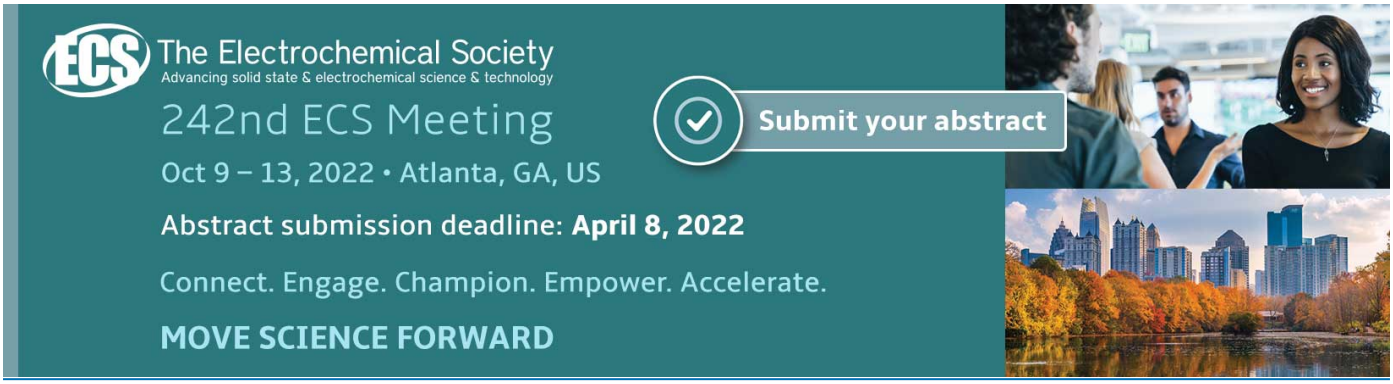
Urban soils: the results of the study of the territory of the city of Ekaterinburg



Urban soils: the results of the study of the territory of the city of Ekaterinburg

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Abstract. In this article, we will consider the interesting, in our opinion, presented data of practitioners and scientists in terms of studying the formation and composition of urban soils, which is the most objective and stable indicator of man-made pollution, it clearly reflects the spread of pollutants and their actual distribution in the components of the urban environment. In this article, we have only shown the results of the analysis of the soils of g .For the period of the last 10 years, it is possible that for conclusions about the impact of the existing situation of the city territory on the entire environment, a more complete study of not only the chemical composition of soils, but also the impact of the economic mechanism of land management on the state of the city is necessary, the authors have not yet set themselves such a task.

1. Introduction

In the introduction, we will present a brief overview of the opinions of scientists on this topic.

We fully agree with the statement of N. A. Bogdanov that identifying trends in the spatial and temporal variability of the state of the habitat for assessing the quality of life, including in the ecological aspect, is one of the fundamental tasks of the earth sciences (Fig.1) [1].

Figure 1. Fragments of urban soil pollutants.

Unlike water and atmospheric air, which are only migration media, soil is the most objective and stable indicator of man-made pollution, it clearly reflects the distribution of pollutants and their actual distribution in the environmental components of the urban area.

The largest industrial cities, forming vast zones of pollution, are gradually turning into continuous man-made territories that pose a serious danger to the health of the population living on them.

The State report "On the state and environmental protection of the Sverdlovsk Region in 2020" correctly indicates that a special place among the manifestations of anthropogenic impact on the soils of megacities belongs to the pollution of the urban territory with heavy metals, since rapid self-purification of soils from metal pollution to the required level corresponding to hygienic and environmental safety is difficult.

Soil scientists claim that the soil cover plays an important role in the biosphere. He, like the World Ocean , is the purifier (purifier) of the planet [2-4,8]. In the soil, the destruction of many is completed organic and organomineral compounds. The soil is a receiver of various waste products of the economy and vital activity. Due to the high concentration of life in the soils, this property is manifested to dispose of, decompose what living organisms leave behind [3-5].

It is known that the soil also performs important ecological functions: by regulating the flow of moisture and matter, it protects other components of nature from pollution, the soil protected by plants extinguishes water and wind erosion, regulating the ratio between surface and underground moisture outflow, it forms river runoff, ensuring, in particular, the life of rivers in the summer dry period.

The main result of the development of the urbanization process is a significant alienation of productive land for buildings and industrial facilities, while the area of such land is increasing everywhere.

2. Basic provisions and methods

In our work, we want to present the opinions of scientists about the influence of soil composition on the state of the city's environment.

According to S. A. Gerasimova, in the process of urbanization, an urban ecosystem is formed, understood as a natural-urban system consisting of fragments of natural ecosystems surrounded by houses, industrial zones, highways, etc. The urban ecosystem is characterized by the artificial creation of new types of systems as a result of degradation, destruction and (or) replacement of natural systems [6-8].

Currently, for many large cities of the world, it is established that heavy metals enter the soil mainly from the air. On the territory of cities, the greatest attention is attracted by pollution with such elements as Pb, As, Cu, Zn, Cd, Ni [7].

Numerous studies of urban ecosystems show that the soils of the city differ significantly from their natural counterparts in physical and chemical parameters.

The main difference between urban and natural soils is the presence of a diagnostic horizon called "urban". This is a surface bulk, mixed horizon, part of a cultural layer with a thickness of more than 50 cm, with an admixture-more than 5% - of anthropogenic inclusions (construction and household garbage, industrial waste). In addition, soil - like technogenic surface formations-urban technozems-are formed on the territory of cities. They are artificially created by enriching with a fertile layer or a peat-compost mixture of bulk or other fresh soils of soils.

Intensive human activity within large cities leads to a significant and often irreversible change in the surrounding natural environment: the relief and hydrographic network undergo changes, natural vegetation is replaced by phytocenoses created by man, a specific type of urban microclimate is formed due to an increase in the area of development and artificial coverings, the soil cover is destroyed or greatly changes.

Thus, considering the soil as a component of urban ecosystems, it should be emphasized that, due to its physico-chemical properties, the soil accumulates various toxic compounds, thereby becoming one of the most important biogeochemical barriers for most toxicants on the way of their migration from the city atmosphere to ground and surface waters [3,6,7].

This is one of the most important ecological functions of urban soils. Since in most of the urbanized territories the anthropogenic impact prevails over the natural factors of soil formation, in cities we have

specific types of soils, the characteristic feature of which is a high level of pollution. With the maximum manifestation of chemical pollution processes, the soil completely loses its ability to productivity and biological self-purification, which leads to a violation of its ecological functions [2,3].

The soil has the greatest information content and attractiveness when studying various ecosystems, including those formed under conditions of deep anthropogenesis. Systematic monitoring of the soil condition, migration and accumulation of various chemical elements and compounds in it is the most important component of general environmental monitoring in urbanized territories [3,4,7].

3. Results, discussion of the study

The city of Yekaterinburg (Fig.2) is located in the central part of the Eurasian continent, on the border of Europe and Asia, in the middle part of the Ural Ridge, at 56 ° 51’ north latitude, 60 ° 36 ' east longitude.

The city is located on the eastern slope of the Ural Mountains, in the floodplain of the Iset River (a tributary of the Tobol).

Figure 2. Ekaterinburg: top view.

The formation of a network of permanent soil pollution monitoring points in the cities of the Sverdlovsk region began in 1989 in Yekaterinburg (Fig. 3). Currently, the soil pollution monitoring network includes 23 cities on the territory of the Sverdlovsk region. Surveys of 2-5 cities are conducted every year. Every 5 years, repeated observation is carried out at the same reference points.

Soil contamination is monitored by 11 parameters (heavy metals, nitrates, etc.), the soil reaction (pH, KCl) and mechanical composition are determined. Currently, two forms of heavy metals (acid-soluble and mobile) are determined in soil samples. Point samples are taken at the test site from one or more layers or horizons by the envelope method, diagonally or by any other method, so that each sample represents a part of the soil typical of the genetic horizons or layers of this type of soil. Soil samples were taken with a special soil drill from a depth of up to 25 cm, i.e. the root layer. The combined sample is made by mixing 20-40 point samples.

The selection of point soil samples during our studies was carried out radially (8 points), located relative to the source of contamination at distances from 0.1 to 10.0 km. The layout of the monitoring sampling points in Yekaterinburg is shown in Fig. 3.

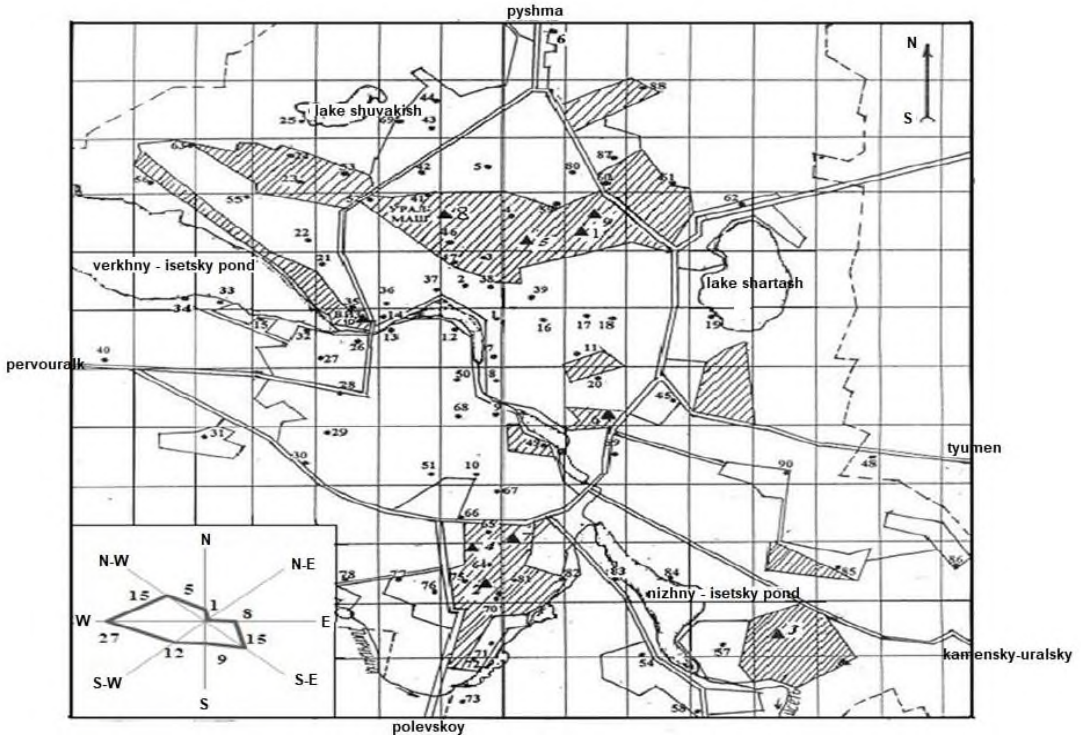

Figure 3. The layout of monitoring points for soil sampling in Yekaterinburg.

The main criterion for the hygienic assessment of soil contamination with chemicals is the maximum permissible concentration or approximately permissible concentration of chemicals in the soil. Priority when choosing observation points for soil contamination with heavy metals is given to areas with the presence of enterprises of non-ferrous and ferrous metallurgy, energy, mechanical engineering and metalworking, fuel and energy, chemical and petrochemical industries, enterprises for the production of building materials, the construction industry.

In Yekaterinburg, natural soils have been preserved only in forest parks, some gardens and on the outskirts. But they also bear traces of human influence: their upper horizons are compacted, the reaction is acidic, they are enriched with nitrogen, phosphorus, potassium and some trace elements, but are poor in humus. More than half of the city's area is occupied by so-called bulk, or displaced, soils. They are very dense and heavy, they are characterized by low fertility. All the soils of the city need proper treatment and fertilization.

We present in the article the results of the analysis of the soil pollution index for 7 districts of Yekaterinburg in the period of 10 years (2010 and 2020) for the analysis of the state of the soil layer of the city as a whole. The territory of Yekaterinburg is divided into 7 administrative-territorial units — districts. These are Verkh-Isetsky, Zheleznodorozhny, Kirovsky, Leninsky, Oktyabrsky, Ordzhonikidzevsky and Chkalovsky (Fig. 4). Their location slightly resembles the sectors of the circle, while the historical center of the city is distributed among all districts except Chkalovsky and Ordzhonikidzevsky.

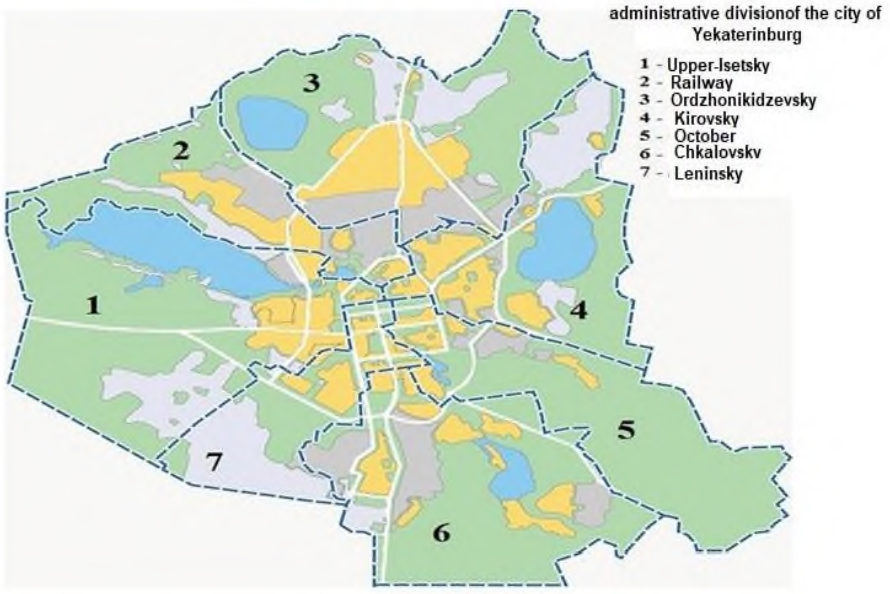

Figure 4. Administrative division of the city of Yekaterinburg.

During the reporting period, the monitoring group of technogenic soil pollution in Yekaterinburg selected and analyzed 90 samples (mixed samples) for the determination of heavy metals. The number of samples and their distribution by administrative districts of Yekaterinburg are presented in Table 1.

Table 1. Distribution of samples in the administrative districts of Yekaterinburg.

№	Administrative districts	Number of samples (average samples) by district
1	Railway	13
2	October	8
3	Upper-Isetsky	16
4	Ordzhonikidzevsky	17
5	Chkalovsky	20
6	Kirovsky	7
7	Leninsky	9

According to the results of the analysis of the study data in 2010, the total index of soil pollution with heavy metals in the city as a whole was 11.0, which corresponds to the permissible category of pollution. The average pH value for the regions ranged from 6.53 to 6.84, which corresponds to close to neutral, neutral soils. The greatest contribution to the pollution of the soils of Yekaterinburg of acid-soluble forms of heavy metals was made by: chromium, lead, nickel, zinc, copper (Table 2).

According to the results of data analysis in 2020, the total index of soil pollution with heavy metals in the city as a whole was 7.6, which corresponds to the permissible category of pollution. The average pH value for the regions ranged from 6.20 to 6.81, which corresponds to close to neutral, neutral soils. The greatest contribution to the pollution of the soils of Yekaterinburg of acid-soluble forms of heavy metals was made by: chromium, lead, nickel, cobalt, cadmium.

Table 2. Single indices of soil contamination with heavy metals for 2010.

Administrative districts	Single indices of soil pollution by heavy metals (Ksi)									
	Cr	Pb	Mn	Ni	Zn	Cu	Co	Cd	Fe	Hg
Railway	3.4	4.8	0.7	7.2	2.2	1.7	1.3	0.9	1.2	1.1
October	3.4	1.8	0.6	5.8	1.9	1.5	1.3	1.0	1.2	1.2
Upper-Isetsky	2.1	3.2	0.8	4.2	2.4	1.7	1.1	0.9	1.3	2.6
Ordzhonikidzevsky	2.8	2.8	0.8	4.3	2.4	4.8	1.1	1.0	1.2	3.4
Chkalovsky	2.8	2.3	0.8	4.6	2.1	2.3	1.2	0.9	1.2	1.1
Kirovsky	3.7	1.9	0.7	6.1	2.3	1.5	1.5	0.9	1.3	2.0
Leninsky	2.8	2.0	0.7	5.0	2.1	1.4	1.2	1.1	1.3	1.9

Table 3. Single indices of soil pollution with heavy metals for 2020.

Administrative districts	Single indices of soil pollution by heavy metals (Ksi)									
	Cr	Pb	Mn	Ni	Zn	Cu	Co	Cd	Fe	Hg
Railway	1.8	2.3	0.9	4.5	1.5	1.4	1.4	1.6	0.9	0.9
October	2.0	2.3	0.8	5.5	1.3	2.1	1.5	1.5	1.0	0.5
Upper-Isetsky	1.5	3.3	0.9	3.0	1.3	1.3	1.2	1.9	1.0	0.8
Ordzhonikidzevsky	1.7	2.6	1.0	4.5	1.7	1.9	1.3	1.5	0.9	1.1
Chkalovsky	1.5	2.4	1.0	4.9	1.6	1.6	1.6	1.9	0.9	0.9
Kirovsky	1.5	2.6	0.9	4.4	0.9	1.7	1.4	2.3	0.9	0.8
Leninsky	2.0	2.1	0.9	3.3	1.5	1.2	1.3	1.6	0.9	0.6

4. Conclusion

According to the results of the analysis of all data for 2010 and 2020, the total index of soil pollution with heavy metals in the city has decreased by 2.1 times by 2020.

In 2020, almost all districts have the lowest total pollution index, compared to previous surveys.

Making a conclusion, it is worth noting the positive dynamics in the total index of soil pollution in Yekaterinburg (Fig.5).

The survey of urban lands in the monitoring observation system is necessary for the timely identification, assessment and forecast of changes in the state of the soil cover under the influence of anthropogenic influences and the development of recommendations for the prevention and elimination of the consequences of negative processes and for providing information activities for the maintenance of the real estate cadastre, the implementation of state land supervision/CONTROL over the use and protection of land.

It should be added that based on the results of the assessment of the level of chemical and biological contamination of soils and soils of the city, recommendations are being developed for the use or movement of soils and soils for the sections of the surveyed territory, depending on the type of their functional purpose and use.

It should also be noted that anthropogenic impact becomes the predominant factor of soil formation in cities. As a result, specific types of soils and soil - like bodies are formed-urban soils.

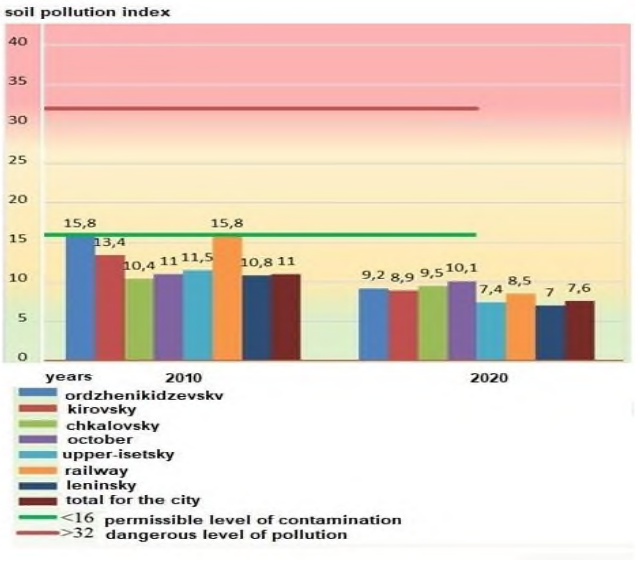

Figure 5. Total indices of soil pollution in Yekaterinburg by districts for the studied years.

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