International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 06 ISSUE 03 Pages: 28-35
OCLC – 1368736135

Journal Website: http://sciencebring.com/index.php/ijasr

Copyright: Original content from this work may be used under the terms of the creative commons attributes 4.0 licence.

Research Article

Study of The Negative Impact of Industrial Enterprises Located in Transboundary Areas on The Dynamics of Groundwater and Surface Water Elements in The Fergana Region Based on Scientific Research

Submission Date: January 20, 2026, **Accepted Date:** February 15, 2026,
Published Date: March 09, 2026
Crossref doi: https://doi.org/10.37547/ijasr-06-03-04

Abdurasul Abdusamatovich Bazarov
Lecturer, Fergana State Technical University, Fergana, Uzbekistan

Abstract

This study investigates the dynamics of groundwater and surface water elements in the Fergana region and evaluates the negative environmental impacts of industrial enterprises located in transboundary areas. The research focuses on the influence of water inflows from the northern and southern territories on the hydrochemical composition and ecological condition of regional water resources. Special attention is given to the assessment of anthropogenic pressures caused by nearby industrial activities and their potential contribution to changes in water quality. Field observations and analytical assessments were used to examine the concentrations of selected heavy elements in both groundwater and surface water systems. The study also considers the hydrological characteristics of major rivers in the region, including the Isfara, Sokh, Shohimardon, and Isfayram rivers, which play an important role in shaping local water balance. The results highlight the increasing vulnerability of water resources to industrial pollution and emphasize the need for improved environmental monitoring and sustainable management of transboundary water systems.

Keywords

Fergana region, groundwater, northern and southern territories, industrial enterprises, surface water, heavy elements, Isfara River, Sokh River, Shohimardon River, Isfayram River, industrial waste, riverbeds.

International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 06 ISSUE 03 Pages: 28-35
OCLC – 1368736135

Crossref doi Google Scholar WorldCat MENDELEY

ISSN-2750-1396

INTRODUCTION

Water resources represent one of the most important natural components of regional ecosystems and play a key role in ensuring environmental sustainability and socio-economic development. In arid and semi-arid regions such as the Fergana Valley, groundwater and surface water systems serve as essential sources of drinking water, irrigation, and industrial supply. However, intensive industrial development and mining activities in transboundary territories have significantly increased anthropogenic pressure on water resources, leading to changes in their chemical composition and ecological condition [1–3].

In recent decades, numerous scientific studies have focused on the influence of industrial activities on hydrogeological environments, particularly in regions with complex geological structures and transboundary water systems. Industrial enterprises located near river basins and groundwater recharge zones can contribute to the accumulation of toxic elements and heavy metals in aquatic environments, thereby posing potential environmental and public health risks [4–6]. Such impacts are particularly significant in mountainous and mining regions where geological formations facilitate the migration of chemical elements into groundwater systems [7].

Based on several years of scientific investigations and monitoring studies, the present research analyzes the changes in the composition of groundwater and surface waters in the Fergana region. Particular attention is given to the influence of industrial enterprises located in surrounding transboundary territories. The conducted scientific analyses examined various types of technogenic impacts on the geological environment and assessed their intensity. As a result, the concentration and distribution of chemical elements in groundwater were identified and evaluated [8].

The formation and recharge zones of groundwater resources in the region are located in areas where mining and mineral-processing industries operate actively. These enterprises significantly influence the physical and chemical properties of both groundwater and surface water and contribute to water contamination processes. In particular, industrial facilities such as the Khaydarkon Antimony Mining Complex, which affects the Sokh River basin, and the Kadamdzhay Antimony Plant, influencing the Shohimardon River basin, play a major role in the contamination of southern transboundary groundwater resources. Similarly, from the northern side of the region, industrial activities of the Mailisu Mining and Chemical Complex, associated with the Mailisu River, and the Shokaptar Mining Complex, connected with the Sumsar River basin, have historically contributed to groundwater pollution. In some areas, these processes continue to the present day, posing a serious threat to the hydrochemical stability of regional water systems [9–11].

Understanding the dynamics of groundwater and surface water elements under the influence of industrial activities is therefore essential for assessing environmental risks and developing effective strategies for sustainable water resource management in transboundary regions.

METHODS

International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 06 ISSUE 03 Pages: 28-35
OCLC – 1368736135

Crossref doi Google Scholar WorldCat MENDELEY

ISSN-2750-1396

The study area covers transboundary groundwater recharge and formation zones within the Fergana region, where both natural and anthropogenic factors influence the hydrogeological environment. Particular attention was given to irrigated agricultural lands and river cone deposits located within the basins of the Isfara, Sokh, Shohimardon, Isfayram, Mailisu, and Sumsar rivers. These areas include alluvial fan deposits, inter-cone territories, foothill plains, and piedmont zones where groundwater recharge and migration processes are actively occurring.

Field investigations were conducted to evaluate the influence of transboundary groundwater systems and surface water flows on the hydrochemical composition of regional water resources. Observations indicated that although contamination levels in some groundwater-bearing layers and surface waters remain relatively limited, noticeable hydrochemical changes have occurred in several parts of the study area.

Mining and mineral-processing enterprises located in neighboring transboundary territories represent an important source of environmental pressure. Waste materials from these industrial complexes are often accumulated near riverbeds, which creates favorable conditions for the migration of pollutants into groundwater systems. Chemical analysis of such waste materials revealed elevated concentrations of potentially hazardous elements, including Pb (6000 mg/kg), As (1700 mg/kg), Zn (2100 mg/kg), and Sb (1640 mg/kg). These elements may gradually migrate into groundwater through infiltration and surface runoff processes.

Agricultural activities also contribute to the modification of groundwater quality. The use of mineral fertilizers in irrigated agriculture introduces additional chemical elements into the soil and aeration zone. It is estimated that the application of mineral fertilizers can lead to the accumulation of approximately 10–300 grams of heavy metals per hectare of cultivated land. Although some sources suggest that nearly 90% of the studied territory is occupied by agricultural land, irrigation practices have also led to secondary hydrogeological changes, particularly in low hypsometric areas where groundwater levels have risen due to excessive irrigation.

Assessment of the present geological and hydrogeological conditions indicates that the mineralization of transboundary river waters—such as the Isfara, Sokh, Shohimardon, Isfayram, and Mailisu rivers—ranges from 0.6 to 0.7 g/L, while water hardness varies between 6 and 7 mg-eq/L. During periods of reduced river discharge these values tend to increase. In addition, localized exceedances of permissible concentrations of heavy metals, petroleum products, and certain chemical elements have been detected in both groundwater and surface water.

Based on the migration time of harmful ingredients to groundwater levels, aquifers in the study area were classified as either weakly protected or unprotected from contamination. The estimated travel time of pollutants reaching groundwater ranges from 64 to 139 days. In particular, groundwater resources in the Vodil, Sumsar, and Dalvarzin areas are considered highly vulnerable due to the absence of natural protective geological barriers.

International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 06 ISSUE 03 Pages: 28-35
OCLC – 1368736135

Crossref doi Google Scholar WorldCat MENDELEY

ISSN-2750-1396

Groundwater within the alluvial deposits of the Shorsuv River is naturally characterized by elevated mineralization, ranging from 1.2 to 1.4 g/L, with total hardness values of 8–12 mg-eq/L. In recent decades, the expansion of irrigated agricultural lands has caused significant hydrochemical changes in several groundwater fields. For example, in the Sokh, Isfara, and Chimyon-Avval groundwater areas, mineralization levels have increased from 0.4–0.6 g/L to 1.1–1.3 g/L, while total hardness has increased from 5–7 mg-eq/L to 10–14 mg-eq/L.

The spatial extent of groundwater contamination has also expanded significantly. Compared with 1980 conditions, the contaminated zone within the Sokh groundwater field has increased to approximately 280 km^2, while the Isfara groundwater field has expanded by 40–50 km^2. Overall, the contaminated area within the southern Fergana transboundary groundwater zone has reached nearly 400 km^2. In some locations, contamination has penetrated to depths of 200–250 meters. Moreover, hydrochemical deterioration has also begun to appear in the central parts of alluvial fan deposits where groundwater was previously considered relatively stable.

Another important factor influencing groundwater dynamics is the development and irrigation of new agricultural lands. Since 1980, the irrigation and cultivation of approximately 5000 hectares within the Burgandi massif of the Kyrgyz Republic have contributed to a significant rise in groundwater levels. In certain areas, groundwater has risen by up to 35–40 meters, which has affected adjacent territories including the Rishton district. As a result, salinization processes have been observed in shallow groundwater systems.

Results and Discussion

The results of the conducted investigations demonstrate that mining and mineral-processing activities located in transboundary areas significantly influence the hydrochemical state of groundwater and surface water resources in the Fergana region. The degree of this impact varies depending on the geological structure, hydrological conditions, and the intensity of industrial and agricultural activities within the study area.

Hydrochemical analyses indicate that several trace elements associated with mining activities are present in groundwater systems. In the Mailisu area, groundwater contamination by chromium, nickel, and selenium was detected at levels approximately one to three times higher than natural background concentrations. At the same time, uranium concentrations were found to be lower than their natural background levels. Analysis of riverbed sediments also showed that the concentrations of heavy metals remain relatively low in some locations, suggesting limited accumulation within river sediments. The distribution of heavy metal concentrations detected in mining waste materials located near riverbeds is illustrated in Figure 1.

International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 06 ISSUE 03 Pages: 28-35
OCLC – 1368736135

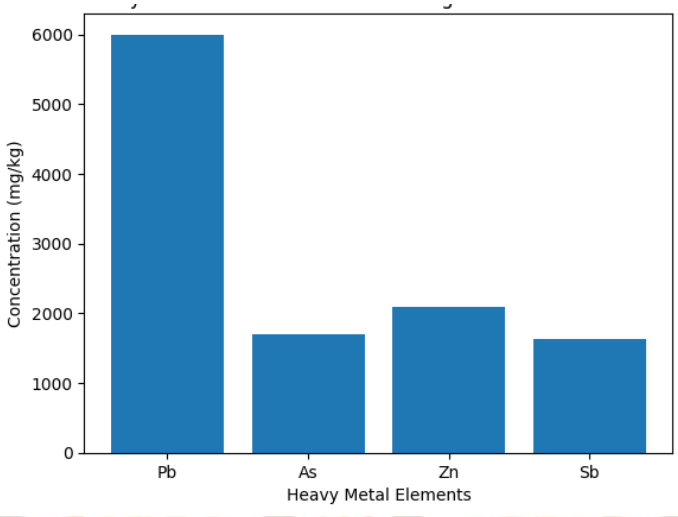

Figure 1. Heavy metal concentrations in mining waste materials located near transboundary riverbeds.

The analysis of groundwater mineralization and hydrochemical characteristics indicates that both natural geological processes and anthropogenic activities contribute to the observed changes in water quality. In particular, the expansion of irrigated agricultural lands and intensive use of mineral fertilizers have influenced groundwater recharge and chemical composition. As a result, groundwater mineralization has increased in several parts of the study area. The dynamics of these changes are presented in Figure 2, which demonstrates the increase in groundwater mineralization associated with agricultural development and irrigation practices.

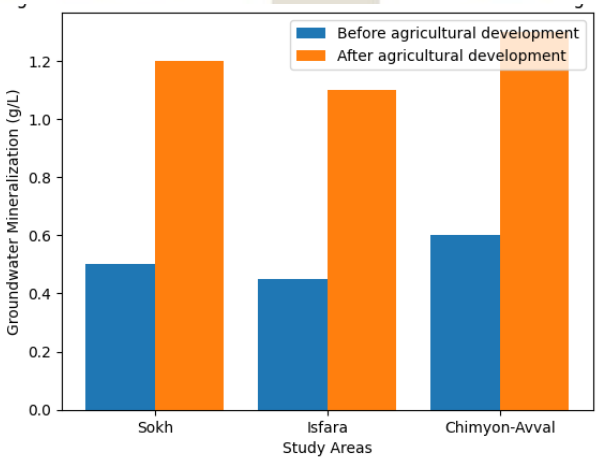

Figure 2. Changes in groundwater mineralization associated with agricultural development and irrigation activities in the study area.

International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 06 ISSUE 03 Pages: 28-35
OCLC – 1368736135

Crossref doi Google Scholar WorldCat MENDELEY

ISSN-2750-1396

Hydrochemical conditions also vary between different locations within the region. In the Sumsar area, investigations showed that groundwater and surface waters are not significantly contaminated with heavy metals or radioactive elements. However, slightly elevated concentrations of arsenic and lead were observed, reaching approximately one to three times their natural background levels. At the same time, some hydrochemical characteristics such as mineralization and hardness indicate the presence of natural geochemical processes influencing groundwater composition.

Soil investigations conducted in the Vodil area revealed moderate to high contamination by antimony and arsenic. These elements are commonly associated with mining and ore-processing activities and may enter the geological environment through industrial waste materials and tailings deposits. The general hydrochemical characteristics of groundwater and surface waters in the investigated territories are summarized in Table 1, which presents the main observed elements, water mineralization levels, and hardness values in different parts of the study area.

Table 1. Hydrochemical characteristics of groundwater and surface water in selected areas of the Fergana transboundary region.

Area	Main Observed Elements	Water Mineralization (g/L)	Water Hardness (mg-eq/L)
Mailisu	Cr, Ni, Se (1–3 background levels)	0.6–0.7	6–7
Sumsar	As, Pb (1–3 background levels)	0.6–0.7	6–7
Vodil	Sb, As contamination	0.6–0.7	6–7
Shorsuv deposits	Naturally mineralized groundwater	1.2–1.4	8–12

The environmental risks associated with these processes are further intensified by the geographical location of eastern regions of Uzbekistan, which border the Kyrgyz Republic and the Republic of Tajikistan. Many mining and mineral-processing enterprises are located directly within the valleys of transboundary rivers. Industrial waste and wastewater generated by these enterprises may enter river systems and be transported downstream, potentially introducing radionuclides, heavy metal salts, and other toxic substances into the geological environment of neighboring territories.

The complexity of transboundary pollution is further increased by the fact that many sources of contamination are located outside the territory of Uzbekistan, while their environmental effects are observed downstream within the country. The geological structure of these mountainous transboundary areas is highly complex and is characterized by significant seismic activity. Additional environmental risks arise from

International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 06 ISSUE 03 Pages: 28-35
OCLC – 1368736135

seasonal floods, heavy precipitation events, mudflows, and the gradual degradation of mountain lake dams. These natural processes may accelerate the migration of pollutants into river systems and groundwater aquifers.

Major industrial facilities located in these transboundary areas include the Mailisu uranium mining waste storage sites along the Mailisu River, the Sumsar lead deposit, and the Khaydarkon and Kadamdzhay antimony–mercury mining complexes located within the Shohimardon and Sokh river basins. Long-term industrial activity in these regions has increased the level of environmental pressure on the geological environment and may pose potential risks to both ecosystems and human health.

Overall, the obtained results indicate that transboundary industrial activities remain one of the most significant factors influencing the hydrochemical dynamics of groundwater and surface water resources in the Fergana region. Continuous environmental monitoring and coordinated transboundary water management strategies are therefore essential for reducing ecological risks and ensuring the sustainable use of regional water resources.

Conclusions

The relevance of this research lies in the identification and assessment of environmental pressures occurring in transboundary territories of the Fergana region. The study focused on determining the degree of contamination within the aeration zone by heavy metals and evaluating the influence of irrigation processes on the migration of these elements into groundwater systems. Particular attention was given to understanding the movement of heavy metals through various geological formations and their potential pathways within groundwater environments.

Field investigations and hydrochemical analyses demonstrated that contamination processes in the aeration zone can significantly influence the chemical composition of groundwater. The migration of heavy metal salts through soils and geological layers was observed under irrigation conditions, indicating that anthropogenic activities, including agricultural practices and mining operations, play an important role in shaping groundwater quality.

The obtained results show that transboundary mining enterprises and agricultural activities contribute to the gradual accumulation and movement of hazardous elements within the geological environment. These processes may pose potential risks to groundwater abstraction facilities and regional water supply systems. Therefore, continuous monitoring of hydrochemical conditions, improvement of environmental management practices, and the development of preventive measures aimed at reducing transboundary pollution are essential for ensuring the sustainable use and protection of groundwater resources in the Fergana region.

References

1. Bazarov, A. A. (2023). Some remarks on the level of study of the geological and hydrogeological structure of the Fergana area. European Journal of Emerging Technology and Discoveries, 1(3), 41–48. https://europeanscience.org/index.php/1/article/view/211
2. Bazarov, A. A. (2023). Problems associated with the Sokh River entering from

International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 06 ISSUE 03 Pages: 28-35
OCLC – 1368736135

neighboring countries, its hydrographic conditions, and the study of heavy metal content in its waters beyond mercury. Modern American Journal of Engineering, Technology, and Innovation, 1(9), 246–251.

3. Bazarov, A. A. (2020). Bukhoro–Karshi va G‘arbiy Sibir neft va gaz hududlaridagi yer osti va yer usti suvlarida simobning tarqalish qonuniyatlarini o‘rganish hamda ularni qiyoslash. Science and Education, 1(3), 86–92.
4. Ibragimov, A. S., Bazarov, A. A., & Omonova, M. S. (2022). Study of the distribution and physico-chemical properties of deep groundwater in some areas of the Altiaryk and Besharik districts of the Fergana region and their rational use. Eurasian Journal of Engineering and Technology, 5, 120–124. https://geniusjournals.org/index.php/ejet/article/view/1266
5. Jorayev, T., & Qurbanov, J. (2010). Assessment of groundwater pollution levels in transboundary areas of the eastern part of the Republic of Uzbekistan and development of environmental protection measures (Research Report No. 322, 2007–2010). State Enterprise “HYDROINGEO Institute”.
6. Appelo, C. A. J., & Postma, D. (2005). Geochemistry, groundwater and pollution (2nd ed.). A.A. Balkema Publishers.
7. Foster, S., & Chilton, J. (2003). Groundwater: The processes and global significance of aquifer degradation. Philosophical Transactions of the Royal Society B: Biological Sciences, 358(1440), 1957–1972.
8. Freeze, R. A., & Cherry, J. A. (1979). Groundwater. Prentice Hall.
9. Smedley, P. L., & Kinniburgh, D. G. (2002). A review of the source, behaviour and distribution of arsenic in natural waters. Applied Geochemistry, 17(5), 517–568.
10. WHO. (2017). Guidelines for drinking-water quality (4th ed.). World Health Organization.
11. Zektser, I. S., & Everett, L. G. (2004). Groundwater resources of the world and their use. UNESCO International Hydrological Programme.