Heavy metals content in the soil cover and woody plants of Krasnoyarsk

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Abstract. The paper describes that in the soil and leaves of Populus balsamifera, Ulmus pumila on the studied zones of the city of Krasnoyarsk revealed: lead, cadmium, zinc, copper, cobalt, nickel, chromium. Soil pollution due to the accumulation of heavy metals directly affects the biogeochemical composition, urban vegetation. There was a high level of accumulation of lead and cadmium Ulmus pumila and Populus balsamifera. Soil pollution in the recreational zones of Krasnoyarsk is increased due to the intensive transport load in the city. Therefore, it is advisable to carry out special measures near recreational areas to reduce the man-made load on the soil.

1 Introduction

As a result of urbanization, intensive pollution of the natural environment occurs, due to the operation of industrial, transport, and thermal power facilities [1, 2, 3].

Heavy metals accumulate in natural environments (atmosphere, water, soil) and vegetation. Elements such as lead, manganese, zinc, nickel, chromium, cadmium, copper are particularly dangerous [4, 5, 6].

Most heavy metals have high bioavailability, therefore, in small quantities they exhibit toxic effects on living organisms [7, 8, 9]. Heavy metal pollution affects various components of the ecosystem, especially soil, plants [10, 11, 12].

The objective of the present research was to study the accumulation of heavy metals in the soil, trees in Krasnoyarsk.

2 Materials and methods

The study objects are soil, balsamic poplar (Populus balsamifera), squat elm (Ulmus pumila). These types of plants are the most common, found in most squares, parks, streets and courtyards, sanitary protection zones of industrial facilities in Krasnoyarsk grow [13, 14].

Sampling was carried out in September 2019.

Study sites for the selection of plant and soil samples in Krasnoyarsk:

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1 – Udachny (control). Suburban zone in the Oktyabrsky district of Krasnoyarsk on the left bank of the Yenisei River, remote from pollution sources at a distance of more than 50 km, and least exposed to anthropogenic influence;

2 – Central Park. Located in the Central district of Krasnoyarsk. A place for recreation of citizens, characterized by a high pedestrian and traffic load;

3 – Troy Park. Located in the Oktyabrsky district of Krasnoyarsk, located next to the shopping district, characterized by an intense pedestrian load, proximity to the city street;

4 – Vetluzhanka microdistrict. Located in the western part of the Oktyabrsky district of Krasnoyarsk, Relatively ecologically safe area with the absence of large enterprises and with an average road load;

5 – Red Square. Transport hub in the Zheleznodorozhny district of Krasnoyarsk (Figure 1).

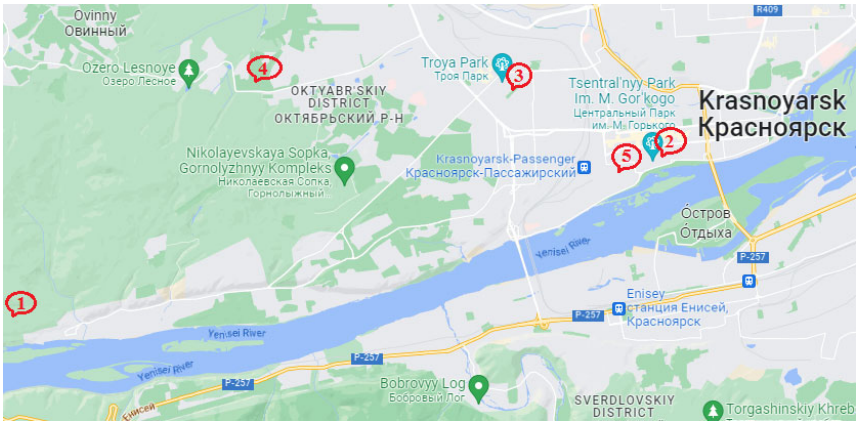

Fig. 1. Map of soil and plant sampling sites in the city of Krasnoyarsk.

Soil samples at each site were taken in accordance with the requirements of GOST 17.4.4.02-84 in a five-fold repetition. A sample of plant samples was 100 leaves at each point from trees of the same age. Poplar and elm leaves were washed with water-flowing water from settled suspended solids and dried at 105 temperature. The concentration of metals (mg/kg) was determined for air-dry mass by the atomic absorption method on the PinAAcle 900T analyzer at the Research Center of the Krasnoyarsk State Agrarian University.

3 Results and discussion

The studied heavy metals were detected in all soil samples. The maximum content of metals in the soil is established in the transport zone - Red Square (5). The content of lead in the soil exceeded the maximum permissible concentration (MPC) [15] in gross form by 50% and in mobile form by 4 times in the area of Red Square - 3 times in Central Park and by 70% in Troy Park. The concentration of cadmium in the soil exceeded the MPC of the mobile form by 38% in the area of Red Square.

The biogeochemical activity of *Ulmus pumila* ranged from 0.33 to 0.77, the highest values at the sites under the influence of vehicles (Table 1).

For *Populus balsamifera*, higher values of biogeochemical activity were revealed, which ranged from 0.44 to 1.44, in areas where group plantations of the studied species are located (Table 2).

Table 1. Biological absorption coefficient (BAC), biogeochemical activity (BCA) of *Ulmus pumila* growing in Krasnoyarsk.

Index	Chemical element	Study area				
		1	2	3	4	5
BAC	Pb	0.02	0.04	0.10	0.09	0.03
	Cd	0.15	0.55	0.34	0.20	0.24
	Zn	0.02	0.02	0.04	0.10	0.02
	Cu	0.001	0.001	0.02	0.05	0.04
	Co	0.04	0.03	0.04	0.02	0.04
	Ni	0.00	0.03	0.03	0.02	0.07
	Cr	0.03	0.01	0.02	0.02	0.02
BCA		0.34	0.33	0.77	0. 66	0.55

The values of biogeochemical activity for the study sites are arranged in the following sequence for Ulmus pumila: Udachny (1) < Vetluzhanka (4) < Troy Park (3) < Red Square (5) < Central Park (2); for *Populus balsamifera*: Udachny (1) < Red Square (5) < Central Park (2) < Troy Park (3) < Vetluzhanka (4).

Among the elements such as cadmium and lead, *Ulmus pumila* and *Poplus balsamifera* have the highest bioabsorption coefficient. According to the biological absorption intensity of lead and cadmium, it can be divided into low and medium absorption elements (BAC =0.1-1), zinc, copper, cobalt, nickel, chromium – low absorption elements (BAC =0.01-0.1) [16].

Table 2. Biological absorption coefficient (BAC), biogeochemical activity (BCA) of *Populus balsamifera* growing in Krasnoyarsk.

Index	Chemical element	Study area				
		1	2	3	4	5
BAC	Pb	0.03	0.08	0.15	0.14	0.04
	Cd	0.22	0.86	0.90	1.02	0.32
	Zn	0.03	0.02	0.05	0.10	0.02
	Cu	0.001	0.01	0.02	0.05	0.06
	Co	0.05	0.04	0.04	0.02	0.04
	Ni	0.001	0.03	0.04	0.01	0.08
	Cr	0.03	0.01	0.02	0.02	0.03
BCA		0.44	1.12	1.30	1.44	0.78

Heavy metal pollution of recreational areas of the city is due to high traffic load. According to a number of researchers [17, 18], roadside dust and soils, as well as plant leaves contain ions of such metals as barium, lead, aluminum, iron, zinc, manganese, strontium. Due to the small size, the heavy metal particles have been found to have high adhesion.

Through roadside dust, soil, plants, particles, entering the human body, contribute to the development of cancer [19].

Among the representatives of wood species we studied (elm and poplar), the most widely used in landscaping in Krasnoyarsk, is the accumulation of the most toxic heavy metals - cadmium and lead.

4 Conclusion

The accumulation of heavy metals in wood species depends on the biological characteristics of the species and the content of heavy metals in the soil. Under the technical load, brown algae can accumulate high concentrations of zinc, and cadmium is the concentrator of these metals.

In order to effectively recover heavy metals from the biogeochemical cycle, it is suggested to establish a community composed of mixed tree species under urban conditions to prevent secondary pollution of heavy metals, and remove deciduous substances during active defoliation.

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