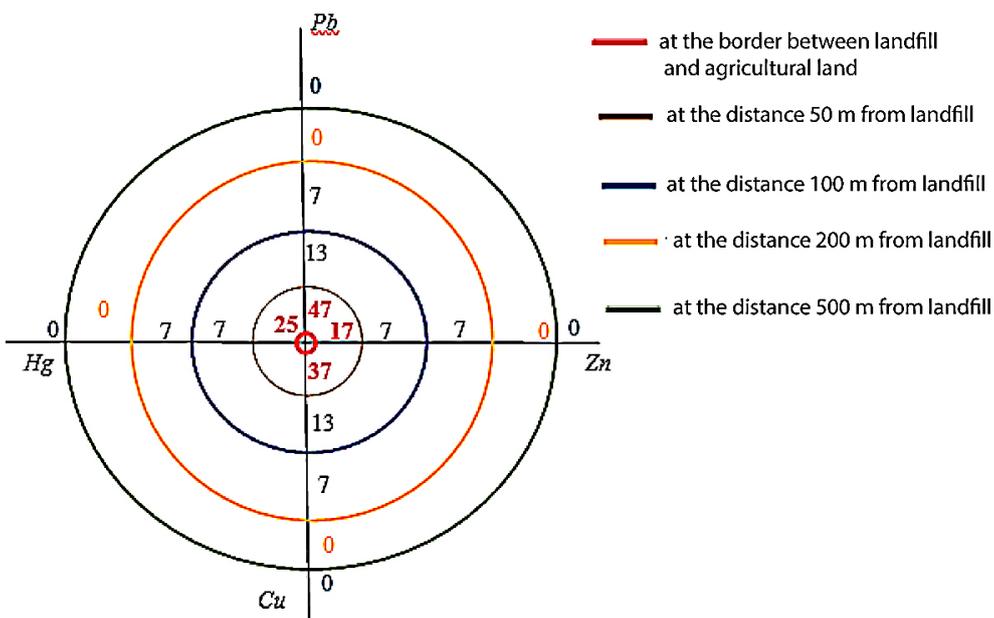


Figure 3. Amount of municipal solid waste landfills where pollutants values exceed MPC in the soil, %

of studied landfills (in 1.1–5.7 times). In some landfills Hg value exceed MPC in 4.7–5.7 times. Hg value on the 50 m and 100 m value exceed MPC in 1.7–2.3 times and 1.1–1.2 times respectively. Research results of soil contamination by Hg at the 50 m and 100 m show exceeding MPC in 7% of studied landfills. At the distance 200 and 500 m from landfill Hg value not exceed MPC (Figure 3).

Research results of soil contamination by Cu on the border between landfill and agricultural land show that Cu value exceed MPC in 37% of studied landfills. Exceeding MPC was in range 1.1–4.3 times. On the distance 50 m from landfill Cu value exceed MPC in 1.1–1.4 times which characteristically for 20% studied landfills. On the distance 100 m from landfill Cu value exceed MPC in 1.1–1.4 times (in 7% studied landfills). On the distance 200 and 500 m from landfill Cu value not exceed MPC (Figure 3).

Research results of soil contamination by Zn on the border between landfill and agricultural land show that Zn value exceed MPC in 17% of studied landfills. On the distance 50 m from landfill for 7% of landfills Zn value exceed MPC in 1.1–1.8 times. On the distance 100 m from landfill Zn value exceed MPC in 1.1–1.3 times. On the distance 200 and 500 m from landfill Zn value not exceed MPC (Figure 3).

Research results of soil contamination by petroleum products on the border between landfill and agricultural land show that petroleum

products value exceed MPC in 1.1–6.6. times for 30% of studied landfills. On the distance 50 m from landfill petroleum products value exceed MPC in 1.1–3.1 times (23% of studied landfills), on the distance 100 m – in 1.1–1.2 times (7% of studied landfills). On the distance 200 and 500 m from landfill petroleum products value not exceed MPC (Figure 3).

Thus, our research show that at a distance of 50 m and 100 m from landfills there are exceeding of pollutants MPC (heavy metals and petroleum products). This creates a threat to environmental and food security, considering close location (less than 200 m from landfills) of agricultural land to landfills in 90% of the studied areas.

Assessment of municipal solid waste landfill sites impact on leachate pollution

Research results of leachate content from 30 landfills show exceeding of NO_2^- value MPC in 1.01–3.22 times, which is typically for 30% of landfill. In 33% of studied landfill NO_3^- value exceed MPC in 1.06–1.27 times. In 50% of studied landfill NH_4 and SO_4^{2-} values exceed MPC in 1.02–3.56 and 1.02–3.56 times respectively. In 43% of studied landfill. Fe value exceed MPC in 1.36–9.12 times in 84% of studied landfill. Cu, Zn and Ni values exceed MPC in 2.06–2.77, 2.09–1.83 and 1.5–2.5 times respectively only in 7% of studied landfill. Pb and PO_4^{3-} values exceed MPC in 2.00–10.00 and 1.01–2.03 times respectively in 44% of studied landfill. Petroleum

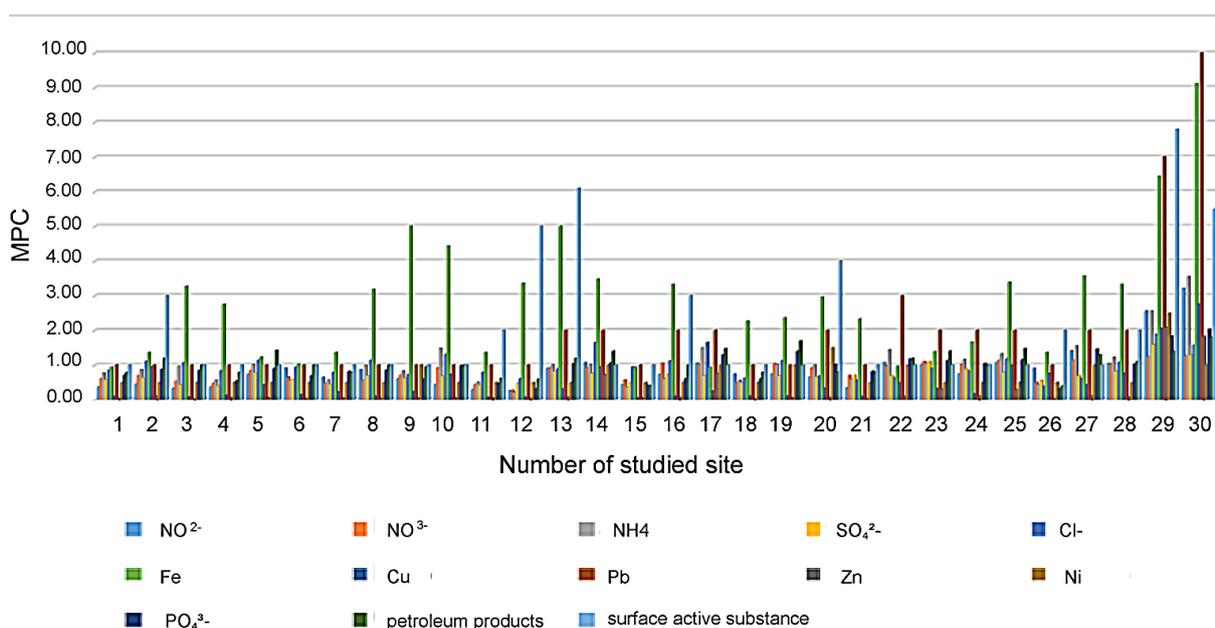


Figure 4. Content of pollutants in the leachate from municipal solid waste landfill sites, MPC

products value exceed MPC in 2.0–7.8 times in 47% of studied landfill. Surface active substance value exceed MPC in 1.1–1.8 times in 47% of studied landfill (Figure 4).

The results of the assessment of leachate from municipal solid waste landfill sites established the exceeding of MPC of investigated pollutants for 60% of the studied areas. This creates an additional chemical load on groundwater, soils and can lead to decreasing the quality of agricultural products which grown in technogenic pressured areas.

CONCLUSIONS

The results of our study show that that 90% of studied municipal solid waste landfills are in close proximity to agricultural land and have technogenic impact on the neighboring areas.

The assessment of landfill impact on atmospheric air established the exceeding of MPC of all investigated pollutants at the border between landfill and agricultural. Exceeding of the MPC of pollutants in atmospheric air at a distance of 200 m and more have not been established.

The assessment of landfill impact on soil contamination established the exceeding of MPC of heavy metals and petroleum products at the border between landfill and agricultural land and at a distance of 50 m and 100 m from landfills. Exceeding of the MPC of heavy metals and petroleum products in the soil at a distance of 200 m and more has not been established.

The results of the assessment of leachate from landfills show the exceeding of MPC of investigated pollutants for 60% of the studied areas. This creates an additional chemical load on groundwater, soils and can lead to decreasing the quality of agricultural products which grown in technogenic pressured areas.

Thus, our research confirmed the existence of a threat to environmental and food security of areas, neighboring with the landfills. The need to solve the issues of reducing the negative impact of landfills on the environment was considered. Therefore, this research results can be use during the development of the measures of decrease the negative impact of technogenic polluted lands with the aim of area restoration and turning them in economic circulation in the context of regional environmental and food security, creation sustainable agroecosystem.

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