Unauthorized landfills of the city of Tobolsk and Tobolsk district as a source of environmental pollution

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Abstract. The paper presents the results of comprehensive research of unauthorized landfills in Tobolsk district of Tyumen region, Russia. As a result of the research, fifteen unauthorized landfills of municipal solid waste (6 landfills with the total area of 1,378.33 m^2 within the city limits and 9 landfills with the total area of 4,679.64 m^2 in the district) were found. A sketch map with the landfills' coordinates was drawn up. The study was carried out to evaluate the composition and morphological structure of the MSW landfills. Heavy metals were found in the soils of the unauthorized landfills, namely zinc (11.2–54.3 mg/kg), cadmium (0.1–3.1 mg/kg), and lead (5.0–18.1 mg/kg). In terms of toxicity, these metals belong to hazard class I. Unauthorized landfills are sources of environmental pollution in urbanized areas.

1 Introduction

In the modern world one of the main problems in regard to environmental pollution is the rapid increase of unauthorized landfills, which are most often arranged in mined-out quarries, ravines, along roadsides, and the shores of rivers and lakes, which is unacceptable from the environmental point of view [1, 2]. This constitutes a violation of existing sanitary and hygienic norms and requirements. At the unauthorized landfill sites accumulation of dangerous carcinogens occurs and the anthropogenic load increases. The pollutants released at such sites affect all components of the environment. Many chemical compounds are not biodegradable and can release various hazardous substances into the environment for years. Fires are common at unauthorized landfills and they are accompanied by a release of harmful chemicals into the environment. Ignition can occur not only as a result of human actions, but also due to glass thrown into a landfill. On the sites of illegal landfills one can often find substances of hazard classes 1–4 [3, 4]. Heavy metals are considered especially hazardous. Leachate from illegal landfills can get into underground and groundwater, which is the only source of drinking water in many settlements. In this regard, the problem of lack of ecologically sound waste management in the city of Tobolsk, as well as in Russia as a whole, is very relevant.

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The study was conducted to analyze the component composition of solid municipal waste at unauthorized landfills and their impact on the environment.

An unauthorized landfill is a landfill arranged in an area not intended for waste disposal. It is created without permission from the authorities and without concluding an agreement on the transfer of garbage for storage and disposal. At unauthorized landfills wastes are disposed in the open, in bulk, in mixed form. Landfills can vary significantly in size and occupy various elements of the landscape. In most cases, unauthorized landfills are found as a result of a survey of the area [5].

As part of our study, we drove and walked through the territory of the city of Tobolsk and Tobolsk district in order to locate unauthorized landfills.

2 Material and methods

The locations of landfill sites were marked in coordinates on the map in the 2GIS geoinformation system and then recorded in the Google Earth application.

When an unauthorized landfill was detected, the site was numbered and then described as follows: a) location (coordinates); b) area; c) dimensions; d) morphological composition; e) soil sampling. Fifteen unauthorized landfills were found, which were located near roadsides, rivers, undulating areas, and wastelands. Most of the landfills exist for several years, as garbage stays in these places for a long time without removal and the amount of waste there only grows over time.

Soil sampling and sample preparation for quantitative chemical analysis were carried out according to [6,7,8]. Fifteen integrated samples were collected. The five-point sampling method (also known as the “envelope method”) was used in soil studies. Each soil sample represented a portion of soil typical of the soil horizons and land plots under study. The points should be arranged so that if connected by straight lines they would form the pattern of a sealed envelope (the length of the square side can range from 2 to 5-10 m).

Humus horizon samples were taken from a depth of about 20 cm (spitter). Each sample 1 kg in weight was packed and signed.

Quantitative chemical analysis was performed using the inductively coupled plasma method with the atomic emission spectrometer OPTIMA 7000 DV by PerkinElmer (USA).

The morphological composition of waste in unauthorized landfills was determined according to International Standard ISO 10390:2007 and GOST 26488-85. The following components were identified: food waste; waste paper (including cardboard); metal; glass; rubber and leather; plastics; textiles; wood; construction waste, etc.

3 Results

The result of the study was the identification of unauthorized landfills in the city of Tobolsk and Tobolsk district of Tyumen region, Russia.

We investigated landfills located in residential development areas, as well as cottage building co-operatives and garage co-operatives, which have been used by the population for many years for solid municipal waste disposal. These landfills have not been eliminated for many years and have been increasing every year. Such sites of unauthorized landfills are poorly studied, especially from the point of view of their impact on the components of the environment.

The first three sites are located along roadsides near the village of Vesnina. Landfills numbered four and five are located near roadsides in the village of Sokolovka. Sites six and seven were found near a dirt road in the Mendeleevo microdistrict. The eighth fly dumping site is located in Priirtyshsky settlement. The ninth site is located in Zhukovka microdistrict

near a ruined 2-storey building. The tenth unauthorized landfill is located along a side of the road leading to the Ceramic Wall Materials Plant, opposite the Michurinets gardening community. The eleventh site is located near a roadside 1.5 km away from a waste sorting plant. The landfill site number twelve is located in a garage co-operative, next to the Yermak shopping mall. Plot thirteen was found in the village of Durynina, along the Irtysh River. Illegal landfill site fourteen is located to the left of the Palace of Sports "Krystall", along a garage co-operative.

The fifteenth unauthorized landfill site is located near a roadside, in the foothill part of the city. When unauthorized landfills were detected, the area and perimeter of the sites were determined, the coordinates were marked (Fig. 1).

Fig. 1. Map - scheme of the studied plots

The largest in area and perimeter is the third plot (3,049.57 m², 418.75 m). The smallest one is plot seven (65.24 m², 29.68 m). In terms of total volume, the studied unauthorized landfill sites can be arranged in the following order: 7 < 15 < 2 < 6 < 10 < 5 < 11 < 4 < 13 < 1 < 9 < 8 < 14 < 12 < 3.

The study revealed that six unauthorized landfills are located within the city limits (sites 6, 7, 9, 12, 14, 15). Their total area is 1,378.33 m^2. Nine landfills with the total area of 4,679.64 m^2 were found in Tobolsk district (sites 1, 2, 3, 4, 5, 8, 10, 11, 13) (Table 1).

Table 1. Dimensions and coordinates of the study area

Plots	The area of the object, m²	Perimeter, m	Coordinates
1	308.66	125.67	N 58.3055273 E 68.1913788
2	94.65	41.39	N 58.3028813 E 68.1889568
3	3049.57	418.75	N 58.3010292 E 68.1999127
4	180.87	60.01	N 58.232623 E 68.3484061
5	159.18	47.88	N 58.2503925 E 68.3741879
6	148.69	49.22	N 58.2970797 E 68.3391317

7	65.24	29.68	N 58.2893522 E 68.3391317
8	326.2	96.07	N 58.1634521 E 68.3344996
9	312.38	68.75	N 58.1864710 E 68.2947614
10	156.04	49.21	N 58.1944211 E 68.3351688
11	166.56	63.66	N 58.1870113 E 68.3977506
12	454.73	89.79	N 58.2236087 E 68.2658099
13	267.91	77.04	N 58.3379091 E 68.3094851
14	330.37	75.79	N 58.2265319 E 68.2634581
15	66.98	32.11	N 58.1701391 E 68.2666551

In the course of the study the morphological composition of solid municipal waste in the unauthorized landfills was determined. The following components were identified: food waste; waste paper (including cardboard); metal; glass; rubber and leather; plastics; textiles; wood; construction waste.

Construction waste accounted for the main percentage of the composition of fly dumping landfills. For example, at site eleven it accounted for 33%, which is the maximum value for this component for all of the studied sites.

Construction waste consists of brick rubble, concrete mortar, expanded clay, and material debris.

The major items of wood waste in the studied sites were logs, bark, trimcuts. The maximum amount of wood was found at site eight (36%) and the minimum amount was at site three (7%). At the remaining sites, the wood waste portion in the overall composition ranged from 11% to 35% (Fig. 2).

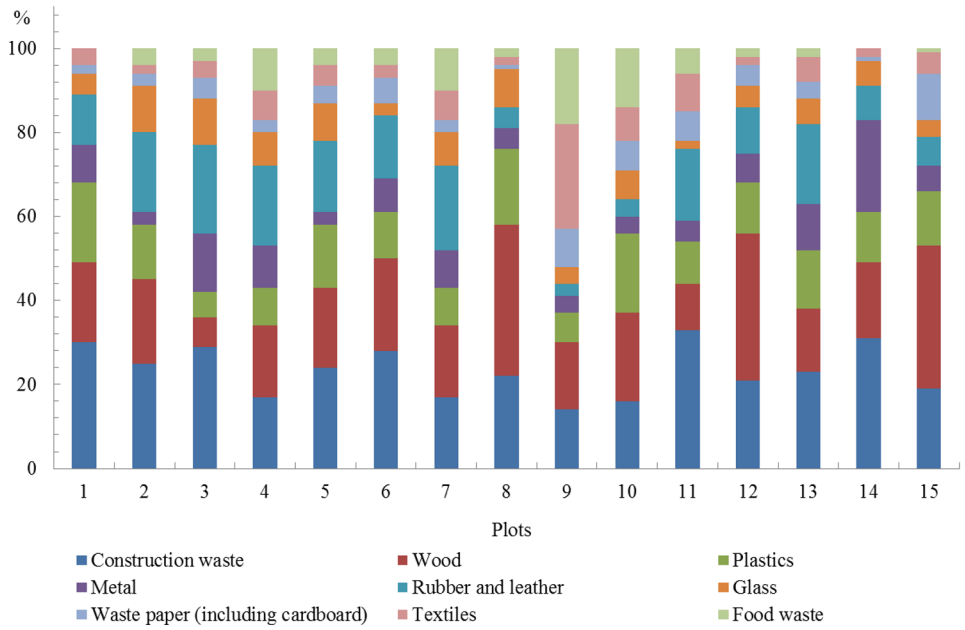

Fig. 2. Morphological composition of solid municipal waste in the unauthorized landfills, %

The most common material in the studied unauthorized landfill sites was plastic. Most of the plastic products found are disposable dishes, canisters, bottles, bags, etc. The largest amount of plastic waste was recorded at sites one and ten (19%). The least amount of this waste was found at site three.

Tin cans, metal lids, old buckets, nails, pieces of pipes and reinforcement bars were also found in the landfills. The greatest amount of this type of waste was found at the fourteenth site (22%), and the least amount of this type of waste was found at the second and fifth sites (3%).

High environmental hazard on the landfills is represented by worn-out car tires, which have toxic properties. The highest amount of rubber tires was found at the third site (21%), the minimum amount – at the ninth site (3%.) At the other sites the rubber waste content ranged from 4% to 20%.

The passive waste storage sites contained glass waste (bottles, cans, broken window panes). The maximum amount of this sort of waste was found at sites two and three (11%).

Waste paper and textile waste constitute a small proportion of waste.

The state of the environment is the most important factor determining the standard of living of the population.

One of the main and important criteria of change in the natural environment is its pollution by various carcinogens. Heavy metals can be singled out from the huge list of carcinogens. Heavy metals are chemical elements with high toxicity affecting the vital activity of all organisms.

Illegal landfills are a source of accumulation and spread of heavy metals into the environment and soil.

Landfills polluting large areas with waste have a negative impact on soils and groundwater. During heavy gusts of wind, garbage litters the adjacent areas with plastic bags, waste paper and other waste.

During the survey conducted, soil samples were taken to analyze for heavy metal accumulation. Fifteen integrated samples were taken. We tested the soil for the presence of zinc, cadmium, and lead. These carcinogens pollute the environment to the greatest extent, thus posing a serious hazard in terms of their biological activity and toxic properties (Fig. 3).

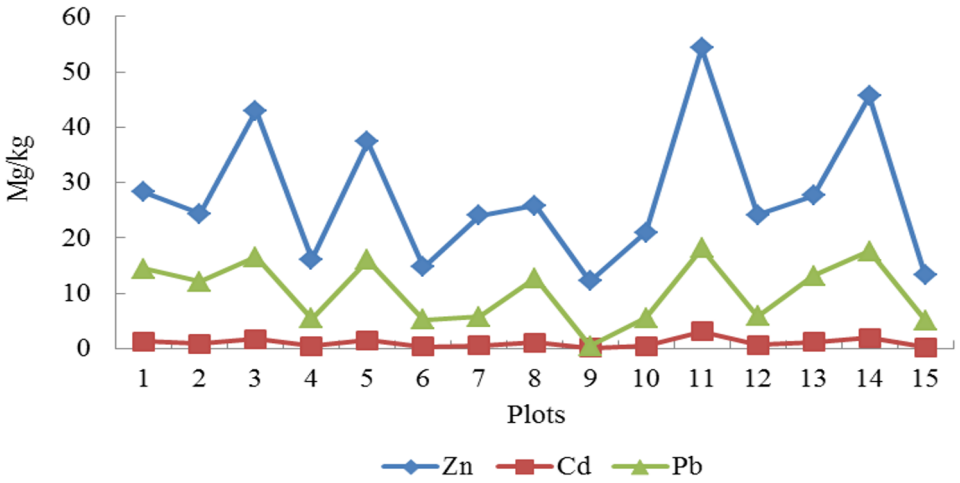

Fig. 3. Accumulation of heavy metals, mg/kg

The maximum concentration of these metals was observed at site 11: Zn – 54.3, Pb – 18.1, Cd – 3.1 mg/kg, presumably this is due to the fact that these elements are contained in construction waste, waste related to motor transport, electric cables, lead-coated glass,

waste paper and plastic products. The lowest concentration of heavy metals was found at landfill 9: Zn – 11.2, Pb – 5.0, Cd – 0.1 mg/kg.

Zinc accumulates in the soil of the studied sites in the following order: 15 (13.3) > 6 (14.7) > 4 (16.1) > 10 (21.0) > 7 (24.0) > 12 (24.2) >2 (24.4) > 8 (25.8 mg/kg) > 13 (27.7) >1 (28.3) > 5 (37.4) > 3 (43.0) >14 (45.6) mg/kg. The characteristic zinc-containing component in fly dumpings are zinc-coated household items that are easily corroded, as well as food waste, construction waste, waste related to motor transport, and waste from machinery or aircraft devices.

Cadmium was found in the soils at all of the studied unauthorized landfill sites of the city of Tobolsk and Tobolsk district.

The maximum concentration of cadmium was found at site 11 (3.1 mg/kg). The minimum accumulation of cadmium (0.1 mg/kg) was found at the ninth site.

The amount of Cd in soil at the other sites varied insignificantly from 0.2 to 1.9 mg/kg. Probably, this carcinogen enters the environment during incineration and recycling of materials containing it (plastics and construction waste), which were used in the production of varnishes, enamels and ceramics.

Recently, soil contamination with lead has been rare. Like many other heavy metals, lead can be found in the component composition of waste disposed at unauthorized landfills.

At the studied sites, typical waste are electric cables, lead-coated glass shards and waste paper (books, magazines, newspapers are printed using typographical equipment containing lead). According to the analysis, a high concentration of Pb in soil was observed at site 11 (18.1 mg/kg). The minimum value was found at site 9 (5.0 mg/kg). The concentration of Pb in soil at the rest of the sites varies from 5.1 to 17.6 mg/kg.

Thus, based on the conducted studies, it can be concluded that the content of heavy metals in the soil of unauthorized landfills does not exceed the maximum permissible concentrations of Zn and Pb, except for the eleventh site, where the concentration of Cd was 1.5 times higher than the maximum permissible value.

4 Discussion

The increase of unauthorized landfills is one of the environmental problems of our time. Illegal landfills negatively affect the environment. The presence of organic waste leads to the formation of breeding grounds for rodents, insects, which worsens the epidemiological situation in cities and districts [9, 10].

The greatest danger is posed by unauthorized landfills placed in the floodplains of rivers and on their banks. Rain and melt water carry pollutants and toxic compounds directly into streams and river beds. According to literature data, in places of unauthorized garbage storage in rural areas open combustion sources become the cause of forest fires.Many researchers have noted that unauthorized landfills can ignite spontaneously. Burning waste release harmful substances into the air [11, 12].

In our studies, a large amount of waste comes from construction waste.With prolonged decomposition of this composition, Zn and Cd enter the soil. The EC of plastic destruction is formed in the soil Cd. Pb enters the soil during the decomposition of electrical cables, lead glass and crystal, and waste paper (printing metal containing lead).

5 Conclusion

As a result of the research, fifteen unauthorized landfills of solid municipal waste (6 landfills with the total area of 1,378.33 m^2 within the city limits and 9 landfills with the

total area of 4,679.64 m^2 in the district) were found. A sketch map with the landfills' coordinates was drawn up.

A study was carried out to evaluate the composition and morphological structure of the MSW landfills. The main waste components of the landfills were: construction waste (14 to 33%), metal (3 to 22%), waste paper (1 to 11%), wood (7 to 36%), rubber (3 to 21%), textiles (2 to 25%), plastic (6 to 19%), glass (2 to 11%), food waste (1 to 18%).

Heavy metals (zinc, cadmium, lead) were found in the soils of the unauthorized landfills. In terms of toxicity, these metals belong to hazard class I. As a result of the study, it is possible to range the elements of heavy metals accumulated in descending order of their concentrations in soils (Zn > Pb > Cd). Based on the conducted study, it can be noted that in the soil of the sites, heavy metals ranged as follows: Zn 11.2–54.3, Pb 5.0–18.1, Cd 0.1–3.1 mg/kg.

The conducted studies show that unauthorized landfill sites are sources of environmental pollution. In order to solve the problem and reduce the growth of unauthorized landfills, the liquidation procedure can be used, as well as involvement of public utilities, the administration and volunteer community.

References

1. P. Ranta, J. Kesulahti, A. Tanskanen, V. Viljanen, T. Virtanen, Urban Ecosystems, **118 (2),** 341-354, (2014)
2. L. Kullman, Journal of Ecology, **86(2),** 421-428 (1998)
3. Decree of the Government of the Russian Federation of September 28, 2015 No. 1029 "On approval of the criteria for classifying objects that have a negative impact on the environment, to objects of categories I, II, III and IV" (Russian Newspaper Pub., Moscow, 2015)
4. V. N. Lyubomirova, Comprehensive assessment of the environmental hazard of unauthorized landfills in rural areas of the Ulyanovsk region (USTU, Ulyanovsk, 2013)
5. F. Aloulou, M. Kallell, H. Belayouni, Environmental Forensics**, 12(3),** 290–299 (2011)
6. Sanitary Rules and Regulations 42-128-4433-87
7. Maximum allowable concentrations of chemicals in the soil, list 4, of 30.04.82 # 2546- 82
8. E. V. Arinushkina, Guidance on chemical analysis of soils (MSU, Moscow, 1970)
9. Federal Law of January 10, 2002 No. 7-FZ "On Environmental Protection" (Russian Newspaper Pub., Moscow, 2002)
10. K. Staab, F.A. Yannelli, M. Lang and J. Kollmann, Ecological Engineering **84**, 104-112) (2015)
11. D. Jewitt, P. S. Goodman, B. F. N. Erasmus, T. G. O'Connor, T. F. Witkowski, Environmental Management, **59 (5),** 792-806 (2017)
12. M. Jaźwa, W. Heise, B. Klimek, S. Factors Bulletin of Environmental Contamination and Toxicology **97 (4),** 554-560 (2016)