ECOLOGICAL ASSESSMENT OF RIVERS FLOWING IN THE KARABAKH AND EASTERN ZANGAZUR REGIONS

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Abstract: Due to limited research in the Karabakh and Zangezur regions until 2021, indirect methods were used to assess river samples, revealing concerning levels of manganese (Mn), aluminium (Al), and iron (Fe). While most metals are below WHO safety thresholds, the variability in concentrations highlights the need for regular monitoring. Acts of sabotage have damaged agriculture, the environment, and irrigation systems, necessitating purification efforts and prevention measures. Elevated levels of nickel and copper also require attention. Ensuring water safety in- volves treatment to remove heavy metals and further studies to evaluate its suitability for crops or blending with cleaner sources.

Keywords: Water Quality Analysis, Heavy metals in river waters, Fish species, Dynamics of Heavy Metal Concentrations.

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Introduction:

Water quality and the preservation of aquatic ecosystems are crucial concerns for any region, and Azerbaijan is no exception. Despite its rich natural resources, a significant portion of the population—approximately 75%—relies on river water that does not meet basic sanitary and hygienic standards for drinking. This alarming statistic underscores the urgent need for effective water management and pollution control to safeguard public health. The Kharabakh and Eastern Zangazur regions are particularly important in this regard, not only due to their significance as freshwater sources but also because of their unique biodiversity, which includes various fish species critical to the region's ecosystem (Rustamov and Kash- kai, 1989).

The diverse ichthyofauna found in these areas—ranging from carp and goldfish to loaches and catfish—serves as a vital indicator of the health of these freshwater systems. The preservation of these species, many of which are listed in the "Red Book" of Azerbaijan, is vital for maintaining ecological balance and ensuring sustainable fisheries. However, decades of interrupted hydrometric research, especially since 1988 due to regional conflicts, have limited our understanding of the dynamics of water resources in these areas. This lack of continuous monitoring, particularly concerning water discharge and quality, highlights the need for renewed efforts in environmental research (Eminov et al., 2023; Hasanov et al., 1973).

This study aims to address these gaps by analyzing the quality of water in key rivers such as the Tartar, Hekari, and Oxchu, focusing on the mineralization, cation and anion flows, as well as the concentrations of metals and pollu- tants. Through a series of chemical analyses, this report aims to assess the current state of water quality in these rivers and recommend solutions for improving the sustainability of aquatic resources in the region. The findings of this study are crucial for the continued protec- tion of both the natural environment and the health of the population dependent on these water sources (Junfang Liu, et al., 2020).

Materials and Methods:

This study focused on assessing the water quality of rivers in the Karabakh and Eastern Zangazur regions, specifically the Tartar, Hekari, and Oxchu rivers. Water samples were collected from various points along these rivers to analyze parameters such as mineralization, ion composition, and metal content.

Water sampling followed standard protocols, with samples collected in sterile containers to avoid contamination. A total of 10 samples were gathered from different upstream, mid- stream, and downstream locations. Key pa- rameters measured included cations (calcium, magnesium, sodium, potassium), anions (chloride, sulfate, bicarbonate), and trace metals (lead, mercury, cadmium). Mineralization was determined through conductivity, and ion concentrations were analyzed using ion chromatography. Metal concentrations were measured using inductively coupled plasma mass spectrometry (ICP-MS).

Physical properties like temperature, pH, and turbidity were also recorded with field me- ters. The results were compared to water quali- ty standards to evaluate the suitability of the water for drinking, agriculture, and ecosystem health. Data analysis was performed to identify trends and potential pollution sources in the re- gion (Samah Al-Jabari, et al.,).

Results and discussions:

One of the most alarming issues in Azerbaijan is that 75% of the population uses the waters of these rivers, which do not meet sanitary and hygienic requirements, as drinking water. If urgent measures are not taken in this area, it is not difficult to imagine the consequences that may arise.

The information you provided about the ichthyofauna in the Karabakh and Eastern Zangazur regions is very important. Analyzing the fish species living in these regions is crucial for the conservation of water resources and the protection of fish species.

Fish Species and Distribution Areas

1. Fish Families and Species:

- Carps: 17 species (approximately 75% of all species)
- Goldfish: River goldfish, naked angora, naked Kura
- Loaches: Caucasian loach, golden loach
- Catfish: Caucasian catfish

2. In the Karabakh Region:

- Kondelenchay: 14 species of fish
- Qarqarchay: 8 species of fish
- Terterchay: 14 species of fish

3. In the Eastern Zangazur Region:

- Besitchay, Oxchuchay, and Hekerichay: 22 species of fish
- Hekerichay: 10 species of fish
- Terterchay: 6 species of fish

4. Species Listed in the "Red Book" of the Republic of Azerbaijan:

- River Goldfish: Found in Zangilan, Lachın, and Qubadlı districts, as well as in Kelbecer
- Zerdeper: Found in Zangilan, Lachın, and Qubadlı districts, and in Xocalı and Fuzuli

This information reflects the richness and diversity of the region's ecosystems. Additionally, it is essential to implement special measures for the protection of species listed in the "Red Book." The conservation of these species, along with the protection of their habitats and the sustainable use of water resources, will ensure the ongoing development of both the region's ecosystems and its fisheries.

Since 1988, the operation of hydrometric stations regarding the rivers of the region has been halted by Armenia. The last station to cease operations was the Kelbajar station on the Tartar River. Continuous stationary observa- tions of water discharge at this station were conducted for 44 years, covering the period from 1949 to 1992. Due to the lack of research in the Karabakh and Zangezur regions over a long period, the presented studies were con- ducted using indirect methods till 2021 years.

In hydrochemical studies, correlation, linear interpolation, and analogy methods are primarily used for the restoration of mineralization series. Through these methods, the mineralization series of the studied rivers has been restored based on previous research.

To study the cation and anion flow of rivers, the restored series was used to calculate the long-term average values of the main ions. By summing the quantities of the main ions given in mg/l, cation and anion flows were determined for each river station.

Table 1: Calculated cation and anion flow based on the restored chemical flow series rivers

Test station	Multiannual average water consumption, Q (m³/s))	Flow volumeW (million m³)	Multiannual average ion current	Cation flow, thousand tons			Total Cation flow	Anion flow, thousand tons			Total Anion flow
				Ca	Mg	Na+ K		HCO_3	SO_4	Cl	
Incachay-Gulistan	1,1	35	8,8	1,3	0,5	0,34	2,13	4,48	2	0,15	6,63
Tartar-Kalbajar	5,2	164	50	8,4	1,3	4,1	13,8	23	11,6	1,6	36,2
Magavuz	18,2	573	218	36,6	4,5	21,3	62,4	94,2	47,4	13,7	155,3
Tartar-Suguvung	20	631	223	30,5	9	20	59,5	105,4	33,6	24	163
Levchay-Kamishli	5,74	181	55	8	1,9	5	14,9	27	10,6	2,37	40
Gloomy-mansab	3,95	124	44	5,5	3	1,8	10,3	28,8	4	0,95	33,75
Khachinchay-Vankulu	4,02	127	40	5,6	1,4	3,53	10,57	22,4	5,57	1,83	29,8
Gargarchay Ashagikorpu	2,09	66	33	3,26	0,8	4,9	8,96	8,5	15	0,77	24,27
Okchuchay-Gafan	9,76	308	226	25	9	34,5	68,5	70	60,3	27,8	158,1
Bazarchay-Eyvazlar	22	693	206	32,4	6,8	14,8	54	109	32,2	10,7	151,9
Hekarichay-Lachin	10,1	319	97	15,8	2,8	7,6	26,2	50,6	16,5	3,6	70,7
Zabukhchay-Zabukh	4,97	157	46	7,5	2	1,87	11,37	30,9	2,34	1,5	34,74
Guruchay-Togh	1,3	41	14	2,2	0,7	0,47	3,32	9,49	0,3	0,5	10,3
Kondalanchay-Kırmızı Bazar	0,58	18	8,7	1,28	0,3	0,82	2,38	3,8	1,6	0,87	6,27

Analysis of Water Quality Monitoring Results (2021-2023)

During the monitoring of Zabuxchay, Khachinchay, and Kondelenchay throughout the year, water samples were analyzed, and the quality indicators were found to be within permissible limits. Notable findings include:

- In the Tartar River, the concentration of iron (Fe) was 1.2 times higher.
- In the section of the Hekari River passing through the Zangilan region, cadmium (Cd) levels were 1.3 times higher.
- In Tutqunchay, cadmium (Cd) levels reached 2.9 times higher than permissible limits.
- In the section of Quruchay passing through Fuzuli, iron (Fe) levels were 1.5 times higher, while in the section near Shukurbayli village, cadmium (Cd) levels were 4.0 times higher than allowable limits.

Throughout 2022, monitoring of Hekari, Zabuxchay, Tartar, Tutqunchay, Quruchay, and Kondelenchay resulted in water sample analyses that indicated quality indicators remained within permissible limits.

In 2023, monitoring was conducted quarterly on Zabux, Quruchay, Khachinchay, Tartar, Hekari, and Kondelenchay. Analysis of samples from Zabuxchay and Quruchay confirmed that the quality indicators were within allowable limits (Imanov et al., 2021).

Additionally, four monitoring sessions were conducted in the Balasoltanlı area of the Hekari River in the Qubadli region, resulting in the collection of four water samples. "Azelab" LLC performed 70 relevant physicochemical analyses on these samples. The results indicated that only the concentration of iron (Fe) was 2.9 times higher than permissible limits in the second quarter, while other determined indicators remained within acceptable ranges.

Table 2. Sample Water Quality Indicators:

River	pH	Conductivity µS/cm	(TDS) mg/L	Salinity %	DO mg/L	DO %	T °C	Resistance µs/h
Oxchu River	7.87	508	254	0.03	8.89	96.2	19.2	0.047
Zangilan, 3rd Aghali	8.04	320	160.7	0.02	9.59	103.6	19.1	0.043
Hekari River	7.93	506	253	0.03	8.44	91.3	17.2	0.047
Zangilan, entrance bridge, Oxchu River	7.96	228	114.1	0.01	9.46	101.9	18.9	0.043

The pH values of the water samples range from 7.87 to 8.04. This indicates that the water is neutral to slightly alkaline. A neutral pH (7) reflects the overall water quality of the environment. Conductivity values range from 228 µS/cm to 508 µS/cm. This indicates the ion content of the water. Higher conductivity values suggest a greater presence of minerals and ions. TDS values range from 114.1 mg/L to 254 mg/L. Higher TDS values increase the mineral content of the water. Water with high TDS levels contains more pollutants and mineral substances. Salinity values range from 0.01% to 0.03%. This indicates that the water is slightly saline, but these values are very low, suggesting that the water is clean. DO values range from 8.44 mg/L to 9.59 mg/L. High DO values indicate that the water is rich in oxygen, which is essential for the health of aquatic ecosystems.DO % values range from 91.3% to 103.6%. This indicator reflects the degree of saturation of oxygen in the water. Values above 100% indicate that the water contains more ox- ygen than typical levels. Water temperature ranges from 17.2°C to 19.2°C. Temperature affects the physical state of the water and chemical reactions. Resistance values range from 0.043 µs/h to 0.047 µs/h. This indicator shows the conductivity resistance of the water. A higher resistance may indicate a lower ion content in the water.

Table 3. Measured Concentration of Metals in the Analyzed Samples (µg/L)

River	Cr	Mn	Ni	Zn	Al	Fe
Hekari River, 3rd Aghali	0.1	7.592	<0.20	23.18	34.74	137.26
Best River	1.96	3.485	<0.20	3.47	46.86	111.9
Spring	6.03	3.477	0.27	7.16	15.1	29.82
Oxchu River 1	1.09	181.8	<0.20	1508.8	725.7	1823
Oxchu River 2 Bridge	1.45	170.84	0.53	732	629	2241
Hekari River	0.57	21.644	2.19	17.35	48.1	274.41
WHO	50	100	70	5000	200	300

All measured **Cr** concentrations are below the WHO guideline of 50 µg/L. The highest concentration (6.03 µg/L) is found in the Spring sample, while the Hekari River, 3rd Aghali has the lowest (0.1 µg/L). Overall, Cr levels appear to be within safe limits.

Mn concentrations show significant variability, with the highest concentration observed in Oxchu River 1 (181.8 µg/L) and Oxchu River 2 Bridge (170.84 µg/L), both exceeding the WHO guideline of 100 µg/L. The presence of high Mn levels in these rivers suggests potential pollution or natural mineral deposits that require further investigation.

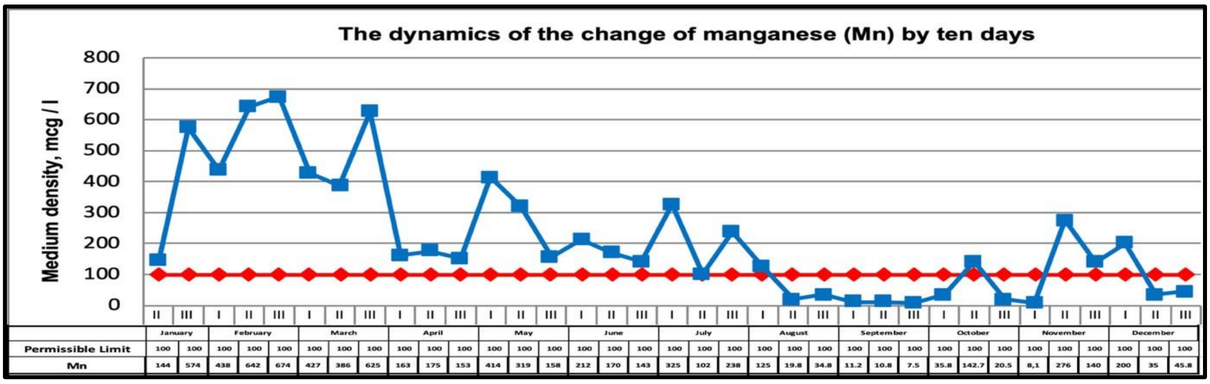


Figure 1. The dynamics of the change of Mn in Oxchu River Sayifli region by ten days of 2023 year

Ni concentrations are generally low across the samples, with values below the WHO guideline of 70 µg/L. The highest measured concentration is 2.19 µg/L in the Hekari River. This indicates that Ni levels are not a concern in these water bodies.

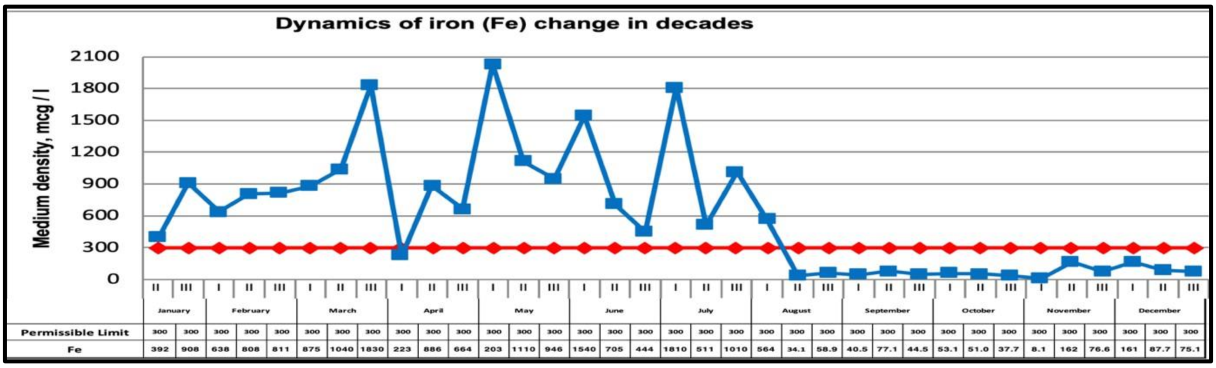


Figure 2. Dynamics of Fe change of Oxchu river Sayifli region by ten days of 2023 year

Fe concentrations are notably high in Oxchu River 2 Bridge (2241 µg/L) and Oxchu River 1 (1823 µg/L), both far exceeding the WHO guideline of 300 µg/L. The elevated Fe levels could be attributed to mining activities, industrial runoff, or natural geological factors.

Zn concentrations vary significantly, with a maximum of 1508.8 µg/L in Oxchu River 1, which is still well below the WHO guideline of 5000 µg/L. However, such high levels may indicate localized pollution sources. Other samples, like the Besit River, have much lower concentrations (3.47 µg/L).

Al levels vary widely, with the highest concentration (725.7 µg/L) also found in Oxchu River 1, exceeding the WHO guideline of 200 µg/L. This suggests possible contamination and warrants monitoring, especially in rivers with elevated aluminum levels.

Concerns for Pollution: The Oxchu River samples (1 and 2 Bridge) show concerning levels of Mn, Al, and Fe, indicating potential environmental issues that may need immediate attention and further investigation.

Overall Water Quality: While many metals remain below the WHO safety thresholds, the variability in concentrations, especially for Mn, Al, and Fe, suggests a need for regular monitoring to ensure water quality and address potential pollution sources. However, in the Oxchu

River, which flows into the Zangilan region of Azerbaijan from the territory of the Republic of Armenia, the concentration values for the element Mn are 1.7-1.8 times higher, for Al are 3.1-3.6 times higher, and for Fe are 6-7.5 times higher than the permissible limits. It should be noted that the maximum allowable conductivity value for drinking water is determined by the WHO as 400 µS/cm. The conductivity values of the samples taken from the Oxchu River (508 and 506 µS/cm) are above this limit, indi- cating that the river cannot currently be used as a source of drinking water. All of this suggests that the Oxchu River has been subjected to the influence of anthropogenic pollutants before entering the country's territory. The impact of such heavy pollution on the ecosystem of the river basin is also inevitable. Given that the pollution process likely continued during the long years of occupation of Zangilan, it is essential to carry out research and monitoring of water and sediment samples in the riverbed to thor- oughly study and control the pollution

Oxchu River

Based on the analysis results of water samples taken from the Oxchu River in 2023, the dynamics of pollutant variations by ten-day periods in the water environment are as follows:

Table 4. Summary of water quality parameters (Sayifli region)

	Hardness			NH_4			Mn			Mo			Fe			SO_4		
	PCL = 7			PCL = 0.5			PCL = 100			PCL = 250			PCL = 300			PCL = 500		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
January		16.4	16.5		0.0	1.3		144	574		164	308		392	908		372	586
February	17.1	14.0	10.0	1.3	1.2	2.4	438	642	674	233	247	674	638	808	811	498	476	277
March	10.6	10.8	9.9	1.5	1.6	1.6	427	386	625	234	170	233	875	104	183	372	381	247
April	11.8	8.4	7.6	0.0	0.0	0.0	163	175	153	95.4	202	219	223	886	664	205	104	200
May	8.8	8.4	6.0	0.0	0.0	0.0	414	319	158	234	204	122	203	111	946	212	294	171
June	3.1	3.89	4.2	0.0	0.0	0.0	212	170	143	38.5	44.4	65	154	705	444	93	133	141
July	4.86	6.0	6.9	0.0	0.0	0.0	325	102	238	135	143	245	181	511	101	129	205	217
August	7.3	7.76	8.3	0.0	0.2	0.0	125	19.8	34.8	221	248	237	564	34.1	58.9	213	225	253
September	8.2	8.1	8.0	0.1	0.0	0.0	11.2	10.8	7.5	263	141	94.9	40.5	77.1	44.5	251	257	372
October	9.69	8.33	10.1	0.0	0.0	0.0	35.8	142.7	20.5	153	126	170	53.1	51	37.7	359	390	403
November	10.45	12.5	12.4	0.0	0.0	1.1	8.1	276	140	73.5	273	114	8.1	162	76.6	348	476	498
December	11.4	9.23	11	0.0	0.4	0.0	200	35	45.8	295	237	277	161	87.7	75.1	400	272	365

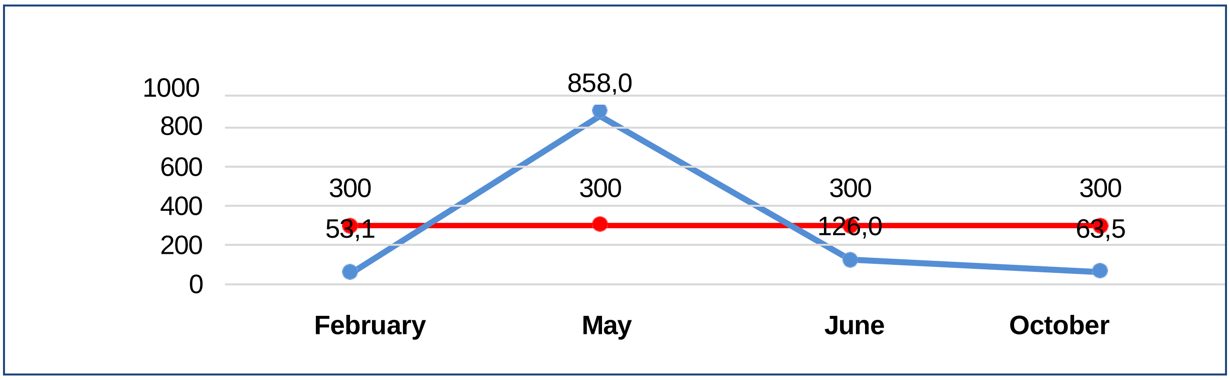
Observations:

- Hardness levels vary, with the highest in February.
- NH_4 levels are consistently low, mostly at 0.0, except for February and March.
- Mn shows significant variation, peaking in March.
- Mo remains mostly low, with peaks in March and May.
- Fe levels fluctuate significantly, especially high in March and August.
- SO_4 levels also vary, with notable peaks in March and October.

Hakari river

The dynamics of iron (Fe) in Hakari River's water environment were variable in 2023. In May, the analysis results showed a rise to 858 µS/cm, while the permissible conductivity limit (PCL) for the river water is 300 µS/cm.

Figure 3. CHANGE DYNAMİCS OF İRON (FE) İN HEKARİCHAY'S WATER ENVİRONMENT FOR 2023



Tartar River

In recent years, water samples have been periodically taken from the Tartar River (up until August 2020). These samples underwent on-site rapid analyses and radiometric measurements, as well as organoleptic, physicochemical, and microbiological analyses conducted in the laboratory of the Azerbaijan National Academy of Sciences (ANAS). The results of the comprehensive analyses revealed that the quality indicators of the Tartar River water do not meet the relevant regulatory requirements.

Radioactive background levels were measured in the surrounding areas along the Tartar River, and it was determined that the water samples were contaminated with anthropogenic xenobiotics and pathogenic microorganisms.

According to the latest data from January to August 2024, three water samples were taken from the Kelbajar region station of the Tartar River and three samples from the Vang village station, totalling six water samples. These samples were subjected to 101 relevant physical-chemical analyses conducted by “AzeLab” LLC.

Based on the analysis results, it was determined that only the concentration of iron (Fe) among the heavy metals exceeded the permissible limit by 1.1 times in the Kelbajar region station during the second quarter of this year.

Pollution of water resources from serseng and suqovushan reservoirs:

Until August 2020, the waters artificially discharged from the Serseng and Suqovushan (formerly known as “Madagiz”) reservoirs in mountainous areas have been contaminated with organic waste and microorganisms. This is one of the ongoing violations.

Sabotage and Problems:

- Wastewater Issues: The prevention of water flow has resulted in chaotic discharges and artificially created floods in rivers, aimed at hindering agricultural development.
- Damage in Surrounding Areas: During cold periods when irrigation is not needed, disruptions in the technological operating regime have caused soil erosion in agricultural fields and damage to residential communication lines (Mona Fathi, et al., 2018).

These acts of sabotage have had serious impacts on the region’s agriculture, the environment, and irrigation systems. The implementation of appropriate purification methods and the prevention of such violations are crucial.

Microbiological Contamination

Until August 2020, the microbiological contamination of the Tartar River was characterized by serious issues. Analyses indicated that:

- The number of Escherichia coli was 3-4 times higher than allowable limits.
- Unacceptable cocci (such as *Staphylococcus aureus*), microscopic fungi (including *Candida* and *Aspergillus*), and pathogenic bacteria (like *Salmonella*) were detected.

These results indicated that Tartar River water was unfit for direct consumption. The microbiological contamination was linked to the discharge of organic waste into the river from the Suqovushan reservoir, located in an area occupied by Armenian armed forces.

Purification Stages

The contamination of Tartar River with organic waste required the implementation of both mechanical and biological purification stages. The application of a multi-stage complete purification cycle could help make this water safer.

Changes After the Patriotic War

Following the victory of the Azerbaijani Army in the 44-day Patriotic War, positive changes were observed in the microbiological indicators of Tartar River water:

- The number of pathogenic microorganisms sharply decreased.
- Alpha and beta radiation were not detected.

Table 5. Radioactivity of the Tartar River compared to Baku City

Natural Radioactive Radiation Indicators	**Tartar river**		**Baku city**
Dose Rate (μR/h):	0,018-0,030		0,011-0,045
Alpha Radiation Intensity (Bq/cm²):	0-0,02		0-0,04
Concentration of Isotopes:	Surface:	Bottom:	Surface:
Na-22 Isotope (Bq/L):	0,30-0,40	0,31-0,42	0,28
K-40 Isotope (Bq/L):	0,08-0,10	0,09-0,11	0,16

Conclusıon:

This study provides a comprehensive analysis of water quality in the Tartar, Hekari, and Oxchu rivers, illustrating the significant impact of both natural factors and anthropogenic activities on these vital water bodies. The observed variations in pollutant levels across different regions highlight the growing environmental challenges that threaten water resources, particularly in the Karabakh and Eastern Zangazur regions. Elevated concentrations of specific pollutants in certain areas serve as a warning about the potential consequences of unsustainable practices. These findings underscore the critical need for continuous monitoring, effective resource management, and the implementation of sustainable practices to ensure the long-term preservation and quality of water resources in the region.

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