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Article

Impact of Angren Coal Mining on Soil Biological and Chemical Properties

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Abstract: This study investigates the impact of coal mining activities at the Angren coal mine on soil properties, addressing the gap in understanding the biological and chemical alterations in the soil due to mining. The research utilized comparative geographical and laboratory methods to analyze soil samples for enzymatic activity, heavy metal content, and physical properties such as humus content and water capacity. The findings indicate significant increases in heavy metals and alkaline elements in the soil near the mine, leading to reduced microbial activity and altered enzymatic functions. These changes have adverse effects on soil health and plant growth. The results underscore the necessity for implementing effective soil remediation and phytomelioration measures to mitigate the environmental impact of coal mining activities and promote sustainable ecosystem management in the region.

Keywords: Soil, Ph Medium, Enzymatic Activity, Coal, Catalase, Urease, Invertase, Quantity Of Microorganisms, Anthropogenic Ecosystem, Mining Industry.

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1. Introduction

Soil is a non-renewable resource that plays a vital role in human life and the stability of other ecosystems. Often, this non-renewable resource is degraded by various anthropogenic activities, including agriculture and mining[12]. To restore the soil profile and ecosystem condition, mining regulations stipulate that the original topsoil and reusable layers - rich in nutrients and supporting plant growth - should be carefully excavated and coal waste stored separately. Unfortunately, these changes can lead to the deterioration of important components of soil health, including chemical, physical, physicochemical properties, and the diversity of soil biota[13].

The main pollutants in coal mining can be listed as follows: Silicon (II) oxide, ash, formaldehyde, lead, cadmium, mercury, arsenic, volatile organic compounds, and hydrocarbons. In the Angren coal mine in Uzbekistan, coal is also extracted through open-pit mining. This mine accounts for 85 percent of the coal mined in Uzbekistan, with current mining operations taking place at a depth of 250 meters and producing up to 10-12 thousand tons of coal per day. Soil samples were collected from the area surrounding the mine under field conditions based on interstate standards (Figure 1).

a) Satellite image of the Angren coal mine

b) Angren coal mine

c) Area where soil samples were collected

Figure 1. Location of the research area

The combination of physical, chemical, and biological components of soil is an important parameter for assessing the ecological state of soil. Such an assessment provides comprehensive information about the soil condition. Regarding the biological components of soil, microbes and enzymes play several crucial roles in the soil ecosystem. It is necessary to study the composition of soils around mines, including soil humus content, NPK, mechanical composition, microaggregates, soil enzymes, and microorganism activity, and based on this, implement melioration and phytomelioration measures[15].

In such cases, this includes mobilization of essential nutrients in the soil, mediation of plant nutrient uptake, resistance to plant pathogens, secretion of plant growth-promoting hormones, and decomposition of soil organic matter. Thus, enzyme activity and microbial diversity have been used as soil quality indices to determine nutrient cycling and availability in the soil[4].

2. Materials and Methods

The research was conducted on dark gray soils surrounding the Angren coal mine in Angren city, Tashkent region, employing both field and laboratory methods to evaluate the soil's biological and chemical properties[16]. Soil samples were collected from various locations around the mine, adhering to interstate standards to ensure consistency and reliability. In the field, the distribution of vegetation cover was visually monitored to assess the immediate impact of mining activities on plant life[17]. The pollution status of the research area was also documented. In the laboratory, the soil pH environment was determined using the ISO 10390 method with a pH meter. To analyze the properties of soil with disturbed fertile layers, the interstate standard GOST 17.4.2.02-83 was utilized, while the activity of the catalase enzyme was measured based on the methods of R.S. Kasnelsova and V.V. Yershova[18]. The total number of microorganisms was assessed using techniques developed by S. Razumov and R. Remezov, and soil humus content was determined through the Tyurin method. Heavy metals in the soil were analyzed using mass spectrometry to identify the concentration of elements such as Na, Mg, Al, K, and Ca. Additionally, the microaggregate composition of the soil was studied to evaluate the physical properties, including the presence of large clods and the soil's field and total water capacity. The combination of these methods provided a comprehensive understanding of the impact of coal mining on the soil's biological activity and chemical composition, allowing for the identification of significant changes and the formulation of appropriate remediation strategies[19].

3. Results and Discussion

According to the results of studies conducted on the physical properties of dark gray soils distributed around the Angren coal mine[20]:

In the microaggregate composition of the soil, a high amount of particles larger than 10 mm was found in the 1st cross-section taken near the coal mine.

In the sample taken 1.5 km away from the coal mine, there was a high amount of 10 mm particles at 41.59%, forming large clods. Due to the increase in the amount of such particles in the soil and their combination with coal, it is possible to observe a large number of solid, large clay clods in the area (Figure 2)[21].

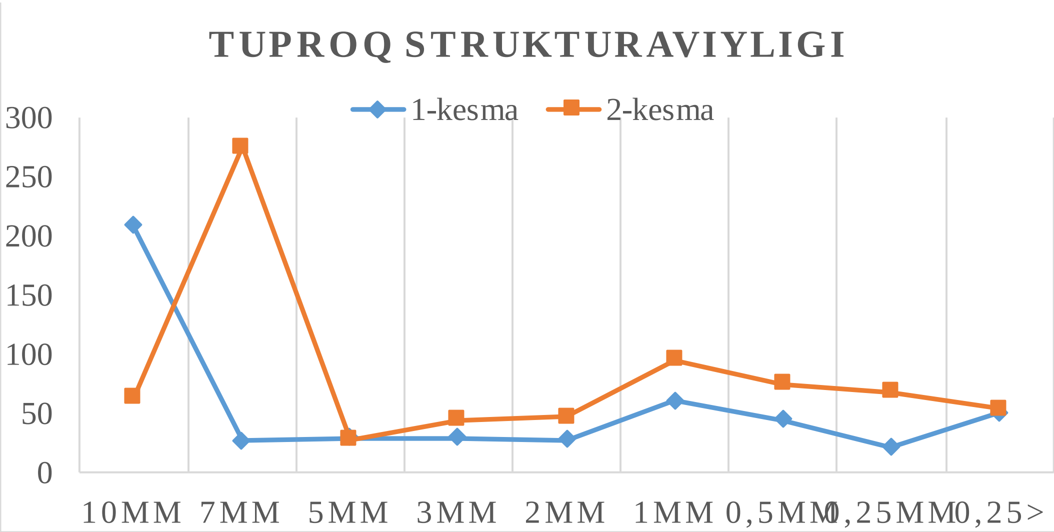


Figure 2. Fraction of soil layers

The pollution around the coal mine has affected the soil's water-physical properties, specifically the Field Capacity and Total Water Capacity (Figure 3)[22]. The Total Water Capacity in the 0-15 cm layer of the 1st cross-section near the coal mine was 80%, while in the 2nd cross-section, this value was 70%. The Field Capacity in the 1st cross-section was 34.4%, and in the 2nd cross-section, it was 30.1%. The high values of Total Water Capacity and Field Capacity near the coal mine are related to the adsorption property of coal. Coal has the ability to absorb substances[23], and due to this property of coal, the values of Total Water Capacity and Field Capacity in the soil composition showed high results[24].

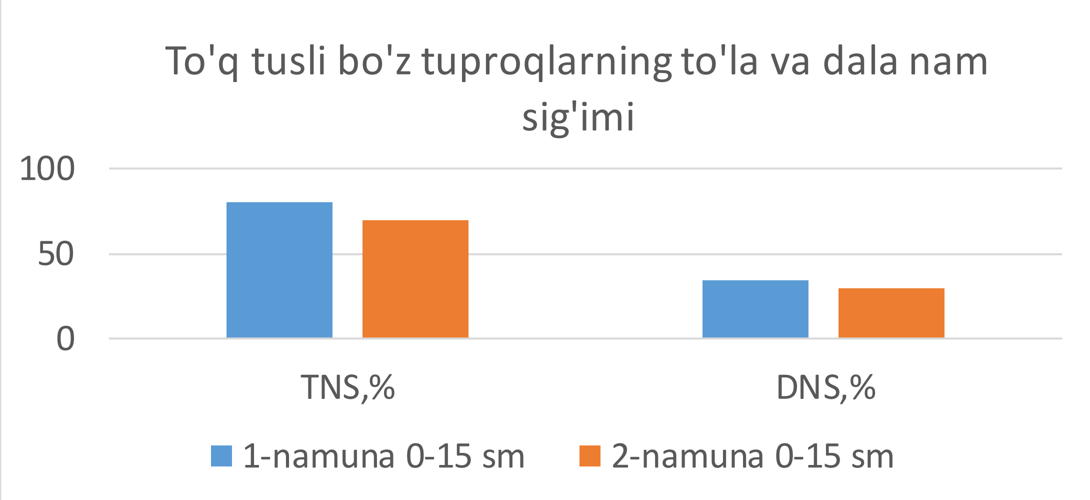


Figure 3. Impact on Field Capacity and Total Water Capacity

In the natural environment, the pH level of soil has a significant impact on the soil's biogeochemical processes[25]. The soil pH level is described as a "key soil indicator" that affects many biological, chemical, and physical properties of the soil, as well as plant growth and biomass yield. The pH indicators in the soils of the studied area are as follows: in the soil sample 1.5 km away from the mine, the pH is 8.48, indicating an alkaline environment, while in the soil sample 3.5 km away from the mine, the pH is 7.16, indicating a slightly alkaline environment[26].

One of the reasons for the alkaline environment near the mine is the high content of elements with a strong alkaline nature in the soil composition. (Table 2)[27]

Table 2. Elements exceeding the established norm in the elemental composition of dark gray soils

Element	Cross-section 1 (ppm)	Cross-section 2 (ppm)
B	15	19
Na	8500	16000
Mg	9100	11000
Al	70000	56000
K	18000	30000
Ca	50000	9300

When the soil composition was examined using mass spectroscopy analysis, as shown in the table above, it was observed that the amounts of elements with strong alkaline properties such as Na, Mg, Al, K, and Ca exceeded the norm. This, in turn, has caused the soil environment near the mine to have a strongly alkaline nature[29].

The humus content, which is one of the main indicators determining soil fertility in soils distributed near the coal mine, was studied using the Tyurin method, and the following results were obtained (Figure 4).

In the soils near the coal mine, the humus content in the 0-15 cm layer was 3.05%, and in the 15-50 cm layer, it was 2.55%. In the second cross-section, 3.5 km away from the coal mine, the humus content in the 0-15 cm layer was 1.45%, and in the 15-50 cm layer, it was 1.12%[30].

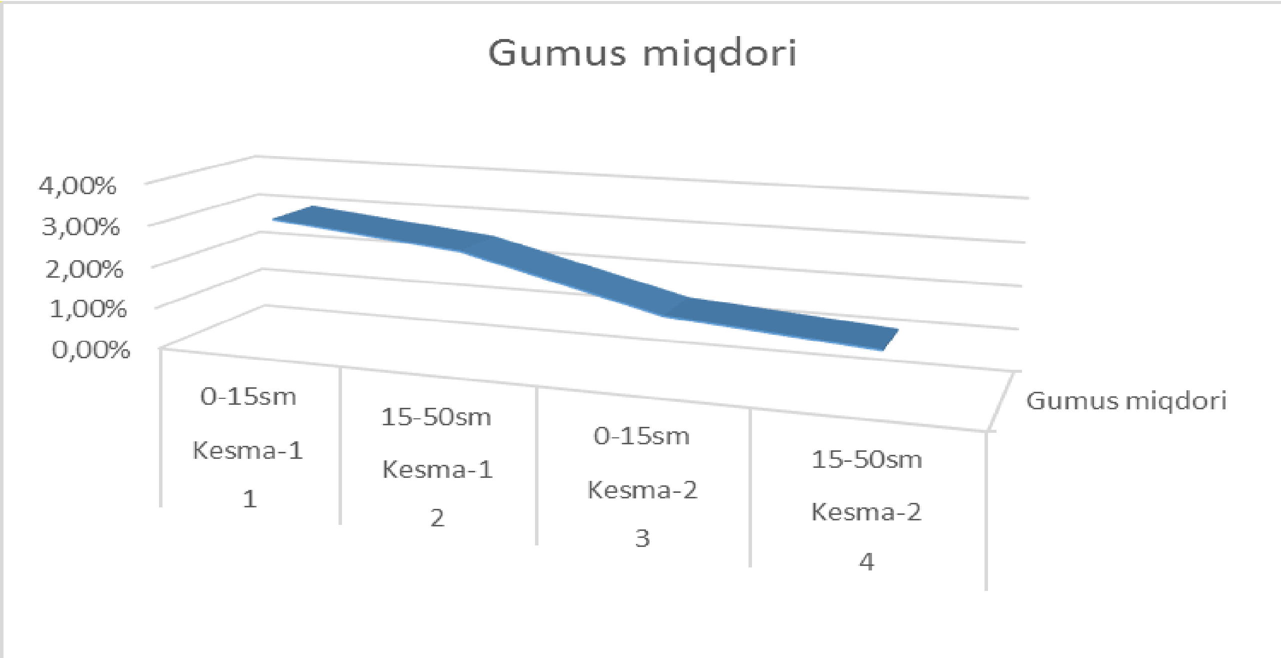
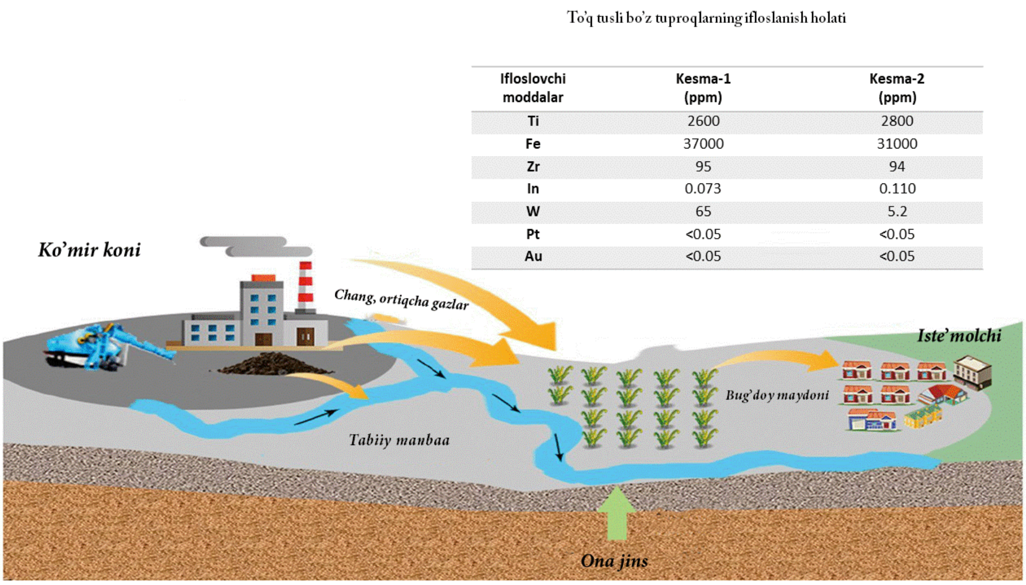


Figure 4. Humus content in dark gray soils

The high value of humus content (3.05%) in soils distributed near the coal mine is due to the total carbon in coal contributing to the formation of anthropogenic carbon in the soil. This, in turn, has led to an increase in the total C reserve that is stored in the soil but cannot be utilized by plants (Figure 5).



Ifloslovchi moddalar	Kesma-1 (ppm)	Kesma-2 (ppm)
Ti	2600	2800
Fe	37000	31000
Zr	95	94
In	0.073	0.110
W	65	5.2
Pt	<0.05	<0.05
Au	<0.05	<0.05

Figure 5. Impact of the coal mine on population and vegetation

Tungsten in soil composition belongs to the group of elements with low hazard levels. Heavy metals are considered toxic for soil, plants, aquatic life, and human health. Heavy metals exert a toxic effect on soil biota by influencing key microbial processes and reduce the number and activity of soil microorganisms. Even low concentrations of heavy metals can adversely affect the physiological metabolism of plants. The uptake of heavy metals by plants and their subsequent accumulation along the food chain is considered a potential threat to animal and human health.

Soil enzymes, being part of soil microorganisms and plants, participate in soil functioning by ensuring nutrient cycling, decomposition of organic matter and other pollutants, and are considered more significant for their important role in maintaining soil health. Dehydrogenase activity is used as an indicator of microbial activity in soil, as they participate in the electron transport chain and their activity depends on the intracellular environment of microbes.

Comparing urease activity among various soil samples; the lowest activity was recorded in soils around the mine. The current findings indicate that for these soils, urease activity shows a significant correlation with organic carbon (Table 3).

Table 3. Catalase enzyme activity in soils distributed around the Angren coal mine

№	Soil Sample	Catalase Enzyme Activity ml O2 / g soil	
		Soil 1.5 km from the mine	Soil 3.5 km from the mine
1	0-5 cm	8	9.33
2	5-50 cm	8.33	8.6

The results showed that the catalase enzyme activity in the sample taken from the top 0-5 cm layer was very low, almost not differing from the activity in the 5-50 cm layer soils. It was found that the microorganism activity in both upper and lower layers was very low. Visual monitoring of the area around the coal mine clearly shows a very sparse plant life and evident pollution of the topsoil eco-environment.

4. Conclusion

The findings of this study highlight the significant impact of coal mining activities at the Angren coal mine on the surrounding soil's biological and chemical properties. The research identified increased levels of heavy metals and alkaline elements in the soil, leading to diminished microbial activity and enzymatic functions, which adversely affect soil health and plant growth. These changes underscore the necessity for effective soil remediation and phytomelioration strategies to mitigate the environmental impacts of coal mining and promote sustainable ecosystem management. Further research is recommended to explore long-term soil rehabilitation techniques and their effectiveness in restoring soil health and productivity in mining-affected areas.

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