Monitoring of microbiological pollution of the Alazani River and assessment of its ecological risks

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Abstract: The scientific paper discusses the microbiological state of the Alazani River in 2023–2024, in two sections: Gurjaani and Akhmeta. Within the framework of the study, we conducted microbiological pollution monitoring of the Alazani River and assessed ecological risks associated with it.

Within the framework of monitoring conducted in 2023–2024, we quantitatively enumerated indicator microorganisms—Escherichia coli, total coliforms, fecal streptococci, and Salmonella—in Alazani River water in accordance with international standards ISO 9308-2:2012/2013, ISO 7899-1:2011, ISO 6222:2008, and ISO 19250.

Microbiological monitoring conducted in 2023–2024 in the Gurjaani and Akhmeta sections of the Alazani River revealed significant fecal and organic pollution, indicating a deteriorating ecological status of the river water. In the Gurjaani section, data from 2024 show an increase in pollution levels compared with 2023, reflecting intensified anthropogenic pressure. In contrast, the Akhmeta section exhibits pronounced seasonal pollution peaks, particularly during summer and autumn. High concentrations of Escherichia coli, total coliforms and fecal streptococci were recorded in both sections, which confirms the presence of fecal pollution of water and indicates the significant impact of organic substances generated as a result of domestic wastewater and agricultural activities. Despite the absence of Salmonella, high levels of indicator microorganisms pose ecological and sanitary risks, especially in the context of agricultural and domestic use. These findings underscore the necessity of long-term and systematic monitoring, strengthened wastewater management, and integrated river ecosystem management to improve the ecological status of the Alazani River and inform effective environmental policy development.

Keywords: Alazani, Microbial pollution, Fecal streptococci, Salmonella, Escherichia coli.

Research Methods: In order to monitor and ecologically assess the microbiological pollution of the Alazani River, a sanitary-microbiological study of water was conducted. The analyses were conducted using ISO standards. The following indicators were examined: total coliforms and Escherichia coli (ISO 9308-2:2012/2013), fecal streptococci (ISO 7899-1:2011), mesophilic aerobic and facultative anaerobic microorganisms (ISO 6222:2008), and Salmonella (ISO 19250).

Introduction: Monitoring and analysis of Alazani River water quality form the basis for effective ecological risk assessment, contributing to the safe and sustainable use of water

resources, the ecological stability of river ecosystems, and the preservation of aquatic biodiversity. At the same time, the integration of microbiological data, along with other physical and chemical parameters, allows for the assessment of the ecological state of the river ecosystem. This is a necessary condition for both the safe use of water resources and the preservation of the habitat of hydrobionts, including fish, and the protection of the ecological stability of their populations. Microbiological study of the Alazani River is one of the important components in the process of monitoring the sanitary and hygienic condition of water bodies and protecting biodiversity. Microbiological analysis of water provides detailed information not only for assessing the ecological and sanitary quality of the river, but also for assessing the sources and extent of anthropogenic pollution (Havel et al., 2015; WHO, 2017). One of the most important indicators in evaluating the sanitary and hygienic condition is the microorganism - Total Coliforms, which are naturally found in the environment, although their high concentration directly indicates fecal pollution (WHO, 2017; Edberg et al., 2000).

In this context, monitoring of sections of the Alazani River provides a basis for the use of the Alazani River and the preservation of ecosystem biodiversity, especially in areas where river water is used for agricultural, domestic and recreational purposes. Escherichia coli is of particular importance in surface waters, as it is widely used as a direct biological indicator of fecal contamination. Even though E. coli belongs to a broad taxonomic group of bacteria, and most of them are non-pathogenic, certain strains are characterized by pathogenic properties and can cause various infectious diseases. (Mchedluri, T. (2022)This microorganism is widely used to assess the degree of water contamination and sanitary-hygienic conditions, since its presence indicates contamination of fecal origin and the possible coexistence of pathogenic microorganisms. The detection of Escherichia coli in surface waters therefore represents a significant ecological risk to both human health and river ecosystems, particularly to ichthyofauna, which are highly sensitive to changes in water quality (EPA, 2023).

Fecal Streptococci are also important indicator microorganisms in assessing the degree of fecal pollution of water, which effectively reflect water contamination with human or animal fecal masses. Microorganisms of this group are distinguished by their relatively high resistance in the environment, which makes them particularly reliable indicators for monitoring water quality and assessing the long-term impact of pollution. The use of fecal streptococci significantly complements the data of coliform bacteria and provides a more complete assessment of the ecological state of water.

Study results: Given the urgency of the problem, we considered it appropriate to conduct a microbiological study of the Alazani River water in order to assess the ecological state. We monitored the microbiological pollution of the Alazani River and assessed its ecological risks seasonally in 2023-2024. Within the framework of the sanitary-microbiological study of water, such indicators as total coliforms, Escherichia coli, fecal streptococci, mesophilic aerobic and facultative anaerobic microorganisms, and Salmonella were evaluated. Microbiological analyses of the study were carried out in accordance with the requirements of ISO standards.

The results of the microbiological study of the Alazani River in 2023-2024 in the Akhmeta territory are presented in Tables No. 1 and 2, which clearly show the annual dynamics of microbiological parameters of water.

Table№1

Results of Microbiological Analysis of the Alazani River in the Akhmeta Region

River Alazani (Akhmeta)						
№	Test parameters	Unit	Results 2023			Method used
			Spring	Summer	Autumn	
1	*Escherichia coli*	1 dm³	3100	3950	4850	ISO 9308-2:2012/2013
2	Total Coliforms		3150	4080	4300	
3	Fecal streptococci		240	310	400	ISO 7899-1:2011
4	Mesophilic aerobic and facultative anaerobic microorganisms (22 °C)		280	300	355	ISO 6222:2008
5	Mesophilic aerobic and facultative anaerobic microorganisms 37^{0}C		230	250	280	ISO 6222:2008
6	*Salmonella*		Not detected			ISO 19250

Table№2

Results of Microbiological Analysis of the Alazani River in the Akhmeta Region

River Alazani (Akhmeta)						
№	Test parameters	Unit	Results 2023			Method used
			Spring	Summer	Autumn	
1	*Escherichia coli*	1 dm³	3550	4000	4900	ISO 9308-2:2012/2013
2	Total Coliforms		3330	4452	5000	
3	Fecal streptococci		250	330	360	ISO 7899-1:2011
4	Mesophilic aerobic and		285	300	380	ISO 6222:2008

	facultative anaerobic microorganisms (22 °C)					
5	Mesophilic aerobic and facultative anaerobic microorganisms 37^0C		230	230	285	ISO 6222:2008
6	*Salmonella*		Not detected			ISO 19250

Microbiological monitoring of the Alazani River in the Akhmeta section in 2023 and 2024 revealed both seasonal and annual variations in water quality, reflecting the impact of anthropogenic factors on the river ecosystem.

A comparative analysis of Escherichia coli concentrations indicates that in 2024, a higher indicator was recorded in all seasons compared to 2023. In both years, a clear trend of growth from spring to autumn was observed, indicating a seasonal intensification of fecal pollution and the accumulation of organic matter in water during the warm period. Similar dynamics are observed in the case of total coliforms, the concentrations of which are generally higher in 2024, which may indicate an increase in the impact of domestic wastewater and agricultural runoff.

Comparison of fecal streptococci levels shows that in both years their concentrations increase seasonally; however, in 2024, a relatively stable, but still high level is recorded, which indicates the constant or recurring nature of fecal pollution of water.

The number of mesophilic aerobic and facultative anaerobic microorganisms, both when incubated at 22°C and 37°C, in 2024 generally exceeds the corresponding indicators in 2023, reflecting the increase in biodegradable organic substances in water and the formation of favorable conditions for microbial metabolism. It is noteworthy that Salmonella was not detected at any stage of the study, which should be considered a positive circumstance from an epidemiological point of view. However, high concentrations of indicator microorganisms still indicate ecological and sanitary risks.

Thus, the level of microbiological pollution in the Akhmeta section of the Alazani River in 2024 has been maintained or somewhat increased in most parameters compared to 2023, which emphasizes the need for regular monitoring and strengthening water resources management measures.

The results of the microbiological study of the Alazani River in 2023-2024 in the Gurjaani territory are presented in Tables №3 and 4.

Table№3

Results of Microbiological Analysis of the Alazani River in the Gurjaani Region

Alazani River Gurjaani						
№	**Test parameters**	**Unit**	**Results 2023**			**Used method**
			Spring	**Summer**	**Autumn**	
1	*Escherichia coli*	1 dm^3	3958	3750	5350	ISO 9308-2:2012/2013
2	Total Coliforms		4850	5250	7800	

3	Fecal streptococci		390	440	420	ISO 7899-1:2011
4	*Salmonella*		Not detected			ISO 19250

Table№4

Results of Microbiological Analysis of the Alazani River in the Gurjaani Region

Alazani River Gurjaani						
№	**Test parameters**	**Unit**	**Results 2024**			**Used method**
			Spring	**Summer**	**Autumn**	
1	*Escherichia coli*	1 dm³	4650	5460	5850	ISO standard 9308-2:2012/2013
2	Total Coliforms		5100	6258	8800	
3	Fecal streptococci		402	620	644	ISO standard 7899-1:2011
4	*Salmonella*		Not detected			ISO 19250

A microbiological study conducted in the Alazni River (Gurjaani section) in 2023–2024 revealed a trend of deterioration in water quality both seasonally and over the years. The assessed parameters clearly reflect the increase in the intensity of fecal and organic pollution.

According to the data for 2023, the concentration of Escherichia coli increases from spring to autumn and reaches a maximum in autumn (5350 units per 1 dm³), which indicates an increase in fecal pollution. A similar trend is observed in the case of total coliforms, the number of which is especially high in the autumn period (7800). This fact indicates the enrichment of the river with organic substances and the increase in anthropogenic impact.

The indicators of fecal streptococci in 2023 are relatively stable, although their consistently high level confirms the chronic nature of the contamination. From an epidemiological point of view, the absence of Salmonella in any of the samples should be considered a positive circumstance. The data for 2024 indicate a further deterioration of the situation. The number of Escherichia coli in all seasons exceeds the corresponding indicators of 2023 and reaches a maximum value in autumn (5850). The concentration of total coliforms increases significantly, especially in summer and autumn (8800), which indicates an increase in anthropogenic pollution.

Of particular note is the significant increase in the concentration of fecal streptococci in 2024, which may reflect increased pollution by domestic wastewater. In addition, Salmonella was not detected in any of the samples within the scope of the study, which should be assessed as a positive factor from an epidemiological point of view.

Thus, the above-mentioned trend reflects the increase in anthropogenic impact, which, in our opinion, is associated with the uncontrolled discharge of urban and agricultural pollution sources, including domestic wastewater, agricultural waste, and other types of pollution sources caused by human activity, into the waters of the Alazani River.

The results of the study show that in the waters of the Alazani River, in the territory of Akhmeta Municipality, the level of microbiological contamination increases downstream and reaches a maximum in the Gurjaani territory, in the spring and autumn seasons. Which indicates the strengthening of anthropogenic load and its fecal contamination.

The obtained results indicate the need for systematic and targeted monitoring of the Alazani River, especially taking into account microbiological and sanitary-hygienic indicators, which is important for ensuring the purity of river water, the biological safety of humans, aquatic organisms (hydrobionts) and ecosystems, as well as for maintaining ecosystem stability.

Conclusion

1. Microbiological monitoring of the Alazani River water in the Gurjaani and Akhmeta sections showed that the ecological state of the water during the study period is characterized by the presence of fecal and organic pollution and an increasing trend, both seasonally and annually.
2. Data for 2024 on the Gurjaani section indicate an increase in the level of pollution compared to 2023, which reflects the strengthening of anthropogenic impact, while in the Akhmeta section seasonal peaks of pollution were especially pronounced in summer and autumn.
3. High concentrations of Escherichia coli, total coliforms and fecal streptococci recorded in the Alazani River (in the Akhmeta and Gurjaani sections) confirm the presence of fecal pollution of the water and indicate the significant impact of runoff from domestic wastewater and agricultural activities.
4. During the study period, Salmonella was not detected in any of the samples, which should be considered a positive circumstance from an epidemiological point of view; however, this fact does not reduce the ecological and sanitary risks caused by the high level of indicator microorganisms.
5. The conducted study emphasizes the need for long-term and systematic microbiological monitoring, wastewater control, as well as integrated water resources management, in order to improve the ecological condition of the Alazani River and effectively implement environmental policy.

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