POLLUTION

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CONTENT OF HEAVY METALS IN SOILS UNDER THE INFLUENCE OF UNAUTHORIZED DUMPS IN SURGUT

Research article

Abstract

The article examines the influence of unauthorized dumps on the accumulation of heavy metals (lead, copper, zinc, cadmium, chromium) in the soil in Surgut. We analyzed the soils in the areas affected by unauthorized dumps and adjacent areas with the same vegetation and soil cover that are not affected by dumps. A total of 12 sites are examined, of which 6 are contaminated and 6 are control sites. It has been established that the soil cover effected by dumps accumulates heavy metals, in concentrations exceeding the maximum allowable concentration by several times.

Keywords: soil, heavy metals, urban pollution, unauthorized dumps.

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СОДЕРЖАНИЕ ТЯЖЕЛЫХ МЕТАЛЛОВ В ПОЧВАХ ПОД ВЛИЯНИЕМ НЕСАНКЦИОНИРОВАННЫХ СВАЛОК В Г. СУРГУТЕ

Научная статья

Аннотация

В статье рассматривается влияние несанкционированных свалок на накопление тяжелых металлов (свинца, меди, цинка, кадмия, хрома) в почве города Сургута. Анализировались почвы участков, находящихся под воздействием несанкционированных свалок и соседние участки, с тем же растительным и почвенным покровом, не подверженные влиянию свалок. Всего исследовано 12 участков, из них 6 – загрязненные и 6 контрольные. Установлено, что почвенный покров под влиянием свалок накапливает тяжелые металлы, в концентрациях превышающих предельно допустимые в несколько раз.

Ключевые слова: почва, тяжелые металлы, загрязнение городов, несанкционированные свалки.

1. Introduction

Heavy metals are one of the main soil pollutants, both in the city and in the areas adjacent to the city. The routes of entry of heavy metals into the soil can be of a different nature, both natural - weathering of bedrocks, and technogenic - landfills of municipal solid waste (MSW), atmospheric emissions from industrial enterprises, exhaust gases from vehicles, etc.

Besides the known permanent sources of pollution by the heavy metals, which are recorded as a result of environmental monitoring, uncontrolled sources of pollution – the unauthorized solid waste dumps do cause concerns. Such dumps are formed in residential, recreational (forest, water protection, park) areas of the city, where the impact of contaminated soils on humans cannot be not excluded and the risk of contamination of adjacent environment cannot be avoided [1, P. 119]. The unauthorized dumps introduce heavy metals into the city soil and thus change ecological and geochemical environment in the local zones, which can be variously used by the local citizens [1, P. 119].

The content of one or another heavy metal at the background level is optimal. However, it should be noted that this background level of heavy metals in soils is very different in different regions [2, P. 550]. Different soils have different buffering and inactivation levels for heavy metals, therefore, in addition to the maximum allowable concentration (MAC), an indicator of the approximate allowable concentration (AAC) was introduced, taking into account the granulometric

composition of the soil and the acidity of the environment [3, P.6]. Heavy metals content at a level below the MAC (AAC) is considered safe, at a level above the MAC (AAC) it may become limiting [4, P. 8].

The purpose of this research was to evaluate the degree of the influence of the heavy metals acid-soluble forms in the soils, which are found under unauthorized dumps in Surgut.

2. Materials and methods

In the territory of Surgut as a result the route inspection of park, forest areas, territories near dacha communities 6 sites with unauthorized dumps are discovered of various areas and time of appearance. A survey of the vegetation was carried out and soil samples were taken from the sites. To compare the degree of negative impact of the dumps on the soil, territories adjacent to the dumps with the same type of vegetation and soil type were also surveyed (Figure 1). Dump sites (1, 3, 5, 7, 9) are located in urban natural forests in the northeastern and eastern parts of the city, and border an industrial zone, garages and highways. Site №11 is located on a disturbed herb meadow on the outskirts of dacha communities in the northern part of the city.

In all 12 Sites the soil samples were taken in accordance with GOST 17.4.3.01-83 and 17.4.4.02-84 from a depth of 5-20 cm by the envelope method, 4-5 samples from each site. Total 48 samples were taken, of which mixed samples were prepared (12 samples).

The heavy metals mass concentration (Cu, Pb, Zn, Cr, Cd) was measured by atomic-absorption method with the electrothermal atomization with the use of an atomic-absorption spectrometer of the modification of MGA-915 MD and they were carried out on the base of the Surgut State University Center for Collective Use. Nitric acid solution with a molar concentration of 5 mol/dm^3 was used according to PND F 52.18.191-89 to extract acid-soluble forms of copper, lead, zinc, chromium, and cadmium into the solution. Statistical processing of the results was carried out using the Microsoft Excel program.

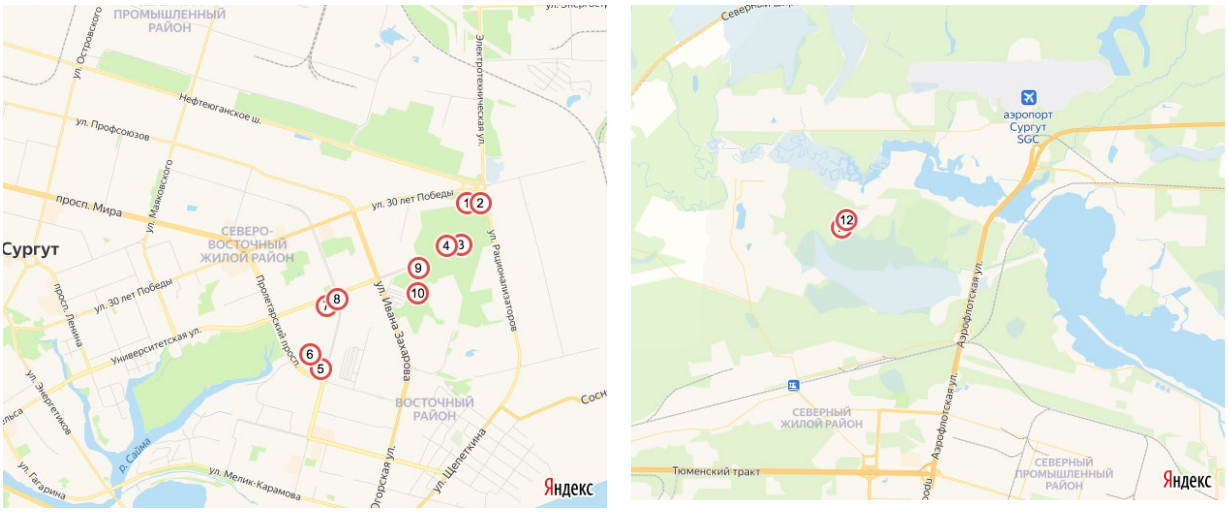

Figure 1 – Schematic map of the surveyed area in Surgut, Khanty-Mansiysk Autonomous Okrug-Yugra: Points 1, 3, 5, 7, 9, 11are the areas with unauthorized dumps, 2, 4, 6, 8, 10, 12 are the neighboring areas, without direct impact of the dumps (Source: Yandex Maps)

3. Results

The surveys revealed big differences in the content of heavy metals in the soils between the sites; this differences are very significant for some metals.

Copper. The approximate allowable concentration of copper in the soil is 33.00 mg/kg [3, P.6]. The analysis of heavy metals in the six background samples did not reveal any excess of acceptable values.

Three of the six sites studied from contaminated areas showed excess concentrations of copper. In the sample of Site №1, the copper content exceeded the AAC by 5.9 times and amounted to 194.91mg/kg (Figure 2). Analysis of the soil of Site №9 revealed an excess of AAC 4.7 times and amounted to 157.05 mg/kg. Copper concentration was so great in the soils of Site №3, that the given quantity it did not enter into the range of the measurement of atomic-absorption spectrometer and it was impossible to determine its actual value.

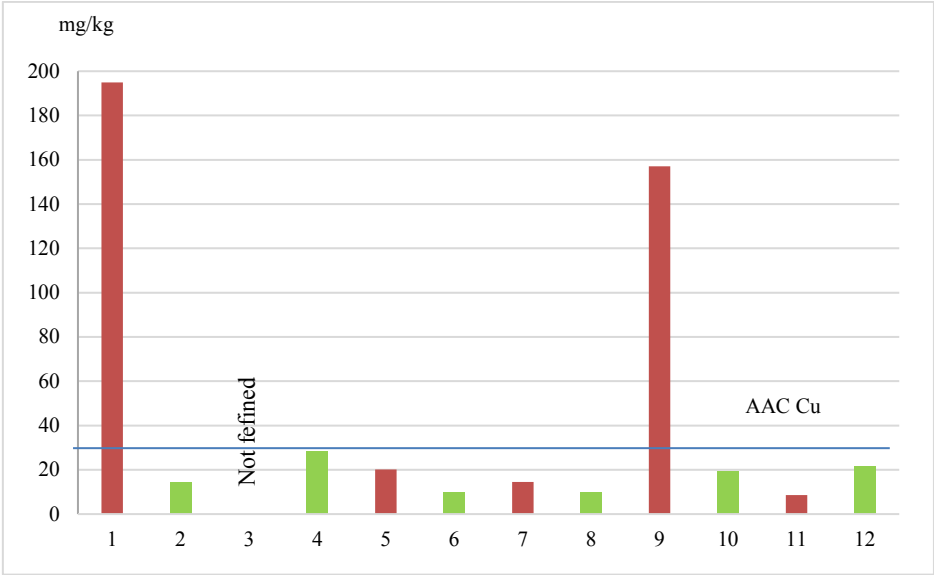

Figure 2 – Gross content of Cu in the soils, contaminated by the unauthorized dumps (Sites 1, 3, 5, 7, 9, 11) and the soils are not impacted by dumps (Sites 2, 4, 6, 8, 10, 12), the line indicates MAC in the soil for Cu. Cu concentration for Site №3 is not defined

Lead. According to hygienic standards, AAC of Pb in soil should not exceed 32 mg/kg [3, P.7]. The content of lead in the soils under unauthorized dumps in samples 1, 2, 3, 7, 9, and 10 exceeded several times the approximate allowable concentration for this element (Figure 3).

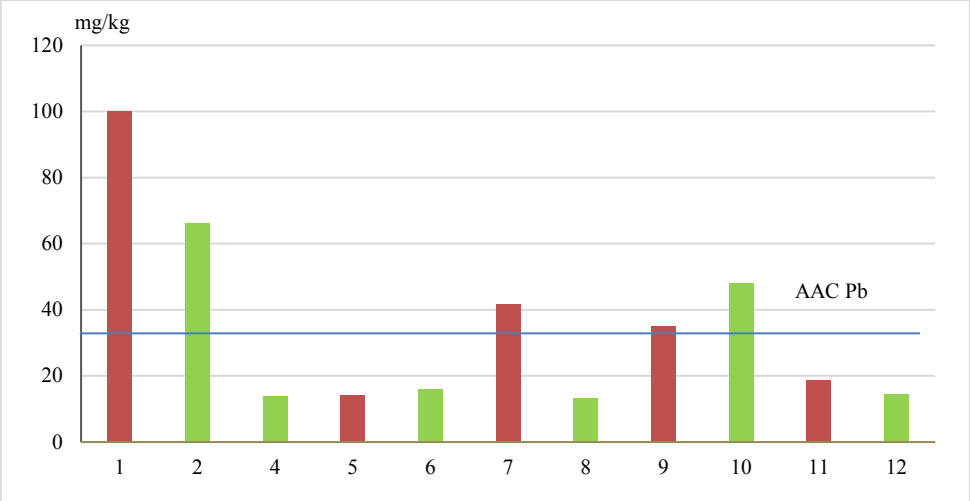

Figure 3 – Gross content of Pb in soils contaminated by unauthorized dumps (Sites 1, 5, 7, 9, 11) and the soils are not impacted by dumps (Sites 2, 4, 6, 8, 10, 12). Pb concentration for Site №3 is shown in Figure 5

Particularly high concentrations exceeding the critical level of contamination are observed in Site №3 (1861.14 ± 521.12 mg/kg), exceeding the AAC by more than 58 times (Figure 5).

Evaluating the results, two background areas were identified that are susceptible to the negative impact of unauthorized dumps, even being sufficiently distant from them. One of them – Site № 2 -– 66.20 ± 18.54 mg/kg. Although this background sample showed a lower lead concentration than in the comparable sample No. 1, the result still exceeded MAC. This is probably due to the fact that Site №2 is located lower in relief to Site №1, and there is a transfer of pollutants along with the surface water flow. The second background sample No. 10 with lead concentration of 47.91 ± 13.42 mg/kg. The content of the same element in the area of the unauthorized dump No. 9 is very close to the values found at Site №10 and amounts to 32.63 ± 9.14 mg/kg. Regarding the results of these two sites, the negative impact of lead from the adjacent territory of the unauthorized dump can be traced and the obtained data from the "clean" Site №10 cannot be regarded as the background measurement. Further investigation and expansion of the border of the contaminated Site №9 is required. For the rest of the samples, lead concentration corresponds to the regional background content and does not exceed AAC.

Zinc. According to morphological properties, all 12 soil samples are classified as loams. According to the established hygienic standards, the approximate allowable concentration (AAC) in loamy soils is 110 mg/kg [3, P.7]. The results of the investigated samples show that the concentration of zinc in eleven samples does not exceed the indicated level of AAC (Figure 4). Sample from Site №3 is the only sample that exceeded the concentration by 11 times. The zinc content in it was 1294.75 ± 362.53 mg/kg (Figure 5).

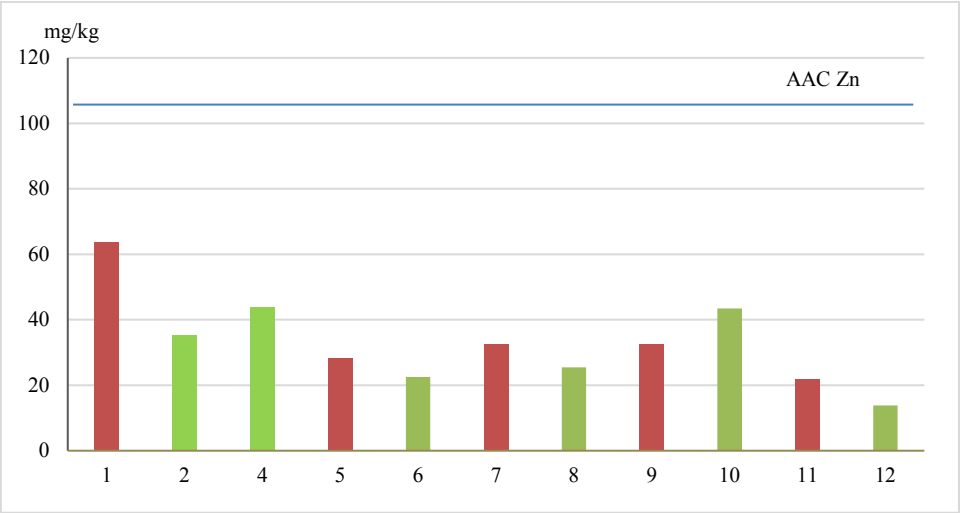

Figure 4 – Gross content of Zn in the soils contaminated by unauthorized dumps (Sites 1, 5, 7, 9, 11) and the soils are not impacted by dumps (Sites 2, 4, 6, 8, 10, 12). Zn concentration for Site №3 is shown in Figure 5

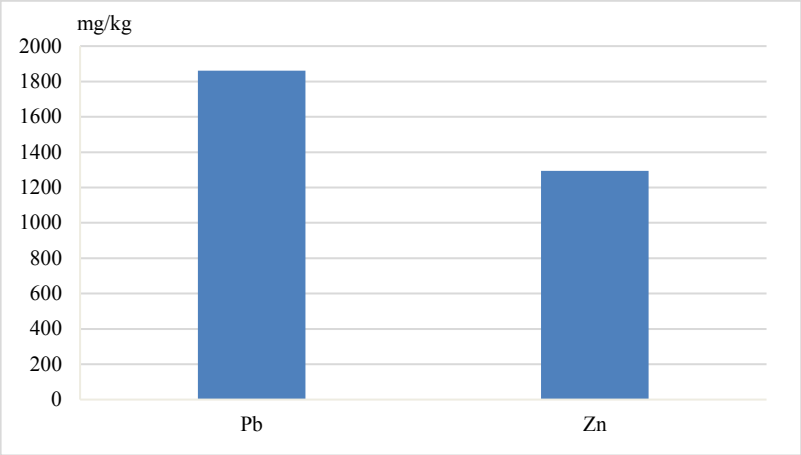

Figure 5 – Content of Pb and Zn in the soil on Site №3 impacted by an unauthorized dump

Chromium. There are many methods and regulations to evaluate the geochemical state of the soil cover. Employment of established MAC to evaluate chromium pollution, in our opinion, can be criticized [5, P. 23] as there is some inconsistency between the background content of this element and its MAC. Therefore, most often the maximum allowed concentration of chromium is considered as 100 mg/kg [6 P.34, 7 P. 9].

As a result of the survey, it was found that all the soil samples have a chromium concentration lower than MAC. It should be noted that chromium content ranges from 3.6 to 11.7 mg/kg for 10 samples. At the background of Site №8, there is an increase in chromium concentration up to 39.46±11.05 mg/kg (Figure 6). According to the graph, sample 11 from the area of an unauthorized dump, an increase in chromium to 43.61±12.21 mg/kg is also traced; however these results fall into MAC.

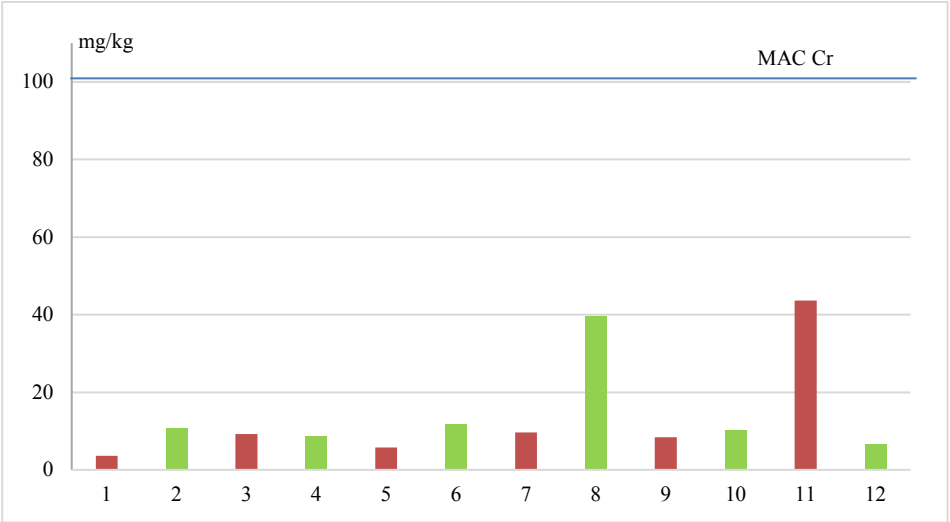

Figure 6 – Gross content of Cr in soils contaminated by unauthorized dumps (Sites 1, 3, 5, 7, 9, 11) and the soils are not impacted by dumps (Sites 2, 4, 6, 8, 10, 12). The line indicates the maximum concentration limit in soil for Cr

Cadmium. The main sources of environmental pollution with cadmium are: metallurgy, combustion of solid and liquid fuels, motor vehicles.

The approximate allowable concentration of cadmium in soils, taking into account the background, is 1 mg/kg [3, P. 6]. In eight samples out of twelve, cadmium concentration did not exceed the AAC level. The content of this element ranges from 0.21 to 0.93 mg/kg.

In samples 3, 5, 11, which were taken at the dump sites, there is an increase in cadmium concentrations by more than 2 times. The highest concentration of cadmium was observed in the third Site – 3.27±0.92 mg/kg (Figure 7). This is due to the presence of household and construction waste Dump №3 on the territory as well as polymer waste with traces of thermal decomposition.

Analysis of cadmium showed a high content of the element in sample №2, which appears in the study as a background territory. Concentration of cadmium at this Site is 1.95 mg/kg, which is an excess of the AAC. This is due to the location of the selected Site. It is located at the intersection of the main highways of the city's microdistrict - ul. 30 let Pobedy and ul. Ratsionalizatorov. Accumulation of passenger and cargo vehicles on the roads impacts the adjacent area and the selected Site cannot be considered as a background for cadmium comparison.

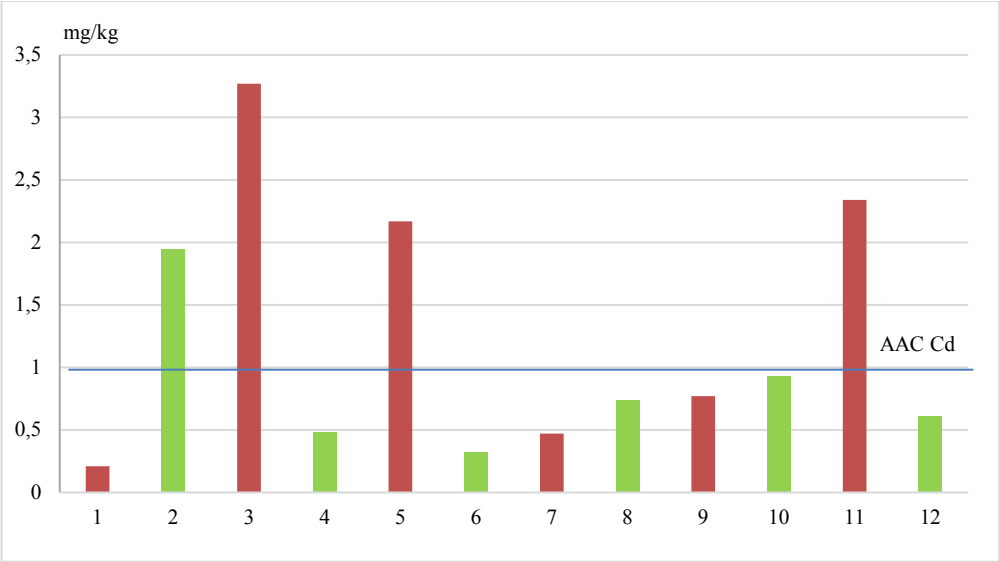

Figure 7 – Gross content of Cd in soils contaminated by unauthorized dumps (Sites 1, 3, 5, 7, 9, 11) and the soils are not impacted by dumps (Sites 2, 4, 6, 8, 10, 12). The line indicates MAC in soil for Cd

4. Conclusion

Thus, the analysis of the heavy metals content in the soils of six unauthorized dumps revealed a significant deviations in concentrations of Cu, Pb, Zn, Cd from MAC. Possibly, the excess of the MAC in the samples is due to the fact that all the sites are located in the old areas of the city next to garage buildings and private housing.

There is a significant increase in the content of copper, lead, and zinc in the sample taken from Dump №3, located in the eastern part of the city. This is due to the composition of the solid waste in this Dump. There is wood, plastic, construction materials, metal constructions and the spare part of automobiles, flammable liquids and oils, which wash the means and other unidentified substances.

The only element that did not exceed the MAC level is chromium.

It is safe to say that unauthorized dumps that are found in Surgut pollute the soil with heavy metals. Analysis of the soil control samples taken near the dumps showed that there is also an excess of heavy metals, albeit with their lower concentration. However, even very small quantities of lead, copper, zinc, cadmium and chromium can do harm to the environment and to living organisms inhabiting the area.

Conflict of Interest

None declared.

Конфликт интересов

Не указан.

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