Int.J.Curr.Microbiol.App.Sci (2026) *15*(6): 228-235

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 15 Number 6 (2026)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2026.1506.025

Soil Contamination with Various Chemical Elements during Coal Mining (A Case Study of the Angren Coal Deposit in Tashkent Region, Republic of Uzbekistan)

Jobborov Bahrom Turg‘unovich* and Xurramov Nodir Norboyo‘g‘li

National University of Uzbekistan named after Mirzo Ulugbek, Tashkent, Uzbekistan

**Corresponding author*

Keywords

Soil pollution, industrial waste, heavy metals, environmental monitoring, anthropogenic impact, soil fertility, reclamation, environmental protection.

Article Info

Received:
16 April 2026
Accepted:
30 May 2026
Available Online:
10 June 2026

A B S T R A C T

The article presents the results of a study on the impact of the Angren coal deposit on the chemical composition of soils in the Tashkent region of the Republic of Uzbekistan. Particular attention is given to the spatial distribution of heavy metals and other chemical elements in soils depending on the distance from the pollution source and the prevailing wind direction. Soil sampling was carried out at distances of 0.2–5.3 km from the coal mining area, as well as at a background site (6.7 km), using standard soil sampling methods. Laboratory analyses included the determination of V, Cr, Mn, Co, Ni, Cu, Zn, As, Cd, Sb, and Pb. The results indicated exceedances of the maximum permissible concentrations (MPC) for several elements, especially in areas close to the pollution source. The most pronounced technogenic accumulation was observed for As, Pb, Cu, Zn, and Sb. Statistical data processing (M, σ, CV, CI, correlation analysis, and ANOVA) confirmed a significant relationship between contamination levels and distance from the deposit. It was established that the main factor in the distribution of pollutants is the wind-driven transport of dust particles. The obtained results emphasize the need to strengthen environmental monitoring and develop measures to reduce anthropogenic pressure on soil ecosystems in the region.

Introduction

Currently, the rapid development of industrial sectors, the expansion of manufacturing activities, and the intensification of mining operations are significantly increasing anthropogenic pressure on the natural environment. Ash and dust particles released into atmosphere during these processes, along with various chemical elements, are transported over large areas by wind, subsequently accumulating in surface layers of soil. Under the influence of these anthropogenic factors, the chemical composition of soils is altered, leading to increased concentrations of heavy metals and other hazardous elements. As a consequence, the ecological condition of soils deteriorates, which adversely affects their biological activity, nutrient cycling, and agrophysical properties. Ultimately, the productivity of agricultural crops on irrigated lands declines, with soil fertility significantly decreasing, while environmental risks increase.

From this point of view, it is necessary to assess the level of soil contamination with various chemical elements within the study area, determine their spatial distribution patterns, and scientifically evaluate their impact on the agro-ecological condition of soils. Such studies can be considered important not only for the conservation of soil resources but also for developing effective land management strategies for soil restoration (reclamation) and sustainability.

In coal mining regions of China, the level of soil contamination with heavy metals has been assessed. The results indicated high levels of contamination by Cd, Pb, and Ni. The authors reported that although As, Cr, Cu, Ni, and Zn posed relatively low ecological risks, Cd, Pb, and Hg showed considerably higher ecological risks in soils affected by coal mining activities (1–2).

The spatial distribution of heavy metals and the associated ecological risks were also studied in the coal mining areas of the Loess Plateau in Northern Shaanxi, China. The results revealed that the concentrations of Hg, Cd, Pb, and Cr exceeded their background values by 2.03, 1.36, 1.11, and 1.23 times, respectively.

The study emphasized that coal mining is one of the primary anthropogenic drivers of soil degradation and highlighted the need for integrated environmental management strategies adapted to local conditions (3–4).

Furthermore, studies have demonstrated that soil contamination in coal mining regions can enter the food chain; thereby posing potential risks to human health (5).

Studies conducted in coal mining regions of Europe analyzed soil contamination during the period 2018–2023. The findings revealed that both organic and inorganic pollutants, including polycyclic aromatic hydrocarbons (PAHs) and potentially toxic elements (Zn, Pb, Mn, and Cr), are among the major sources of soil contamination. Among these, Zn, Pb, Mn, and Cr were identified as the principal contributors to soil pollution (6). Investigations of soils and vegetation surrounding coal mines have shown that the concentrations of Cd, Cu, Mn, Ni, Pb, and Zn frequently exceed permissible limits (7–8).

The review of the above-mentioned studies indicates that the mining and fuel-energy industries are among the major sectors with profound substantial anthropogenic pressure on the environment (9–10).

In another study, 13,925 soil samples collected from 55 coal mines across 32 countries were analyzed. The results revealed significant accumulation of As, Hg, Sb, Bi, and Se. These elements were identified as important indicators for soil environmental monitoring and reclamation because of their adverse effects on soil ecological quality (11–12).

In addition, the impacts of coal mining and coal processing on soil properties were evaluated in the Czech Republic. The results demonstrated that coal mining causes significant changes in the physical, chemical, and biological properties of soils. Specifically, decreases in soil fertility, soil compaction, contamination, structural degradation, and the accumulation of heavy metals were observed. The distribution and bioaccumulation of heavy metals in soils and plants that surround coal mines were also investigated. The findings showed that the concentrations of Cd, Cu, Mn, Ni, Pb, and Zn exceeded regulatory limits in the majority of soil samples. Mining activities, industrial waste, and atmospheric transport were identified as the major sources of heavy metals. According to the study, the accumulation of heavy metals in soil and water poses serious threats to ecosystems, vegetation, and human health (13).

Furthermore, soil contamination by potentially toxic elements was investigated in coal and metallurgical mining regions of China. The results demonstrated that heavy metal concentrations exceeded background levels in both types of mining areas, while contamination levels were considerably higher in metallurgical mining regions (14). Therefore, strengthening environmental monitoring, promoting the rational use of natural resources, and implementing large-scale land reclamation measures in mining areas are of considerable scientific and practical importance.

Materials and Methods

To assess the environmental conditions in the vicinity of the Angren coal mine located in Angren City, Tashkent Region, the following field investigations were established:

- Based on the geographical location of the study area, the general survey framework and sampling locations were determined.
- During the investigation of the Angren coal mine, general information was collected on the distribution of harmful substances, including ash and dust particles emitted from mining activities into the surrounding

area.

- To determine the degree of soil contamination with chemical elements, the key sampling points were set along the prevailing wind direction from the Angren coal mine. The soil profiles were excavated, soil samples were taken, and contamination levels were subsequently analyzed.
- The degree of soil contamination caused by various mining-related wastes was determined through chemical analysis. Mass spectrometric analysis was performed at the Central Laboratory of JSC Uzbek Geological Exploration under the Ministry of Mining and Geology of the Republic of Uzbekistan, following the Measurement Procedure UzDSt 0677:2015 (Measurement Procedure No. 499-AEM/MS), originally developed in Russia and officially approved for use in Uzbekistan.

Results and Discussion

At present, the operation of industrial enterprises, manufacturing complexes, and mineral extraction activities release large amounts of waste into the environment, accompanied by the migration of various chemical elements. In this context, a comprehensive investigation was carried out at the Angren coal deposit, located in the Angren district of the Tashkent region of Uzbekistan, to assess its impact on the surrounding environment. In addition, the impact of accumulated chemical elements in the soil on the growth and development of vegetation was evaluated, and the ecological changes occurring within the ecosystem of the study area were analyzed. The study results demonstrated that the very area affected by the Angren coal deposit is characterized by the accumulation of various chemical elements in the soil, resulting in pronounced ecological alterations. The identified spatial distribution patterns of the contaminants are shown in Figure 1.

During coal mining operations, various chemical elements are released into the environment, primarily accumulating in the soil through wind-driven transport. Their accumulation alters the chemical, physical, and biological properties of soils and contributes to the degradation of their ecological functions. As a result, the growth and development of vegetation in the surrounding areas are adversely affected, leading to further disruption of ecosystem structure and functioning. Collectively, these processes may increase the risk of various diseases in living organisms, including humans, due to the deterioration of environmental quality.

During the exploitation of the Angren coal deposit, climatic factors, particularly wind, play a dominant role in transporting dust particles and associated chemical compounds from the mining area to the surrounding environment. The prevailing wind direction in the vicinity of the Angren coal deposit, located in the Tashkent Region of the Republic of Uzbekistan, is presented in Figure 2.

In the study area, the Angren coal deposit in Angren City, Tashkent Region, according to the Uzhydromet of the Republic of Uzbekistan, the prevailing wind direction is from southwest to northeast. Therefore, soil sampling was carried out along the dominant air mass transport pathway, corresponding to the prevailing wind direction.

To investigate the chemical composition of the dark sierozem (Gray Desert) soils distributed within the study area, the systematic soil sampling was carried out on both within the Angren coal mining area and at sites located along the prevailing wind direction. The sampling sites were established at distances of 0.2, 1.1, 1.8, 2.6, 4.0, and 5.3 km from the center of the coal deposit, while a site located 6.7 km away was selected as the background (control) location. The geographic coordinates of all sampling sites were determined using a GPS receiver, and each location was individually georeferenced. The study area extends approximately between 41.23°–41.27° N latitude and 69.15°–69.22° E longitude. All sampling points were accurately positioned according to their distance and direction relative to the pollution source.

The soil samples were collected from the 0–20 cm surface layer, which is considered the most active zone for the accumulation of atmospheric deposition and anthropogenic contaminants. The field surveys were conducted in May 2023, 2024, and 2025 under comparable seasonal conditions to minimize the effects of seasonal variability.

To improve the reliability of the results, the soil samples were collected in triplicate at each sampling site. The composite samples were prepared using the “diagonal + central point” sampling scheme to ensure representative sampling. At each location, 4–5 subsamples were combined to produce one homogeneous composite sample. The average weight of each composite sample ranged from 1.0 to 1.5 kg, which was sufficient for subsequent laboratory determination of heavy metals and other chemical elements.

The collected samples were placed in individually labeled polyethylene bags indicating the sampling point code, sampling distance, year, and sampling depth. Samples were transported under cooled conditions at approximately +4°C and delivered to the laboratory within 24–48 hours after collection. To prevent chemical alteration and secondary contamination, all samples were protected from direct sunlight and high temperatures during transportation and storage.

The background (control) site was selected at a distance of 6.7 km from the coal deposit, where anthropogenic influence was considered minimal. The analytical results obtained from this background site were used as reference values for comparison with the other sampling locations to evaluate the impact of the Angren coal mining activities on the chemical composition of soils.

Analysis of the samples collected at different distances from the coal deposit and during different years revealed that the concentrations of several chemical elements exceeded the maximum permissible concentrations (MPCs). The analytical results are presented in Table 1.

The soil samples collected at the above-mentioned distances were analyzed under laboratory conditions to determine the concentrations of the following chemical elements: V, Cr, Mn, Co, Ni, Cu, Zn, As, Cd, Sb, and Pb. The measured concentrations were compared with the MPCs for soils established by the regulatory standard GN 2.1.7.2041-06 (15). The analytical results showed that the concentrations of several elements, particularly Co, Cu, Zn, As, Sb, and Pb, exceeded the established regulatory limits in the soils of the study area.

These exceedances indicate the presence of anthropogenic impacts on the soil environment and suggest the accumulation of these elements as a consequence of coal mining activities.

The results presented in Table 1 demonstrate that the operation of the Angren open-pit coal mine has a significant influence on the chemical composition of irrigated soils in the surrounding areas. The study revealed a distinct spatial distribution pattern of chemical elements in the soil, with their concentrations varying according to the distance from the source of anthropogenic contamination.

The analytical results indicate that the concentrations of vanadium (V), chromium (Cr), manganese (Mn), nickel (Ni), and cadmium (Cd) at all sampling sites remained below the established MPCs. Nevertheless, these elements exhibited a gradual decline in concentration with increasing distance from the open-pit coal mine, suggesting the influence of atmospheric transport and the subsequent deposition of dust particles.

The most pronounced evidence of anthropogenic accumulation was observed for cobalt (Co). In soils located 0.2, 1.1, and 1.8 km distance from the pollution source, Co concentrations reached 6.22, 5.93, and 5.16 mg/kg, respectively, exceeding the established maximum permissible concentration (MPC) of 5.0 mg/kg. At greater distances, the cobalt concentrations declined to values within the permissible limit. This pattern indicates that the cobalt contamination is primarily localized, with a relatively limited spatial extent.

Copper (Cu) also exhibited the elevated concentrations in the immediate vicinity of the open-pit coal mine. The highest concentrations were recorded at distances of 0.2 km and 1.1 km, reaching 61.2 and 56.4 mg/kg, respectively, which exceeded the established MPC of 55 mg/kg. As the distance from the pollution source increased, copper concentrations gradually declined toward background levels.

A similar spatial pattern was observed for zinc (Zn). The highest concentrations, 103.9 and 101.8 mg/kg, were measured at sampling sites closest to the mine, slightly exceeding the regulatory limit of 100 mg/kg. Beyond a distance of 1.8 km, zinc concentrations decreased to levels consistent with the established environmental standards.

Particular attention should be given to arsenic (As), which exhibited the highest degree of anthropogenic enrichment among the analyzed elements. Within a distance of 0.2–2.6 km from the open-pit mine, the arsenic concentrations ranged from 6.4 to 27.1 mg/kg, substantially exceeding the MPC of 2 mg/kg. Even at a distance of 2.6 km, the arsenic concentrations remained considerably above the permissible level. Given the high toxicity of arsenic, these findings indicate one of the most significant environmental risks within the study area.

The elevated concentrations of antimony (Sb) were likewise detected in soils adjacent to the mining area.

Figure.1 Morphological, physical, and biochemical changes in soils caused by the accumulation of various chemical elements

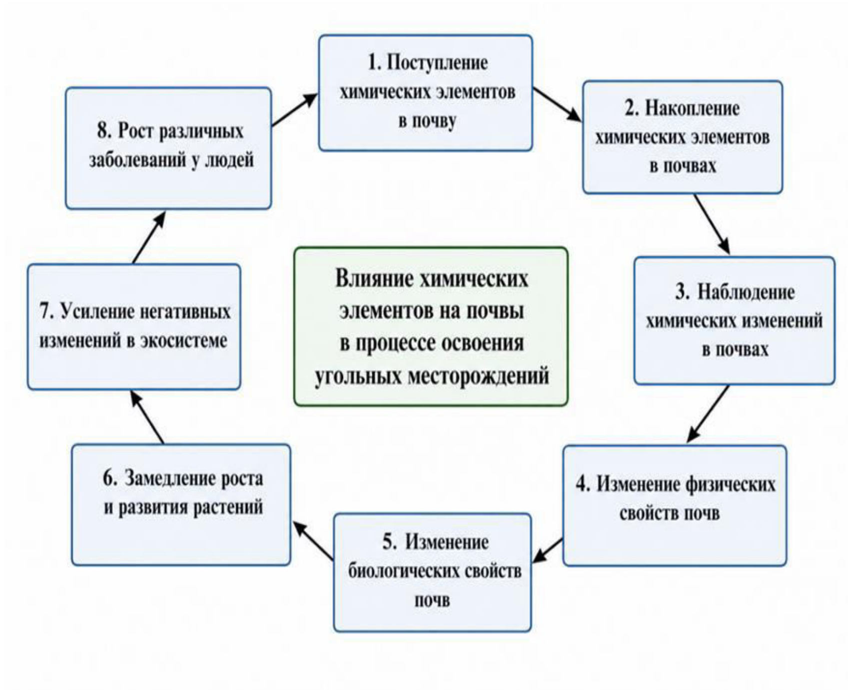

Figure.2 Prevailing wind directions in the vicinity of the Angren coal deposit, Tashkent Region, Republic of Uzbekistan.

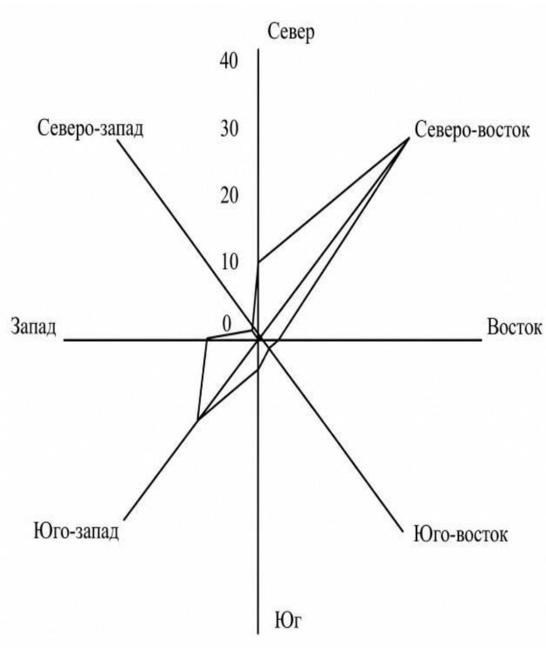

Table.1 The chemical contamination of irrigated soils resulting from the operation of the Angren coal mine (mg/kg).

№	Chemical element	Sampling sites							MPC
		KA-0,2 km	**KA-0,2 km**	**KA-0,2 km**	**KA-0,2 km**	**KA-0,2 km**	**KA-0,2 km**	**KA-0,2 km**	
1.	V	49,5	47,3	45,8	43,4	42,9	41,8	27,1	150
2.	Cr	51,9	48,3	46,9	45,1	40,3	39,1	23,4	100
3.	Mn	499	418	365	309	284	262	160	1500
4.	Co	6,22	5,93	5,16	4,34	3,61	3,48	2,25	5,0
5.	Ni	33,7	31,4	29,6	27,1	24,8	23,3	19,4	40
6.	Cu	61,2	56,4	28,3	26,8	24,9	21,7	18,5	55
7.	Zn	103,9	101,8	87,6	85,7	85,1	83,7	65,9	100
8.	As	27,1	13,8	10,9	6,4	2,0	1,9	1,1	2
9.	Cd	0,299	0,243	0,195	0,145	0,112	0,09	0,03	0,7
10.	Sb	6,02	5,68	4,65	1,95	1,71	1,62	1,33	4,5
11.	Pb	43,3	39,8	34,5	33,1	28,3	26,3	17,4	32

At distances of 0.2–1.8 km, Sb concentrations ranged from 4.65 to 6.02 mg/kg, exceeding the regulatory limit of 4.5 mg/kg. At more distant sampling sites, antimony concentrations declined to values within the permissible range.

Lead (Pb) exhibited a comparable spatial distribution pattern. At distances ranging from 0.2 to 2.6 km, Pb concentrations varied between 33.1 and 43.3 mg/kg, exceeding the established MPC of 32 mg/kg. At distances of 4.0 and 5.3 km, lead concentrations decreased to levels within the regulatory threshold.

A comparison of all analyzed elements indicates that the highest concentrations of contaminants were consistently observed in areas immediately adjacent to the Angren open-pit coal mine. With increasing distance from the pollution source, the concentrations of most chemical elements declined steadily, confirming the dominant role of atmospheric transport and deposition of dust particles in the formation of geochemical anomalies.

Overall, the operation of the Angren open-pit coal mine exerts a substantial anthropogenic impact on the soils of the surrounding agricultural lands. The most significant contaminants are Co, Cu, Zn, As, Sb, and Pb, whose concentrations exceed the maximum permissible concentrations at several sampling sites. The observed spatial distribution of these chemical elements highlights the necessity of establishing a long-term environmental monitoring program, implementing effective dust emission control measures, and developing efficient land reclamation strategies for disturbed areas.

The laboratory results obtained from the analysis of soil samples were statistically processed to evaluate the distribution of chemical elements and the reliability of the measurements. For each chemical element, the mean (M), standard deviation (SD), and coefficient of variation (CV) were calculated based on the analytical results. These statistical parameters were determined separately for each sampling site located at distances of 0.2, 1.1, 1.8, 2.6, 4.0, and 5.3 km, as well as for the background (control) site at 6.7 km.

To assess the reliability of the analytical results, 95% confidence intervals (95% CIs) were calculated. The confidence limits were estimated using Student's t-distribution, allowing the probable range of the true mean concentration of each chemical element to be statistically determined.

To investigate the relationship between the distance from the Angren coal deposit and the degree of soil contamination, Pearson's correlation coefficient (r) was employed. This analysis made it possible to identify trends in the concentrations of heavy metals and other chemical elements with increasing distance from the pollution source. The results indicated the presence of moderate to strong correlations between the distance from the coal mine and the concentrations of the analyzed contaminants.

To evaluate the statistical significance of differences among sampling sites and study years, the Student's t-test and one-way analysis of variance (ANOVA) were applied. These statistical methods enabled the comparisons of the analytical results obtained in 2023, 2024, and 2025, as well as among the different sampling locations. Differences were considered statistically significant at $p < 0.05$.

In conclusion, the results of this study demonstrate that the operation of the Angren coal deposit exerts a significant anthropogenic impact on the soils of the surrounding areas. The increased concentrations of several chemical elements (Co, Cu, Zn, As, Sb, and Pb) were detected within 0.2–2.6 km of the pollution source, with some concentrations exceeding the established MPCs.

Among the analyzed elements, arsenic (As) and lead (Pb) were found to have exhibited the highest levels of contamination, indicating a potentially high ecological risk within the study area.

A gradual decrease in the concentrations of most investigated elements was observed with increasing distance from the open-pit coal mine, confirming the important role of atmospheric transport and subsequent deposition of dust particles in the spatial distribution of contaminants. The obtained results revealed the distinct geochemical contamination gradient aligned with the prevailing wind direction.

Statistical analysis, including the calculation of the mean (M), standard deviation (SD), coefficient of variation (CV), 95% confidence intervals (95% CIs), Pearson's correlation coefficient (r), as well as one-way analysis of variance (ANOVA) and Student's t-test, confirmed the reliability of the analytical results. A statistically significant negative correlation was identified between the distance from the pollution source and the concentrations of the analyzed chemical elements ($p < 0.05$).

Overall, the findings indicate that the exploitation of the Angren coal deposit has a persistent adverse effect on the chemical composition of surrounding soils. These results highlight the need to strengthen environmental monitoring programs, reduce dust emissions, and implement effective land reclamation measures to minimize environmental risks and promote the long-term ecological stability of the region.

Author Contributions

B. T. Zhobborov: Investigation, formal analysis, writing—original draft. N. N. Khurramov: Validation, methodology, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

References

1. Rouhani A., Skousen J., Tack F.M.G. An Overview of Soil Pollution and Remediation Strategies in Coal Mining Regions // Minerals. - 2023. - Vol. 13, Issue 8. - Article 1064. https://doi.org/10.3390/min13081064
2. Chakraborty P., Singh S., Hazra B. Soil pollution in Indian coal mines, available remediation techniques and rock dust application: A review // Journal of Earth System Science. - 2023. https://doi.org/10.1007/s12040-023-02163-5
3. Wang N., Luo Y., Liu Z., Sun Y. Spatial distribution characteristics and evaluation of soil pollution in coal mine areas in Loess Plateau of northern Shaanxi // Science of The Total Environment. - 2024. https://doi.org/10.1038/s41598-022-20865-6
4. Rouhani A., Newton R.A., Al Souki K.S., Quattrini G., Gusiatin M.Z. A 6-year review status on soil pollution in coal mining areas from Europe // Environmental Geochemistry and Health. - 2024. - Vol. 46, Art. 392. https://doi.org/10.1007/s10653-024-02179-w
5. Akbar W.A., Rahim H.U., Irfan M., Sehrish A.K., Mudassir M. Assessment of heavy metal distribution and bioaccumulation in soil and plants near coal mining areas: implications for environmental

pollution and health risks // Environmental Monitoring and Assessment. - 2024. - Vol. 196, Art. 97. https://doi.org/10.1007/s10661-023-12258-7

6. J., Niu L., Chen Q., Zhou Q., Xiao N., Man J., Ma J., Wei C., Zhang S., Luo Y., Yao Y. Escalating arsenic contamination throughout Chinese soils // Nature Sustainability. - 2024. https://doi.org/10.1038/s41893-024-01341-7
7. Swain C.K. Environmental pollution indices: a review on concentration of heavy metals in air, water, and soil near industrialization and urbanisation // Discover Environment. - 2024. https://doi.org/10.1007/s44274-024-00030-8
8. Liu Z., Fei Y., Shi H., Mo L., Qi J. Prediction of high-risk areas of soil heavy metal pollution with multiple factors on a large scale in industrial agglomeration areas // Scientific Total Environment. – 2022. – Vol. 805. – Article 151874. DOI: https://doi.org/10.1016/j.scitotenv.2021.151874
9. Yuan, B., Cao, H., Du, P., Ren, J., Chen, J., Zhang, H., Zhang, Y., & Luo, H. (2022). Source-oriented probabilistic health risk assessment of soil potentially toxic elements in a typical mining city. Journal of Hazardous Materials. https://doi.org/10.1016/j.jhazmat.2022.130222
10. Liu X., Bai Z., Shi H., Zhou W., Liu X. Heavy Metal Pollution of Soils from Coal Mines in China // Natural Hazards. – 2019. - Vol. 99. - P. 1163-1177. DOI: https://doi.org/10.1007/s11069-019-03771-5
11. Alekseenko A.V., Machevariani M.M., Bech J., Karthe D. Pollution of coal mine soils: global reference concentrations of chemical elements // Environmental Earth Sciences. – 2025. – Vol. 84. – Article 286. https://doi.org/10.1007/s12665-025-12160-0
12. Rouhani, A., Gusiatin, M.Z., & Hejcman, M. (2023). An overview of the impacts of coal mining and processing on soil: assessment, monitoring, and challenges in the Czech Republic. Environmental Geochemistry and Health, 45, 7459–7490. https://doi.org/10.1007/s10653-023-01700-x
13. Sharifi, S.A., Zaeimdar, M., Jozi, S.A., & Hejazi, R. (2023). Effects of Soil, Water and Air Pollution with Heavy Metal Ions Around Lead and Zinc Mining and Processing Factories. Water, Air, & Soil Pollution, 234, 760. https://doi.org/10.1007/s11270-023-06758-y
14. Yu, J., Liu, X., Yang, B., Li, X., Wang, P., Yuan, B., Wang, M., Liang, T., Shi, P., Li, R., Cheng, H., & Li, F. (2024). Major influencing factors identification and probabilistic health risk assessment of soil potentially toxic elements pollution in coal and metal mines across China: A systematic review. Ecotoxicology and Environmental Safety, 274, 116231. https://doi.org/10.1016/j.ecoenv.2024.116231
15. ГН 2.1.7.2041-06. Предельно допустимые концентрации (ПДК) химических веществ в почве. Утверждены постановлением Главного государственного санитарного врача Российской Федерации от 23.01.2006 № 1. Москва, 2006. https://files.stroyinf.ru/Data2/1/4293828/4293828439.pdf

How to cite this article:

Jobborov Bahrom Turg‘unovich and Xurramov Nodir Norboyo‘g‘li. 2026. Soil Contamination with Various Chemical Elements during Coal Mining (A Case Study of the Angren Coal Deposit in Tashkent Region, Republic of Uzbekistan). *Int.J.Curr.Microbiol.App.Sci.* 15(6): 228-235. **doi:** https://doi.org/10.20546/ijcmas.2026.1506.025