Estimation of ecological state of national parks in megalopolises (by the example of Losiny Ostrov park, Moscow, Russia)

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Abstract. This paper examines the issues of environmental conditions of a national park in a metropolitan city. The main sources of environmental pollution have been identified. Geochemical state of the environment components has been determined. Main sources of man-induced load, which enable making decisions on this territory further development, have been established.

1 Introduction

Recently, a human has laid the newest ways of moving matter and energy in the geographic environment, occasionally, significantly violating the ecological balance [1]. One of the effective forms of nature protection activity is the formation of a special form of protected natural areas, such as national parks [2]. Annually, the number of public organizations increases and the main direction of their activities is environmental protection. Many of them focus their efforts on the development and improvement of regional systems, particularly, protected natural areas as fairly effective and simplest activities that ensure the genuine preservation of more valuable natural sites and maintenance of the required level of biological diversity in the region. Very often in the course of this work, there is a need to assign specific natural objects possessing exceptional value with the highest - federal status [3]. At the same time, national parks are using particular prominence at the regional level among the federal especially protected natural areas.

The authors studied the papers published [4-10] and conducted an analytical generalization of these materials.

2 Study subject

Environmental condition within the territory of Losiny Ostrov National Park is determined by the long-term influence on its components of the facilities of transport highways, agriculture, industrial production and the constant load associated with the use of the park as a mass leisure venue. The level of man-induced load on different parts of its territory is

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established by their position in relation to various structural elements of the capital [11].

The area of this park within the city limits, exposed by the main man-induced load, exceeds 3 thousand hectares. In the south and westLosinyOstrov borders on industrial zones and residential areas of such municipal districts as: Golyanovo, Bogorodsky, Preobrazhensky, Alekseevsky, Rostokinsky, Yaroslavsky. Two-thirds of this park is located outside the Moscow Ring Road (MKAD), which crosses it from the south-east to the north-west. Two highways go on its borders in the north, west and south: Kaliningrad, Yaroslavl and Shchelkovskoe Highways. In the eastern part, in the 1930s, the Eastern Water-Supply Canal was laid, which supplies Moscow with drinking water from the Uchi and Pirogov reservoirs. A sanitary restricted zone is stretched along the canal. Enterprises and residential areas of Mytishchi and Korolyov are adjacent to the forest park in the north-east and north.

3 Study results and their discussion

The main sources of atmospheric emissions in the industrial zones that adjoin the Moscow part of the park are 6 organizations (Table 1), among them CHPP (combined heat and power plant)-23 prevails.

Table 1. Characteristics of emissions from industrial organizations that are located in the protected zone of Losiny Ostrov National Park (NP).

Enterprise	Hazardous substances		Main hazardous gaseous substances	Composition of dust emissions
	Gaseous ones, t/year	Solid ones, t/year		
CHPP-23	32570	55	Nitrogen oxides, sulfurous anhydride	Sooty and ash particles
Krasny Bogatyr	769	19	nitrogen compounds, carbon monoxide, sulfurous anhydride, organic compounds, including benzene	Dust of soot, barite, sulfur, talc, chalk and other substances that are used as pigments, additives, fillers and raw materials
Vulkan	108	2	Organic compounds, sulfurous anhydride	
Petroleum- and oil plant	97	0.009	Nitrogen compounds, organic compounds	Lead compounds
Asphalt concrete plant (ACP)	100	335	Nitrogen compounds, organic compounds, sulfurous anhydride	Dust of mineral powder, crushed stone, sand
Woodworking integrated plant	80	15	The same	Wood dust

According to the information from the Scientific Research Laboratory of LosinyOstrov State National Natural Park, the maximum dust load, which was recorded as per the snow cover, falls within the south-western part of the park, which includes residential and industrial areas of Sokolniki, Babushkinsky and Central districts of the capital.

Zone of the greatest dust fall, with a value exceeding 160 kg/km2 per day, runs in the north-west direction for a distance over 5 km with a width of up to 2 km and is probably connected with emissions into the atmosphere of solid waste by the Concrete products plant No. 18 and CHPP-23. The smallest centers of dust precipitation in the south of this park are

associated with WIP (woodworking integrated plant)-19, the abrasive plant and the plant of radio engineering products KrasnyBogatyr. The main territory of the park is classified as slightly dusty areas, where the average daily dust fall does not exceed 160 kg/km² per day. This can be explained by the availability of large coniferous plantations, which detain dust on their crowns, and also by the dominance of the winds of the south-east, south and eastern points in February-March, which direct the main emission plume to the north-west and north. A large range of microelements is accumulated in a solid suspension of snow almost throughout the entire territory. The main field of abnormal concentrations can be characterized by a total pollution index (TPI) equal to 40-80, which is consistent with urban areas and corresponds to a very low contamination [12]. There are six polyelement anomalies with the same set of accumulating elements (chrome, barium, lead, cobalt, beryllium, strontium, silver, zinc, nickel, zinc), which differ in the availability of a certain metal in the anomaly series. A larger halo, which exceeds the average content (4 mg/l) by 4 or more times, is found in the snow water by sulphate ion. Zone of maximum content of SO₄²⁻ 32-55 mg/l, which exceed the background by 8-14 times, is confined to the strip along the Yaroslavl highway, particularly, within the city limits.

Research conducted by the Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements (IMGRE) shows that the zone of soil cover contamination above the average and with the average levels (total pollution index TPI exceeds 8) by gross contents was found in the western part of the park. It stretches along Yaroslavl highway with a strip of 3-5 km in width; to the south it is increased to 10 km, maximum pollution is detected along BumazhnayaProseka (TPI = 35-50, very strong pollution level). The eastern and central parts of the territory can be characterized in a significant weak pollution (TPI = 2-8) or as almost pure (TPI<2). Main polluting elements are copper (K_k = 1.8-2.9), silver (K_k = 3.8-9.4) and lead (K_k = 3.5-5.1). Increased content of vanadium (K_k = 1.9), nickel (K_k = 2.2) and tin (K_k = 1.9-2.2) are detected in the Moscow zone. Increased content of antimony (K_k = 3.0) is detected in certain points. The nature of soil contamination with microelements is generally established as an industrial-transport-household one.

Land Resource State Research Institute has performed assessment of soil contamination by the content of active forms in it. It was established that active forms Mn, Pb, Zn, Cu, Cd, Mo are accumulated more intensively in the soil, and to the least extent - Co, Be, Sr, and V, Cr, Ni are not accumulated. Maximum values of total pollution index were observed: in the south-east - 51.4 mg/kg, central - 90.6 mg/kg, north-east - 59.8 mg/kg, northern - 104 mg/kg and south-west parts of the park. Based on the Zc total index, contamination of the forest park soil is characterized as hazardous and moderately hazardous.

Based on the data published by Kh.G. Yakubov, soil contamination with polyaromatic hydrocarbons in the south-western and southern parts of the park in direct proximity to industrial organizations is predetermined by the operation of Prima-M. Among the detected pollutants, 3.4 benzopyrene is especially dangerous, its concentration in the soil in two areas exceeds MPC by 2-4 times, which can be described as an ecological disaster.

Vegetation contamination. The entire territory can be characterized by an average level of vegetation contamination with microelements (TPI>8-16). Against this background, there are local zones of very high and high pollution (TPI>16-45) of 0.25 to 6.0 km² in area, which are mainly confined to residential areas and to the automobile roads of the capital. In the western part, a low contamination with microelements of woody vegetation was revealed. The polyelement composition of the revealed anomalies of high and medium pollution levels is generally homogeneous. Vanadium, zinc, lead, silver are accumulated in plants in small quantities; in some cases - titanium, boron, zirconium (K_k = 1.4-1.5). The danger of vegetation contamination consists in the dose accumulation effect, which deteriorates its general state (changes in growth, loss of turgor, etc.); what is more, biomass begins to decrease or increase, the species composition changes and the buffering properties of

phytocenosis become weaker. As a result, the original ecosystem can be degraded, which, for example, occurs with plantings of the MKAD right-of-way (600 ha). The critical state of coniferous plantations, i.e. drying and weakening of pine and fir trees, is detected.

In order to prevent further degradation of vegetation communities and to preserve a unique wildlife nature reserve that plays an important role in the capital's ecology, it is proposed to do the following:

- execute works to improve the condition of the borderlands of the forest park (planting of pine, soil treatment, washing trees from pollution, etc.);
- create a buffer zone with recreational areas, plantation forests that are resistant to pollution, etc.

According to the information from the Scientific Research Laboratory of LosinyOstrov State National Natural Park, water of the Yauza River from the head to Mytishchi can be characterized by a weakly alkaline reaction of the medium ($\text{pH} = 7.2\text{-}8.3$) and a hydrocarbonate-sulfate-calcium composition. Water is clean, fresh, the mineralization in it varies within the limits of 200-480 mg/l. In river water, as compared with the background, the content of manganese is increased by 1.3-6.0 times, sulfates by 1.2-2.3 times, total iron by 1.2-15.0 times. Abnormal concentrations of sulfates ($K_k = 1.2\text{-}1.7$) and total iron ($K_k = 1.2\text{-}6.5$) are detected in the Ichka river water. Contrast anomalies of iron and manganese have no man-induced genesis. They are associated with the bogging process, which is intensive in the river valleys of the park. Waters of forest lakes can be characterized by a slightly acidic to neutral reaction ($\text{pH} = 6.3\text{-}6.7$) and sulfate-hydrocarbonate-calcium-magnesium composition. In general, the surface water within this park territory is estimated as relatively clean.

In contrast to water, a large range of micro- and macro-pollutants is observed in the bottom sediments. In this place zinc, vanadium, lead, silver and other metals, which are characteristic of snow, vegetation and soils, are accumulated. A strong anomaly of the elements with a total pollution index of 26-102 was found in bottom sediments of the Yauza River within Mytishchi. There are three more anomalies with $\text{TPI} = 26.0$ within the park territory. Among such elements are barium, tin, zinc, lead, cobalt, vanadium, etc. These anomalies' genesis is defined as industrial-agricultural one. More contrast anomalies of chemical elements in the bottom sediments of the Ichka River were found along the MKAD. Silver ($K_k = 2.0\text{-}3.0$), cobalt ($K_k = 4.2\text{-}7.5$), vanadium ($K_k = 4.5$), barium ($K_k = 2.0\text{-}3.0$), zinc ($K_k = 4.5$) are accumulated in this place.

According to the data of Land Resource State Research Institute, water within the natural park territory are classified as sulfate-hydrocarbonate-magnesium-calcium by salt composition. Increased acidity is detected in the Golyanovsky and Bulganinsky ponds water - $\text{pH} = 5.5\text{-}6.3$ and in the lake near the Golyanovsky pond - $\text{pH} = 4.2$. Surface waters are characterized by a large content of biogenic substances - phosphorus, nitrogen, silicon, especially ammonium nitrogen - 8-20 mg/l. The oxygen content in water is within 20-30 mg/l. The content of water-soluble humus is within the range from 6 to 12 mg/l.

Increased concentrations of Cu, Zn, Ni as compared with the background ones are detected in the Yauza River head. In the swamp near the military unit in the east of the park, the following concentrations are detected: Zn by 3 times, Sr by 9 times, Pb by 7 times, Cd by 28 times exceed the background level; Be content is 7 times higher than MPC (maximum permissible concentration). High content of Co was found in some samples (near Pogonnoe village, 28 times higher than the background level) [14, 15].

4 Conclusion

Following the results of a comprehensive assessment, it can be concluded that there is minor contamination of the environment with microelements of the park under consideration. More

contrasting pollution anomalies are typical for the Moscow part of the park considered. Preserved area of the park remained clean. Polyelement composition of man-induced geochemical anomalies in landscapes is quite homogeneous: main polluting elements are tin, nickel, vanadium, cobalt, zinc, lead, silver.

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