OPEN ACCESS
PAPER

Mongolian Journal of Geography and Geoecology - MJGG

Received: 07 May 2025; Accepted: 29 July 2025; Published online: 1 September 2025
https://doi.org/10.5564/mjgg.v62i46.4093

Environmental conditions in the mining areas of the Umnugovi province of Mongolia

***CORRESPONDING AUTHOR**
Olga Gagarinova
gagarinova1963@yandex.ru
0000-0002-2578-3713

CITATION
Olga G, Irina B, Enkh-Amgalan S, Natalia E, Gerelma D, Olga V, Ulgiichimeg G, Bazarvaani S (2025) Environmental Conditions in The Mining Areas of The Umnugovi Province of Mongolia. *Mongolian Journal of Geograhy and Geoecology,* 62(46), 1–6.
https://doi.org/10.5564/mjgg.v62i46.4093

Olga Gagarinova[1,2,*], Irina Belozertseva[1,3], Enkh-Amgalan Sandag[4,5], Natalia Emelianova[1,2], Gerelma Dugarova[1,2], Olga Valeeva[1], Ulgiichimeg Ganzorig[4], Bazarvaani Sarantsetseg[6]

[1]*V.B. Sochava Institute of Geography of the Siberian Branch, Russian Academy of Sciences, Irkutsk, Russia*
[2]*A.E. Favorsky Irkutsk Institute of Chemistry of the Siberian Branch, Russian Academy of Sciences, Irkutsk, Russia*
[3]*Irkutsk State University, Irkutsk, Russia*
[4]*Institute of Geography and Geoecology, Mongolian Academy of Sciences, Ulaanbaatar 15170, Mongolia*
[5]*International University of Ulaanbaatar,Ulaanbaatar, Mongolia*
[6]*Disaster Research Center of Integrated Research Institute at the University of Internal Affairs, Ulaanbaatar, Mongolia*

ABSTRACT
As part of a collaborative project, soil and well water samples were collected from herder households located near the Oyu Tolgoi and Erdenes Tavan tolgoi deposits in Khanbogd and Tsogttsetsii soums of Umnugovi province to assess contamination levels. In 2024, field investigations included sampling soil and well water from herder households within the mining vicinity. The Oyu Tolgoi company conducts monitoring of water quality and water levels for certain wells of herder households within the mine's influence zone. However, comprehensive studies on heavy metal contamination in soil and well water among herders in the mining area remain scarce. More than 20 groundwater samples and over 30 soil samples were collected from areas adjacent to the coal mining operations at the Erdenes Tavan Tolgoi deposit and the copper mining facility at the Oyu Tolgoi deposit. Chemical and analytical procedures were conducted under both field and laboratory conditions using standard methodologies. Metal concentrations were determined by atomic emission spectrometry. Petroleum hydrocarbon contents were measured using a Fluorat analyzer. Soil pH (pH_H2O) was determined potentiometrically. Organic carbon content (C_{org}) was measured using the wet oxidation method according to Tyurin. High concentrations of nickel, copper, zinc, and arsenic, exceeding sanitary and hygienic standards by several fold, were detected in soils of adjacent territories. Near coal mining enterprises, the total soil pollution index (∑c) corresponds to the "moderately dangerous" and "dangerous" pollution categories. Elevated levels of sodium, fluoride, magnesium, chloride, sulphates, and several heavy metals have been detected in groundwater used for residents' water supply. In the vicinity of copper and coal mining enterprises, the water pollution index (WPI) is elevated. Monitoring of water resources conducted by mining enterprises in production areas also indicates contamination and depletion of groundwater. However, these enterprises do not conduct ecological assessments of other natural environmental components.

KEYWORDS
Groundwater, Soils, Pollution, Extreme, Mining enterprises

1. INTRODUCTION

In the mining regions of Umnugovi province, the ecological environment is primarily influenced by water resource scarcity and significant technogenic impacts arising from mining activities. While the expansion of the mining sector has served as a driving force for regional economic development, it has also posed challenges to the traditional livelihood of the local population, namely, livestock herding. Furthermore, industrial growth has already begun to contribute to environmental degradation, including soil, water, and air pollution. To address these concerns, the study was conducted as part of a collaborative project in Khanbogd and Tsogttsetsii soums of Umnugovi Province, where mining has rapidly developed and the population has increased sharply in recent years. The primary objective of this research is to evaluate the impact of mining activities, although economically beneficial, on the livelihoods of indigenous communities and the state of the natural environment. Accordingly, in 2024 and 2025, field investigations were carried out, focusing on landscape-geochemical and socio-economic assessments. This article presents the results of the landscape-geochemical component. Despite the intensity of industrial development in this area, landscape-geochemical research remains insufficient. Within the framework of this study, soil and groundwater samples were collected and analyzed to assess the current ecological status of the region[1].

Field investigations were conducted in the areas of the Oyu Tolgoi and Erdenes Tavan Tolgoi deposits, located in Khanbogd and Tsogttsetsii soums of Umnugovi Province. Oyu Tolgoi is a major copper and gold deposit, whereas Erdenes Tavan Tolgoi represents one of the largest coal deposit clusters in the region. From a landscape-geochemical perspective, this area remains largely unexplored by scientists.

2. RESEARCH METHODS

In July – August 2024, expeditionary landscape-geochemical and water-ecological studies were conducted to determine the level of environmental pollution in the areas of mining enterprises (Tsogttsetsiy and Khanbogd soums of the South Gobi aimag). Samples of groundwater and soils were collected in the areas adjacent to the coal mining enterprises of the Tavan Tolgoi deposit and the copper mining enterprise of the Oyu Tolgoi deposit (Figure 1). The Oyu Tolgoi company conducts monitoring of water quality and water levels for certain wells of herder households within the mine's influence zone.

In 2024, 20 groundwater samples and over 30 soil samples were collected from areas adjacent to the coal mining operations at the Erdenes Tavan Tolgoi deposit and the copper mining facility at the Oyu Tolgoi deposit. The key study sites are located near the mining facilities, on local farmers' lands, and in proximity to wells and boreholes used by local residents.

Groundwater samples were collected using glass bottles and a bathometer from wells (depths ranging from 2.5 to 10 meters) and boreholes (depths ranging from 13 to 120 meters). Soil profiles and test pits were established at the main key sites (Figure 1). Soil samples were taken from mining facilities, agricultural lands, and at varying distances from pollution sources, ranging from 200 meters to 20 kilometres. Background reference sites are located 52 and 60 kilometres away from the mining operations. Soil samples were collected from all horizons throughout the soil profile depth.

According to the Water Pollution Index (WPI) relative to the maximum permissible concentration [2], groundwater samples from wells and boreholes are classified as conditionally clean, moderately polluted, and polluted [3]. Elevated WPI values (2.11; 1.03; 1.29; 1.16) were observed at key sites No. 2, 12, 13, and 15, respectively, located near copper and coal mining facilities, as well as at the border with China, where coal unloading and loading activities take place.

The chemical and analytical analyses were performed both in the field and laboratory settings, following standard procedures at the Institute of Geography and Geoecology of the MAS, as well as at the accredited Chemical and Analytical Center of the Sochava Institute of Geography SB RAS and the "Geoanalyst" laboratory, which is certified under GOST R 51232-98 and ISO 11885 [4]. In the field, parameters such as pH, fluorides, chlorides, hydrocarbonate, phosphates, ammonium, nitrites, and suspended solids in water were measured on the day of sampling using a mobile complex chemical laboratory equipped with appropriate instruments like pH meters and photocolorimeters, employing generally accepted methods [5]. To assess the environmental status of groundwater, the most stringent sanitary and hygienic standards—those of the Russian Federation—were applied [6]. The maximum permissible concentrations (MPCs) for certain heavy metals in drinking water under Russian regulations are up to two times lower than those specified in Mongolian standards. Furthermore, for

some heavy metals, no regulatory limits are defined in the Mongolian standards.

In addition, data from geoecological monitoring of the industrial sites' territories—provided by the respective enterprises, the public organization "Monkhnogoongalba," and the administrations of Tsogttsetsii and Khanbogd districts—were also incorporated into the environmental assessment.

3. RESULT AND DISCUSSION

Existing data are limited to analytical reports from Mongolian public organizations and the mining companies themselves Eco-geochemical studies have been conducted in other, more accessible mining regions, such as the Selenge River basin [7], the Pribaikal region [8], and Zabaikalye [9]. These studies have revealed abnormally high concentrations of trace metals (TMs) in soils and vegetation near both active and long-abandoned mining sites.

The landscape-geochemical and water-ecological investigations conducted in 2024 provided valuable insights into the current condition of soils and water resources in the vicinity of the Oyu Tolgoi and Tavan Tolgoi mining enterprises (Figure 1).

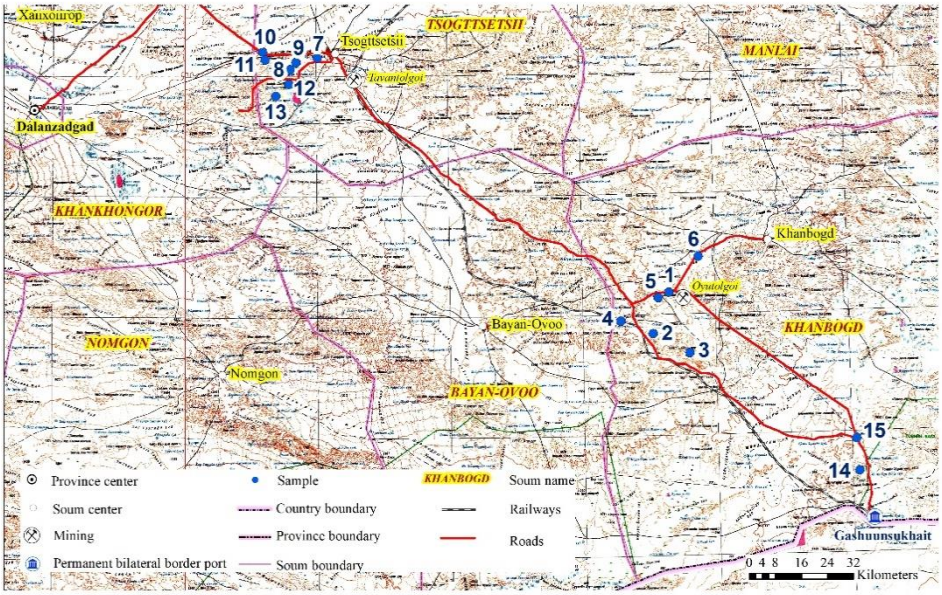

Figure 1. Scheme of soil and water sampling

The soil cover within the study area is predominantly characterized by sierozem-like (Kastanozems) soils. Less frequently, light-humus (Eutric Leptosols) and humus-rich (Eutric Arenosols) soils are observed. The soils in this region are generally carbonate-rich (ranging from 1.09% to 9.09%), with a composition primarily of sandy loam and light loamy textures. Their pH levels vary from slightly alkaline to strongly alkaline (8.0 to 9.2), reflecting the arid climatic conditions prevalent in the area. Most soils are non-saline (with water extract mineralization between 0.01% and 0.09%), except for those located on site 4, which exhibit a chloride-sulfate salinity type with an average salinity level of approximately 0.78% (see Figure 1, site 4). The water extracts from soils at key sites contain ions such as hydrocarbonate (0.030–0.061%), chlorides (0.014–0.070%), sodium (0.028–0.061%), and sulphates (0.021–0.152%). The organic matter content across the soils is relatively low, ranging from 0.07% to 0.84%. Notably, higher nitrate levels (10–18 mg/kg) were observed in the soil samples from farming areas compared to other regions, which showed levels between 0 and 5 mg/kg. The soils in the study region generally exhibit low concentrations of mobile phosphorus (0.4–2.0 mg/kg) and potassium (9–106 mg/kg), with the exception of site 4, where the sierozem-like saline soil demonstrated an average potassium concentration of approximately 347 mg/kg (Figure 1).

Concentrations of Ti, Mn, Ba, Mo, Pb, Be, V, Cr, Sr, Co, Cd in the soils of the study areas do not exceed sanitary and hygienic standards (Table 1). At the same time, in the soils of the areas adjacent to coal mining enterprises, a high content of Ni, Cu, Zn and As is noted, exceeding the Maximum allowable concentrations. And near the copper mining enterprise, elevated concentrations of Ni, Zn and As

were also found (Table 1). Polluting chemical elements accumulate on the carbonate (alkaline), sorption and organic geochemical barriers. The index of total soil pollution (∑c), calculated according to [10] showed that the soils of most of the studied sites belong to the category of permissible pollution (∑c from 3.7 to 13.9). Moderately hazardous pollution category was found in soils on sites No. 2 (∑c = 27.7) and 10 (∑c = 24.9) and hazardous pollution category (∑c = 37.3) was recorded in soil on site No. 7 on the territory of a farm located near a coal mining enterprise.

Table 1. Limit and average values of microelement content in the upper soil horizons (0-20 cm) of the copper and coal deposits and mining area

Limit and average values	Fe	Ti	Mn	Ba	Mo	Pb	Ni	Cu	Be	V	Cr	Zn	Sr	Co	Cd	As
	%	mg/kg														
Oyu Tolgoi (Copper Mining)																
max	3.98	3400	1295	658	2.2	22	27	20	3.6	73	49	149	357	10	0.00	47
min	2.08	2705	484	451	0.0	5	12	9	1.6	65	16	42	204	6	0.00	0
average	2.93	3104	748	546	1.7	10	17	18	2.7	69	26	72	263	9	0.00	12
Tavan Tolgoi (Coal Mining)																
max	3.38	3100	710	580	5.1	17	29	131	3.1	90	49	123	403	13	0.22	13
min	2.12	2007	442	424	0.0	2	9	10	1.5	55	6	38	175	7	0.00	0
average	2.47	2704	611	528	2.6	9	21	39	2.1	73	31	72	323	10	0.12	4
Background (beyond 50 km from enterprises)	2,69	2007	442	424	0,0	6	14	10	1.6	55	17	38	175	7	0.10	2
Maximum permissible concentrations (SanPiN 1.2.3685-21)	-	-	1500	-	-	32-130	20-80	33-132	-	150	100	55-220	-	17	0.5-2.0	2,0
Hazard class**	-	-	3	3	2	1	2	2	-	3	2	1	3	2	1	1

*Note: * According to SanPiN 1.2.3685-21; dash (-) indicates that the installation is not present; Hazard class ** denotes the Hazard class*

The findings of the studies indicate that the underground waters obtained from wells at depths of 13 meters and between 70 to 90 meters, as well as the shallower wells (2.5 to 10 meters deep) near the copper mining operation "Oyu Tolgoi," are generally fresh, with water mineralization levels ranging from 502 to 799 mg/dm³. Notably, only at one location (Site No. 5, well 13 meters deep) was slightly brackish water observed, exhibiting a higher mineralization of approximately 1011 mg/dm³. Based on their chemical composition, these waters predominantly belong to the calcium and sodium group of the hydrocarbonate type, while deeper wells exceeding 70 meters tend to fall within the sodium sulfate class. The boreholes and wells contain elevated concentrations of sodium (203 mg/dm³) and fluorine (ranging from 1.00 to 2.74 mg/dm³). Additionally, certain samples exceeded the MPC established by SanPiN 1.2.3685-21 [11] for manganese (0.12 mg/dm³), lead (0.02 mg/dm³), molybdenum (0.1 mg/dm³), and cadmium (0.003 mg/dm³).

Near the coal-mining site "Tavan Tolgoi," the groundwater exhibits higher overall mineralization levels, ranging from 534 to 2003 mg/dm³ (Table 2). The composition of the water varies depending on the depth and location of the boreholes and wells, ranging from fresh to slightly brackish. Groundwater from deeper horizons (greater than 80 meters) generally belongs to the sodium group within the chloride class. In the water samples from the wells and boreholes, concentrations of magnesium (Mg) exceeded the maximum allowable concentration (MAC) at levels up to 77 mg/dm³, chlorine (Cl) reached up to 430 mg/dm³, and sulphates (SO_4) were found up to 790 mg/dm³. Additionally, elevated levels of iron (Fe) at 0.63 mg/dm³ and cadmium (Cd) at 0.002 mg/dm³ were observed (Table 2). The groundwater's pH is primarily

slightly alkaline, ranging from 7.6 to 8.2, with one site exhibiting a near-neutral pH of 7.3 within the MAC.

The concentration of oil products in the groundwater within the study areas generally ranges from 0 to 0.022 mg/dm³. However, at site No. 6 near the Tavan-Tolgoi coal mining enterprise, the oil product level in well water (located at a depth of 3 meters) was measured at 0.141 mg/dm³, which slightly exceeds the MAC of 0.10 mg/dm³. Based on the water pollution index (WPI) as outlined by Glotova [2], well and borehole waters are classified across a spectrum from clean to polluted. Notably, elevated WPI values of 2.11, 1.03, 1.29, and 1.16 have been observed at sites No. 2, 12, 13, and 15, respectively.

Table 2. Limit and average values of macro- and microelements in groundwater in the territory of copper and coal deposits and mining, mg/dm³

Limit and average values	Mo	Mn	Ba	Al	Pb	Ni	Cu	Fe	Zn	Sr	Co	Cr	V	Cd	As	Hg
Oyu Tolgoi (Copper Mining)																
max	0,10	0,12	0,08	0,04	0,02	0,02	0,02	0,09	0,00	1,71	0,005	0,05	0,02	0,003	0,09	0,000
min	0,01	0,00	0,01	0,00	0,00	0,00	0,01	0,02	0,00	0,21	0,000	0,00	0,00	0,000	0,00	0,000
average	0,04	0,04	0,03	0,01	0,00	0,01	0,01	0,04	0,00	0,71	0,002	0,03	0,01	0,001	0,04	0,000
Tavan Tolgoi (Coal Mining)																
max	0,07	0,06	0,06	0,02	0,00	0,00	0,01	0,07	0,09	4,48	0,001	0,01	3,37	0,002	0,02	0,000
min	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,09	0,000	0,00	0,00	0,000	0,00	0,000
average	0,03	0,03	0,02	0,01	0,00	0,00	0,00	0,03	0,023	1,10	0,001	0,00	0,49	0,001	0,01	0,000
MPC (SanPiN 1.2.3685-21)*	0,07	0,1	0,7	0,2	0,01	0,02	1	0,3	-	7	0,1	-	0,1	0,001	0,01	0,001
Hazard class **	-	4	4	4	2	3	3	2	3	3	3	3	3	2	1	1

*Note: * According to SanPiN 1.2.3685-21; dash (-) indicates that the installation is not present; Hazard class ** denotes the Hazard class*

4. CONCLUSIONS

The results of the conducted landscape-geochemical studies indicate that the high degree of mineralization and the sulfate-chloride class of groundwater correspond to the natural climatic conditions of the dry steppe and semi-desert zones, characterized by low precipitation and high evaporation rates. Analysis of metal content in groundwater from wells and boreholes revealed exceedances of maximum permissible concentrations (MPC) for certain elements (Mn, Pb, Fe, Cr, As mg/dm³), while levels of Mo, Ba, Al, Ni, Cu, Zn, Sr, Co, Cd, and Hg remained within acceptable limits. Groundwater from some farms is suitable only for technical uses. Unfortunately, the local population uses these waters for drinking purposes. Therefore, groundwater in this area requires treatment prior to potable use.

Soil analysis showed that the study area is predominantly covered by sierozem-type soils with a light granulometric composition, low organic matter content, and limited essential plant nutrients. The soils are mainly carbonate-rich, with some saline patches. The land is primarily used by the local population as pasture. Elevated concentrations of Ni, Cu, Zn, and As were observed near mining enterprises. Their accumulation is facilitated by carbonate and sorption geochemical barriers.

The study identified hotspots of adverse environmental conditions, not only within mining enterprise territories but also on farms in adjacent areas. Additional geochemical investigations are necessary to develop environmental protection measures, including assessments of toxic substances in vegetation and livestock products and their impact on local public health. Studies involving specialized experts are needed to design and justify sanitary protection zones around enterprises and water treatment measures at the copper mining facility. Instead of chlorination, ozonation of water is recommended for potable water treatment.

ACKNOWLEDGMENTS

The study was conducted with financial support from the Russian Science Foundation grant No. 24-47-03004, focusing on “Geoeconomic and geoecological priorities of new resource-industrial development of the regions of eastern Russia and Mongolia in the context of an aggravated geopolitical situation and the creation of international transport corridors.” More

information can be found at https://rscf.ru/project/24-47-03004/.

REFERENCE

[1] Environmental monitoring with the participation of the population of the settlement of Khotolbor, Non-governmental organization, "Monkh Nogoon Galba, hamtyn oroltsootoy baigal orchny khyanal tshinjilgee khotolbor," Tsogttsetsii, Umnugovi, pp.23, 2023.

[2] N.V. Glotova, *Monitoring the environment.* Chelyabinsk Publishing house of SUSU, 2006.

[3] ISO 11885 (GOST R 57165-2016), Water quality — Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP-OES), National Standard of the Russian Federation, 2018. Accessed on: March 10, 2025. [Online]. Available: https://docs.cntd.ru/document/1200140392

[4] ISO 14869, Soil quality — Dissolution for the determination of total element content, 2017. Accessed on: March 15, 2025. [Online]. Available: https://nd.gostinfo.ru/document/6267384.aspx

[5] Z. G. Ilkovskaya, A. S. Konovalov, and V. V. Ponomarev, *Agrochemical methods for soil investigation*. Moscow: Nauka, Russia, 1975.

[6] G.M. Shpeyzer and L.A. Mineeva, *Manual for chemical analysis of water.* Irkutsk: ISU, Russia, 2006.

[7] N. Kasimov, N. Kosheleva, P. Gunin, I. Korlyakov, O. Sorokina, and I. Timofeev, "State of the environment of urban and mining areas in the Selenga Transboundary River Basin (Mongolia Russia)," *Environ. Earth Sci*., vol. 75, no. 18, pp. 1283, 2016. Available: doi: 10.1007/s12665-016-6088-1

[8] I. B. Vorobyeva and N.V. Vlasova, "Physicochemical properties and thermal regime of soils and overburden from coal mine dumps," *Geography and Natural Resources*, vol. S5, pp. 60–66, 2020.

[9] V. B. Vyrkin et al., "Current environmental conditions and ecological issues of the Middle Prionony region," *Geography and Natural Resources*, vol. 1, pp. 25–35, 2014. Available: doi: 10.1134/S187537281401003X

[10] Yu. E. Sae et al., *Geochemistry of the environment*. Moscow: Nedra, 1990.

[11] SanPiN 1.2.3685–21, Hygienic standards and requirements for ensuring safety and (or) harmlessness of environmental factors for humans. [Online]. Available: https://ds278-krasnoyarskr04.gosweb.gosuslugi.ru/netcat_files/19/8/SP12368521_0.pdf.