Changes in the environmental condition of soil and plants under the influence of industrial enterprises (in the case of the Almalyk Mining and Metallurgical Combine)

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Abstract. This article provides information on soil pollution with heavy metals under the influence of industrial enterprises, the impact of waste on plants, the increase in environmental problems under the influence of industrial enterprises, and measures to prevent it. This article also provides information on environmental problems caused by the effects of heavy metals such as Cs, K, Ba, Ca, Ag, Au, Hf, Fe on changes in the ecological status of soil and plants and the processes taking place in man-made polluted soils is highlighted.

1 Introduction

Today, identifying and mitigating negative ecological conditions in ecosystems is considered one of the important issues for improving the balance between nature and society. Significant scientific research has been conducted to identify factors and sources contributing to the degradation of soil, particularly due to the heavy metals, by numerous foreign scientists. For example, in Russia, industrial enterprises, energy facilities, transportation, and others emit more than 32 million tons of various toxic gases into the atmosphere annually. Within the last 5 years, the amount of emissions has increased from 3.8 billion tons to over 5 billion tons [1]. This exacerbates the technogenic degradation of soil. The degradation of soil by heavy metals is primarily attributed to the metallurgical industry. It is known that black and colored metallurgical plants rank first among all industrial sectors in terms of emitting harmful substances [2]. Some areas of soil in certain industrial districts in Russia have been identified as exceeding established standards for a number of harmful substances (cadmium, copper, lead, zinc, arsenic) [3]. Research conducted to determine the degree of soil degradation near industrial areas in Vitebsk identified heavy metals such as Cd, Co, Cu, Zn, Pb, Mn in soil samples. The main sources of soil degradation were identified as industrial plants. According to research conducted on urban soils in Russia during the Soviet era, high concentrations of mercury, zinc, tin,

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manganese, and other heavy metals were recorded in industrial and transportation sectors[4].

Increases in concentrations of contrast (Cu, Mo, As, Co, and Cd) were observed near industrial plants, highways, and railways [6]. When comparing the degree of soil contamination with heavy metals in industrial and ecologically clean areas of the Ulyanovsk region, it has been found that the concentration of heavy metals in industrial areas is significantly higher than in ecologically clean areas[5]. The contamination of soil with heavy metals, as a result of their accumulation by plants, is resulting in morphological changes in soil and plants. Plant communities play a role in transferring toxic substances through food chains to humans. Therefore, assessing the quantity of heavy metals in urban soil is considered an important scientific task. In the soils of Tyumen city, heavy metals such as copper, zinc, iron, manganese, lead, and cadmium have been identified. Higher levels of contamination are mainly observed near major highways, as well as around metallurgical, automotive, oil processing, and battery plants [7]. Soil contamination with heavy metals and their subsequent addition to the surrounding environment, including surface and groundwater, and their harmful effects on living organisms are considered. Nowadays, large industrial, construction, and utility companies, with their active operations, contribute to the technogenic degradation of soils, adversely affecting soil genesis, evolution, ecology, physical properties, and chemical and mineralogical composition [8-11, 13].

2 Materials and methods

The soils located around the Almalyk Mining and Metallurgical Combine JC in the city of Olmaliq, Tashkent region, are considered typical saline soils suitable for irrigation. Samples were taken from key sampling points based on the direction of the prevailing winds to determine the ecological condition of the soils in this area under laboratory conditions (Figure1).

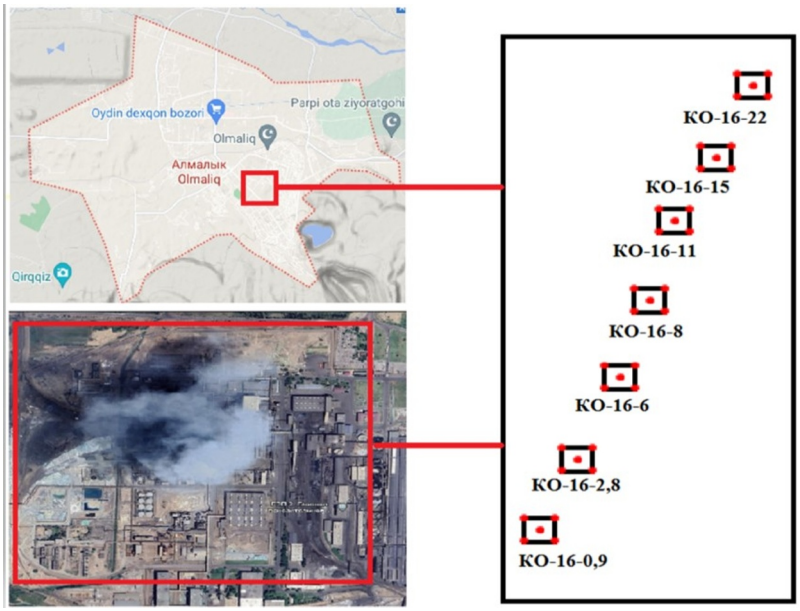


Fig. 1. The disposal points of soil sections around the Almalyk Mining and Metallurgical Combine (Joint-stock company).

To determine the concentration of heavy metals in the soil composition based on the direction of the prevailing winds from distances of 0.9, 2.8, 6, 8, 11, 15, and 22 km from the Almalyk Mining and Metallurgical Combine, soil samples were collected from depths of 0-5 cm, 5-20 cm, and 20-60 cm. Additionally, the method of Mass Spectral Analysis was utilized for determining the concentration of heavy metals in the soil composition. This analysis was carried out according to the Uzbek Geological Exploration Agency under the Ministry of Construction and Geology, using the measurement procedure approved in Russia and adopted in Uzbekistan under the standard (MVI) O‘zO‘U 0677:2015 (MVI No 499-AEM/MS). The Central Laboratory of the Uzbek Geological Exploration Agency was involved in conducting these analysis.

3 Results and Discussion

It is possible to highlight the following based on the research results obtained from the soils around the Almalyk Mining and Metallurgical Combine in Olmaliq city, Tashkent region. It is possible to investigate that in the process of smelting metals at the ferrous metallurgy plant in the region, which directly uses coal, as well as as a result of its combustion residues, heavy metal oxides may be emitted into the surrounding environment. According to the results of the research, heavy metal oxides deposited on the soil surface mainly migrate to the lower part of the soil due to climatic factors and irrigation processes. The heavy metal deposits absorbed by the soil are partially redistributed by the processes of microorganisms and biochemical reactions in the ecosystem. This affects the activity of microorganisms and biochemical processes in the soil composition, increasing its fertility and reducing air permeability. Additionally, the increase in the concentration of heavy metal oxides in the soil composition affects the microorganisms, contributing to their proliferation. The development of vegetation in these areas has been significantly affected by the presence of pollutants.

Soil samples taken from the vicinity of the Almalyk Mining and Metallurgical Combine in Olmaliq city, Tashkent region, were analyzed in laboratory conditions, and the concentrations of heavy metal elements in their composition were determined (Table 1).

Table 1. The degradation status of the soil samples collected in the research area, measured in mg/kg.

No.	Chemical	Title	Almalyk Mining and Metallurgical Combine	REM
1.	V	Vanadium	84.0	150
2.	Cr	Chromium	92.0	200
3.	Mn	Manganese	690	1500
4.	Ni	Nickel	57.0	85
5.	Cu	Copper	350	55
6.	Zn	Zinc	310	100
7.	As	Arsenic	59.0	2
8.	Cd	Cadmium	1.10	0.7
9.	Sb	Antimony	8.40	4.3
10.	Pb	Lead	160	30

The activity of the Almalyk Mining and Metallurgical Combine has had a negative impact on the environment, with harmful substances such as lead and zinc being released into the soil due to the process of extracting metals. Heavy metal compounds emitted from the combine have mixed with the atmosphere and settled in the soil. The main source of environmental pollution from the Almalyk Mining and Metallurgical Combine is considered to be the emissions that have been released into the atmosphere, affecting the ecological state of the ecosystem. Over the years, the amount of soil pollution caused by the

Almalyk Mining and Metallurgical Combine has been increasing, leading to changes in soil characteristics and a decrease in fertility. The impact radius of environmental pollution from the Almalyk Mining and Metallurgical Combine has been estimated to be 2.8 kilometers. According to laboratory results, the levels of Cu, Zn, As, Cd, Sb, and Pb in relation to background values were found to be elevated. In the process of soil contamination by various industrial enterprises, heavy metals are often detected. According to State Standard GOST 17.4.1.02-83, hazardous heavy metal elements are divided into three groups (Table 2).

Table 2. The degree of danger of heavy metals.

Degree of danger	Elements
High	As, Cd, Hg, Se, Pb, Zn
Normal	Co, Ni, Mo, Cu, Cr, Sb
Weak	Ba, V, W, Mn, Sr
Unknown	Ge, Sn, Ce, La, Bi, Y, Rb, Cs

Soils contaminated with heavy metals due to the activities of industries have been found to cause poisoning in animals that feed on plants grown in such soils. In industrial areas, certain chemical elements are introduced into the soil composition. According to research conducted, Cs and K are considered chemical elements that are reactive metals in the soil, produced by elements that actively interact in the soil. As a result, the soil contains chlorides, sulfates, carbonates, and nitrates.

Ba and Ca are also considered reactive metals, being active metals as well. Calcium (Ca) does not occur freely and usually appears in the form of CaO. When it reacts with the soil, $Ca(OH)_2$ is formed due to its alkaline effect on the soil moisture. This reaction can be observed as follows:

$$CaO + H_2O \rightarrow Ca(OH)_2 \quad (1)$$

The substance produced in this reaction is called unslaked lime. It has contributed to the disruption of the ecological state of the soil. It is known that the reactivity level of the soil has increased, indicating its alkalinity.

Ag and Au - these elements have very low chemical activity and do not oxidize in their free state. These chemical elements have been linked to the poisoning of various animal species due to their accumulation by plants.

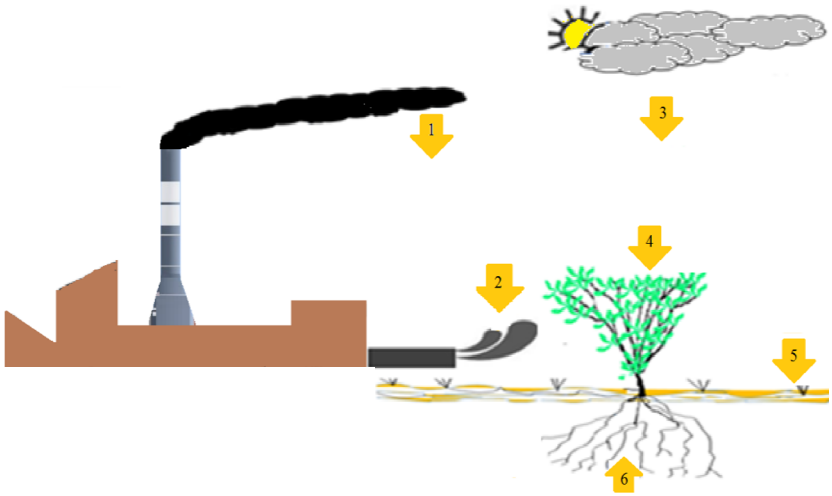
Hf is considered one of the heaviest metals. It has low chemical activity and oxidizes in the soil to form an oxide layer.

Fe - one of the most abundant metals in the soil, oxidizes due to the influence of moisture and air to form $Fe(OH)_3$. Iron is widely distributed in the soil, often appearing as a reddish-brown color. The reaction can be observed as follows:

$$4Fe + 3O_2 + 6H_2O \rightarrow 4Fe(OH)_3 \quad (2)$$

The $Fe(OH)_3$ formed reacts with sulfates, carbonates, and chlorides. In soils with high iron content, the availability of phosphorus tends to be lower.

The impact of industrial emissions on soils has resulted in consequences that affect all living organisms involved in the ecosystem. This process can be visualized in the following diagram.



1. Heavy metals and other hazardous chemicals coming out of the metallurgical plant, 2. Wastewater coming out of the plant, 3. Acidic emissions, 4. Accumulation of hazardous chemical substances such as heavy metal oxides and dust from the plant's emissions, 5. Contamination of soils by heavy metals, 6. Investigation of soil contamination by heavy metals and other elements through soil sampling.

Fig. 2. The impact of the Almalyk mining and metallurgy combine on the environment is causing damage to vegetation.

4 Conclusion

The increase in the population creates a demand for food and today's main issue is the efficient use of technogenically disturbed areas, identifying damaged areas for effective use, and considering the level of degradation, using technologies for appropriate rehabilitation. As a result, the remediation of contaminated soils allows for the cleaning of soils from chemical pollutants and the possibility of restoring clean and quality food production.

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