INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 26, No. 5, p. 202-208, 2025

RESEARCH PAPER OPEN ACCESS

Microbiological regime of some transboundary Rivers of Azerbaijan

A. T. Huseynov[1], G. M. Hasanova[1], S. I. Aliyeva[2], V. Y. Hasanova[1], S. A. Abdullayeva[1], E. I. Tahirova[2], S. I. Aliyev[2], S. S. Suleymanov[2], P. Z. Muradov[*1]

[1]*Institute of Microbiology, Ministry of Education of the Republic of Azerbaijan, Baku City, Azerbaijan*

[2]*Institute of Zoology of the Ministry of Education of the Republic of Azerbaijan, Baku City, Azerbaijan*

Key words: Transboundary rivers, Saprotrophic microorganisms, Physiological groups, Anthropogenic factors, Pollution level

http://dx.doi.org/10.12692/ijb/26.5.202-208 Article published on May 07, 2025

Abstract

In the presented article studied the microbiological regime of the transboundary rivers like as Araz and Ganikh in the territory of the Republic of Azerbaijan. In a country where up to 70% of its surface water resources are formed by transboundary rivers, these rivers, especially the Araz river, enter the territory of Azerbaijan in a biologically and chemically polluted state and the pollution continues throughout the country. In this case, the degree of pollution of these rivers across the country also differs from each other. Thus, while the pollution of the Ganikh River in Azerbaijan is weak, this process in the Araz River weakens somewhat after entering the country, but after a certain distance, the process continues along the entire course until it flows into the Kura River in an ascending line. The reasons for this different pollution are mainly related to the number of settlements along the river, the nature of river use, the lack of a centralized sewage system and so on.

[*] **Corresponding Author:** P. Z. Muradov ✉ mpanah@mail.ru

Introduction

The sustainable development of human society depends heavily on the efficient use of natural resources, including groundwater and surface freshwater resources. One of the most pressing problems of the modern era is the reliable water supply of the population and various economic sectors. The enormous growth of the world's population and demands is leading to the introduction of new land into crop rotation and the constant expansion of industrial sectors. Moreover, there is a trend of decreasing the world's available water resources as a result of climate change. As a result, water supply is deteriorating sharply in many regions (Maria *et al.*, 2021; Páll *et al.*, 2013; Zhao and Boll, 2022). This directly affects the food supply of the population and the ecological security of the regions (Ingrao *et al.*, 2023).

As is known, most of the territory of the Republic of Azerbaijan has an arid and semi-arid climate (Aliyev *et al.*, 2023). A significant part of the country's water resources is provided by highly polluted transit rivers, whose water levels fluctuate significantly throughout the year and often drop sharply (Muradov, 2022). At the same time, in recent years, under the influence of global climate change, serious differences have emerged in the distribution regime of precipitation, and the humidity coefficient has decreased in most regions (Science.gov.az, n.d.). As a result of intensive population growth, the development of the country's economy, including agriculture, the expansion of arable land, irrigation and drinking water supply networks, the demand for water is constantly increasing. As a result of all this, as well as the inefficient use of water resources, there are still problems in providing the country with drinking and irrigation water. There is a growing need to implement urgent, scientifically based measures to ensure the water security of the republic, to find and protect new water sources, to apply advanced irrigation techniques and technologies, and to conduct comprehensive and purposeful fundamental and innovative scientific research for all of this. In general, it should be noted that Azerbaijan's water resources are extremely limited. Thus, the country's water resources per capita and per territory are 7.7 and 8.3 times less than in Georgia, and 2.2 and 1.7 times less than in Armenia (Mamedov and Abduev, 2018). About 90% of agricultural products in the country are produced mainly in the Kura-Araz lowland with arid climate (Science.gov.az, n.d.), that is, the amount of possible evaporation in these areas is significantly greater than precipitation. Naturally, under these conditions, agricultural production is impossible without irrigation.

It is known that more than 70% of the water balance of our republic is formed by transboundary rivers. Most of the transboundary rivers enter our country from the territory of neighboring states Georgia and Armenia. What is dangerous for us is that the republics of Armenia and Georgia have not joined any international conventions on environmental protection (Ansarova *et al.*, 2021; Huseynov *et al.*, 2017; Muradov, 2022). However, Azerbaijan is a party to 17 different international conventions in this area, including the Convention on the Protection of Transboundary Waters. In order to resolve the problems of transboundary water basins at the regional level within the framework of international norms, Azerbaijan has ratified the Helsinki Convention "On the Protection and Use of Transboundary Watercourses and International Lakes". However, the fact that Armenia and Georgia have not joined this convention complicates the solution to the problem (Muradov *et al.*, 2025). We do not have any international agreements that would affect them. Therefore, the biological safety of transboundary river waters coming from this country must be constantly monitored.

Therefore, the purpose of the presented work is dedicated to the microbiological assessment of the modern ecological state of transboundary rivers such as Araz and Ganikh in the territory of the Republic of Azerbaijan.

Materials and methods

Research was carried out on the Araz river, which originates in the territory of the Republic of Turkey

and crosses the borders with Armenia and Iran, and the Ganikh River, which passes through the territory of Georgia. The Ganykh river originates in Georgia on Mount Didi-Borbalo (2837 m) of the Main Caucasus Range. It receives numerous small rivers downstream and receives its largest tributary, the Gabyrri River (Iori), 4.5 km before its mouth. The middle and lower reaches form the Azerbaijan-Georgia state border. 30% of its annual flow is rainfall, 40% is groundwater, and 30% is snow water. The river is widely used for irrigation along its entire course (GSAZ, n.d.).

The Araz River is the largest tributary of the Kura River. The total length of the river is 1072 km, of which 364 km belongs to the territory of Turkey. Its basin area is 101.9 thousand km2. It originates in Turkey, on the northern slope of the Bingoldag mountain range (2990 m).

After the confluence of the Akhura branch, it forms the state border of Armenia and Azerbaijan with Turkey and Iran for a distance of approximately 600 km, up to the vicinity of the Araz-Bahramtepe water junction. The last 80 km of the river flows through Azerbaijan and flows into the Kura River in the area of the city of Sabirabad. It is the second largest river in Transcaucasia in terms of its water volume. The Araz is fed by mixed sources. 44% of the flow is water, 38% snow water, 18% rain water. The average annual water flow near the mouth of the Araz is 279 m^3/sec, and the flow volume is 8.8 billion m^3. Its water is hydrocarbonate-calcium (Salmanov *et al.*, 2020). One of the characteristic features of this river is that part of the territories where it enters the territory of Azerbaijan from the Republic of Armenia (the entire Gubadli, Zangilan, Jabrail districts, part of the Fizulu district, Fi) has been under the occupation of the Republic of Armenia for about 30 years (Köse and Wakızaka, 2022). The occupied territories, as well as the Araz River and its tributaries (rivers such as Bargushadshay, Basitchay, Hekarichay and its tributary Okchuchay, etc.), were subjected to ecological terrorism (Muradov *et al.*, 2025) until their liberation after the Second Karabakh War, which ended in November 2020, and the consequences of this have not been fully eliminated to this day. The occupied territories, as well as the Araz River and its tributaries (rivers such as Bargushadshay, Basitchay, Hekarichay and its tributary Okchuchay, etc.), were subjected to ecological terrorism until their liberation after the Second Karabakh War, which ended in November 2020, and the consequences of this have not been fully eliminated to this day. This allows us to note that the study of these areas is relevant and is of particular interest from the point of view of biosafety.

In order to study the microbiological status of the studied rivers, were conducted seasonal monitoring and taken samples for laboratory analysis. The numerical composition of various groups of microorganisms was determined according to known microbiological methods (Lavrenchuk and Ermoshin, 2019; Netrusov *et al.*, 2005). During the research, both specific (Endo-agar, SS, etc.) and universal (meat peptone agar) nutrient media were used to determine the number of microorganisms. The number of microorganisms was expressed in CFU/ml.

Results and discussion

In the microbiological assessment of waters, including river waters uses the quantitative composition of various groups of microorganisms inhabiting here, and we began our research by clarifying these issues. From the obtained results became clear that the rivers differed from each other in terms of the indicators used for assessment (Table 1 and 2). This difference was also evident at individual stations.

Microbiological analyses of samples taken from the Araz River in Azerbaijan revealed that the amount of saprotrophic bacteria in river water increases from the first point to the last point (Table 1). As seen, at the first point, that is where the water enters the territory of Azerbaijan, the amount of saprotrophic bacteria was 4300 CFU/ml in spring and 3300 CFU/ml in autumn, while at the point where it joins the Kura River, it was 5600 CFU/ml in spring and 4900 CFU/ml in autumn.

The amount of saprotrophic bacteria in the Ganikh river also varies between 1520-2200 CFU/ml in spring and 1350-1900 CFU/ml in autumn. More precisely, although the change of seasons causes quantitative changes in the number composition, the overall trend remains stable in both rivers. In the Araz River, the number of saprotrophic bacteria varies by station, such that when the Araz River enters the country, the number of saprotrophic bacteria decreases slightly until the next station and mainly the increase is observed starting from the next points.

Table 1. Microbiological results in the Araz River (CFU/ml)

Indicators	Spring (April)				
	1	2	3	4	5
Saprotroph	4300	3900	4500	5100	5600
Azotobacter	90	30	50	40	35
Cl.pasteurianum	10^2	10^1	10^1	10^1	10^1
Denitrifier	10^2	10^2	10^1	10^2	10^3
Phenol absorber	10^5	10^4	10^3	10^3	10^4
Oil absorber	10^2	10^3	10^3	10^3	10^3
Autumn (October)					
Saprotroph	3300	2900	4100	4500	4900
Azotobacter	80	60	50	40	40
Cl.pasteurianum	10^2	10^1	10^1	10^2	10^2
Denitrifier	10^2	10^2	10^1	10^2	10^3
Phenol absorber	10^4	10^3	10^3	10^4	10^4
Oil absorber	10^2	10^2	10^3	10^3	10^4

Note: 1-Jabrail, 2- Fizuli, 3-Beylagan, 4-Imishli, 5-Sabirabad (Sugovushan).

Table 2. Microbiological results in the Ganikh River (CFU/ml)

Indicators	Spring (April)		
	Ganikh (Balaken)	Ganikh (Zaqatala)	Ganikh (Gakh)
Saprotroph	2200	1950	1520
Azotobacter	350	290	220
Cl.pasteurianum	10^3	10^3	10^2
Denitrifier	10^5	10^4	10^3
Phenol absorber	10^5	10^4	10^3
Oil absorber	10^4	10^3	10^2
Autumn (October)			
Saprotroph	1900	1640	1350
Azotobacter	310	250	190
Cl.pasteurianum	10^3	10^2	10^2
Denitrifier	10^4	10^3	10^2
Phenol absorber	10^4	10^3	10^2
Oil absorber	10^4	10^3	10^2

It is known that the degree of water pollution is determined by the number of saprotrophic bacteria, and their amount is considered to be less than 0.5x103 CFU/ml in completely clean waters (I), between 0.51-5×103 CFU/ml in clean waters (II), 5.1-10×103 CFU/ml in slightly polluted waters (III), 10.1-50 CFU/ml in polluted waters (IV), 51-100×103 CFU/ml in polluted waters (V) and more than 100×103 CFU/ml in highly polluted waters (VI) (Stroyinf, n.d.; Studfile.net, n.d.). In accordance with this characteristic, the results obtained show that the amount of saprotrophic bacteria in both rivers corresponds to the classification of highly polluted waters from an ecological perspective. According to the law, the amount of saprotrophic bacteria in river waters should decrease as they move downstream, but if river waters are exposed to pollution along the course, the amount of saprotrophic bacteria increases. Thus, the amount of saprotrophic bacteria increases downstream in the Araz river (Table 1), while in the Ganikh river, the amount of saprotrophic bacteria decreases downstream (Table 2). It can be concluded that saprotrophic bacteria increase in the Araz river due to anthropogenic pollution downstream, while in the Ganikh river, due to low pollution, the amount of bacteria in the water decreases. This is also reflected in the amount of dissolved oxygen. Thus, while the amount of dissolved oxygen in the Ganikh River entering the country is 6.9 mg/l, at the last point this indicator is 8.0 mg/l. In the Araz River, this indicator is 6.8 mg/l and 6.1 mg/l, respectively.

Unlike most biogenic elements, nitrogen compounds are considered to be among the most important in the formation of biological products in water bodies (Ataeva *et al.*, 2023). Because the allochthonous biogenic elements entering the water basins from outside are not sufficient for the autotrophic flora of the basin throughout the entire vegetation period, and therefore the demand for nitrogen in the basin is constantly high (Sherbakov *et al.*, 2020). Taking this into account, aerobic and anaerobic bacteria involved in the nitrogen cycle in the basins were studied (Table 1 and 2). It has been determined that the amount of anaerobic denitrifying bacteria in the Araz River exceeds the amount of aerobic nitrifying bacteria. In addition, *Cl. pasterianum*, which is considered

anaerobic due to its respiration and heterotrophic due to its nutrition, which absorbs nitrogen from the atmosphere, was encountered in small quantities, unlike other nitrogen-fixing bacteria.

Unlike the Araz river, the Ganikh river has a high concentration of aerobic and anaerobic bacteria involved in the nitrogen cycle, and the bacteria *Cl.pasterianum* was also found in abundance in almost all locations.

Phenols are one of the main factors disrupting the ecological stability of water bodies (Pradeep *et al.*, 2015).

These organic pollutants have a severe negative impact on water quality and weaken the development of hydrofauna-flora in the environment which in turn leads to a decrease in the overall biological productivity of the basin (Ramos *et al.*, 2024). In both studied rivers were found phenol-absorbing bacteria, and their quantity was sufficient. The amount of phenol-absorbing bacteria in the Araz River increases downstream. This has also been demonstrated in chemical analyses of water. Thus, during the chemical analysis of the water, the amount of phenol in the water was many times higher than the permissible limit.

Oil and various oil products, which are among the main pollutants affecting water bodies, as well as products formed from their decomposition, are organic substances that negatively affect the development of biological organisms in river waters (Loyeh and Mohsenpour, 2020). Oil-absorbing bacteria were studied in both rivers and it was determined that oil-absorbing bacteria in these rivers at the border point exceeded the permissible limit. Unlike the Ganikh river, the amount of bacteria that absorb oil products in the Araz river is increasing downstream (Table 1 and 2).

This once again confirms the continuation of anthropogenic pollution in the lower reaches of the Araz River.

The studies conducted on both rivers show that chemical and microbiological pollution is at a high level in these rivers. It was determined that while the Ganikh River has high concentrations of biogenic elements, phosphorus and nitrogen compounds, the Araz River has high concentrations of heavy metals. Research has shown that the areas crossed by the Ganikh river have been considered the main agricultural regions of the Republic of Georgia in recent years. Fertilizers and pesticides used in agriculture to increase productivity and control pests are also washed away and dumped into the Ganikh river. This also causes an increase in the amount of nitrogen and phosphorus compounds in the river. The fact that there are few settlements in the regions where the Ganikh River flows in Azerbaijan and that other rivers that flow into the river flow here almost only during floods causes the Ganikh river to be less polluted in Azerbaijan. As a result, the self-cleaning properties of river are effectively demonstrated in the analyses conducted.

From the conducted studies on the Araz river, it can be concluded that the Araz river enters the territory of Azerbaijan both polluted chemically and biologically. Unfortunately, river pollution continues within the Republic, and this becomes clear once again during the analysis. The main reason for this is the lack of modern waste treatment plants and centralized sewage systems in the regions where the river flows. It is true that measures are being taken and are planned to be taken to eliminate these shortcomings, which is widely confirmed by the "National Strategy for the Efficient Use of Water Resources" signed by the President of the Republic of Azerbaijan on 10.10.2024, whose implementation covers the years 2024-2040 (President of Azerbaijan, n.d.). Nevertheless, conducting research aimed at developing principles that allow for the efficient use of Azerbaijan's water resources and ensuring their biosafety remains relevant.

Conclusion

The Republic of Azerbaijan is among the world's water-scarce countries in terms of water resources,

and the fact that up to 70% of its surface water resources are formed by transboundary rivers further aggravates an already difficult situation. Studies conducted on the Araz and Ganikh rivers, which are characterized as transboundary rivers, showed that they are polluted both when they enter the country and that the Araz is also subject to biological pollution within the country. This, in turn, allows us to highlight the need to develop principles of biological safety of water resources of the Republic of Azerbaijan, as well as to add biological criteria to the monitoring systems of aquatic ecosystems.

References

Aliyev BG, Isgenderzade AS, Agababaly SA. 2023. Fundamentals of environmental problems in Azerbaijan and ways of their solution. Baku: MFA "Vector", 280.

Ansarova AH, Salmanov MA, Guseynov AT. 2021. Pollution of the middle part of Kura by petro-phenols and their biodegradation by microorganisms. Journal of Complementary Medicine Research **12**(2), 1–5.

Ataeva AA, Vakaraeva MM, Kadisova JT. 2023. The biological role of nitrogen in nature. Pedagogical Journal **13**(9), 247–255. https://doi.org/10.34670/AR.2023.20.38.034

GSAZ. n.d. https://gsaz.az/articles/view/108/

Huseynov AT, Salmanov MA, Ansarova AG. 2017. Questions of ecological safety of transboundary watercourses of Azerbaijan. In: Materials of XIX International scientific conference "Biological diversity of the Caucasus and the south of Russia", 79–81.

Ingrao C, Strippoli R, Lagioia G, Huisingh D. 2023. Water scarcity in agriculture: An overview of causes, impacts and approaches for reducing the risks. Heliyon **9**(8), e18507. https://doi.org/10.1016/j.heliyon.2023.e18507

Köse G, Wakızaka K. 2022. The historical dynamics of the Second Karabakh War and the shift in Turkey's policy: The effects of the Syrian Civil War. Karadeniz Araştırmaları Merkezi **74**, 311–327. https://doi.org/10.12787/karam1843

Lavrenchuk LS, Ermoshin AA. 2019. Microbiology: practicum. Yekaterinburg: PO UralUniversitety, 107.

Loyeh EN, Mohsenpour R. 2020. Investigation of oil pollution on aquatic animals and methods of its prevention. Journal of Aquaculture & Marine Biology **9**(5), 160–165.

Mamedov PM, Abduev MA. 2018. Formation of river water resources of Azerbaijan, their hydrochemical analysis for the purpose of assessing ecological suitability. Water Management of Russia **2**, 19–34.

Maria JF, Robert MH, Marcos C. 2021. The biological assessment and rehabilitation of the world's rivers: An overview. Water (Basel) **13**(3), 371. https://doi.org/10.3390/w13030371

Muradov PZ, Aliyeva LA, Aliyeva SI, Isayeva VK, Hasanova GM, Abdulayeva SA. 2025. Water resources of Azerbaijan and biosecurity. Advanced Studies in Biology **17**(1), 37–46.

Muradov PZ. 2022. Biosecurity problems of liberated territories of Azerbaijan and their solutions. Journal of Life Sciences and Biomedicine **4**(77), 64–69.

Netrusov AI, Egorova MA, Zakharchuk LM. 2005. Workshop on microbiology. Moscow: Publishing Center "Academy", 608.

Páll E, Niculae M, Kiss T. 2013. Human impact on the microbiological water quality of the rivers. Journal of Medical Microbiology **62**(11), 1635–1640.

Pradeep NV, Anupama S, Navya K. 2015. Biological removal of phenol from wastewaters: A mini review. Applied Water Science **5**, 105–112. https://doi.org/10.1007/s13201-014-0176-8

President of Azerbaijan. n.d. https://president.az/az/articles/view/67069

Ramos RL, Moreira VR, Amaral SMC. 2024. Phenolic compounds in water: Review of occurrence, risk, and retention by membrane technology. Journal of Environmental Management **351**, 119772. https://doi.org/10.1016/j.jenvman.2023.119772

Salmanov MA, Ansarova AH, Huseynov AT. 2020. Microbiological specification of the Araz River. Journal of Complementary Medicine Research **11**(5), 146–149.

Science.gov.az. n.d. https://science.gov.az/az/news/open/17743

Sherbakov V, Chizhik K, Shchukina T, Milyaeva A. 2020. Elimination of the biogenic pollution effects on aquatic environments. E3S Web of Conferences **180**, 04010. https://doi.org/10.1051/e3sconf/202018004010

Stroyinf. n.d. https://files.stroyinf.ru/Data2/1/4293727/4293727107.pdf

Studfile.net. n.d. https://studfile.net/preview/9128510/page:37/

Zhao M, Boll J. 2022. Adaptation of water resources management under climate change. Frontiers in Water **4**, 983228. https://doi.org/10.3389/frwa.2022.983228