საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 20(194), №1, 2026
BULLETIN OF THE NATIONAL ACADEMY OF SCIENCES OF GEORGIA, vol. 20(194), no. 1, 2026

Ecology

Concentration of Biogenic Elements in the Water of the Alazani River and Total Nitrogen Content in Fish Organism

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(Presented by Academy Member Guram Aleksidze)

Abstract. Anthropogenic factors negatively affect the water quality and ecological condition of the Alazani river, thus increasing environmental risks. In order to assess the ecological state of the water, it was considered relevant to determine the seasonal determination of biogenic elements (NO_2^-, NO_3^-, NH_4^+, PO_4^{3-}) in the water of the Alazani River in 2023-2024 and the concentration of total nitrogen in fish as a bioindicator. Samples were taken from the Alazani River, in the territory of Akhmeta Municipality (village Alaverdi). The biogenic elements (NO_3^-), (NO_2^-), (PO_4^{3-}) in water samples was determined by the ion chromatography method (ISO 10304-1:2007); and spectrophotometric method was used for (NH_4^+). Total nitrogen in fish samples was determined according to GOST 7636–85. The monitoring results showed that the concentrations of nitrates, nitrites, and phosphates fluctuated within the limits of the MPC, while the level of ammonium ions exceeded the norm in summer and autumn, which is associated with agricultural activities. They are highly toxic to fish and hydrobionts. The total nitrogen content in fish samples in September 2024 was 3.26%, which is 17.3% higher than the similar indicator in 2023 (2.78%). Although the data are within the limits of the MPC, this dynamics indicates the risk of increasing ecological stress, which requires constant monitoring and complex assessment of the river. The data obtained are an important basis for assessing the accumulation of nitrogen compounds and their impact on ecosystem functioning.

Keywords: Alazani, biogenic elements, total nitrogen, fish

Introduction

The Alazani river, one of the most important rivers of eastern Georgia, originates in the Caucasus Mountains at an altitude of 2,800 meters above sea level. Its length is 390 km. The river flows through the territory of Georgia and joins the Mingechauri Reservoir in Azerbaijan.

The impact of anthropogenic factors on the Alazani river poses a serious threat to the sanitary and ecological state of the water and aquatic ecosystems. Potential pollutants of the river include untreated wastewater from livestock and poultry complexes, and agricultural fields (Mchedluri, 2009), as well as unfiltered and/or insufficiently

filtered household, industrial and sewage water and illegal landfills located along the riverbanks.

The incorrect selection and excessive use of fertilizers and pesticides by the population on agricultural land lead to their excessive accumulation in the soil, as a result of which these substances enter rivers during rainfall or irrigation and pollute them (Camargo & Alonso, 2006). Wastewater from factories, poultry farms, and livestock farms contains large amounts of nitrogen and phosphorus. In countries where nitrogen- and phosphorus-based fertilizers are used at high rates, the risk of water pollution with nitrates and phosphates is high (Sinyakova & Krylova, 2023). The increasing economic and agricultural activities of the local population affect the ecological state of rivers, the water ecosystem, hydrobionts, and fish.

Accordingly, it is advisable to identify this problem promptly and take preventive measures.

Materials and Methods

The River Alazani and the Alazani fish Murtsa were selected as the object of our study. Monitoring was carried out in 2023-2024 seasonally (spring, summer, autumn). The main forms of biogenic elements in water samples – nitrates (NO_3^-), nitrites (NO_2^-), phosphates (PO_4^{3-}) were determined by the ionchromatographic method (ISO 10304-1:2007) (International Organization for Standardization, 2007), ammonium ion (NH_4^+) – by the spectrophotometric method (International Organization for Standardization, 2010). Determination of total nitrogen in the fish sample was carried out in accordance with GOST 7636 – 85 (*GOST*, 1985). Field and laboratory studies were conducted in accordance with modern methodology and international standards, which ensured the accuracy and reliability of the data.

Discussion and Results

The sources of anthropogenic pollution of the Alazani river can be considered organic compounds, pesticides, fertilizers, excess biogenic substances (nitrates, nitrites, phosphates, nitrogen), etc. (Mchedluri et al., 2016). Since the quantitative indicators of the content of biogenic elements clearly reflect the degree of pollution of water bodies, both by domestic and communal wastewater, and by mineral fertilizers used excessively in agriculture (Gałamon et al., 1989), it is important and relevant to determine their individual forms in the water of the Alazani River – NO_2^-, NO_3^-, NH_4^+, PO_4^{3-} – which are considered indicators of fecal pollution (Mchedluri, 2009).

Currently, due to the lack of an effective ecotoxicological monitoring network in Georgia, information on the ecological state of river water is scarce, unsystematic, and incomplete. It is noteworthy studies on the impact of pollutants on aquatic ecosystems and organisms, including fish, are not conducted systematically or comprehensively across the country.

Accordingly, to provide a comprehensive assessment of the ecological state of the Alazani river, this study aimed to determine the concentrations of biogenic elements (NO_2^-, NO_3^-, NH_4^+, PO_4^{3-}) in river water in 2023-2024 and to assess total nitrogen concentrations in fish as a bioindicator. The samples required for the study were taken from the Alazani River within the Akhmeta Municipality, in particular, near the village of Alaverdi, located on the right bank of the river.

It is noteworthy that no similar studies have been conducted over the past decade, which adds special importance to this study. The results of the study provide a basis for determining the extent to which nitrogen compounds can penetrate, be absorbed by, and subsequently accumulate in fish body. This integrated approach enables a reliable assessment of the ecological state of the water, the level of biogenic pollution, and its impact on the structure and functioning of the ecosystem.

Within the framework of the two-year monitoring conducted on the Alazani River, data on the concentrations of individual forms of biogenic elements (NO_2^-, NO_3^-, NH_4^+, PO_4^{3-}) are presented in Tables 1, 2.

Tables 1. Parameters of concentrations of biogenic elements in the Alazani river (2023)

River Alazani (Akhmeta)				
Testing parameters	**Unit**	**Result**	**MPC**	**Method used**
Spring				
Nitrites	Mg/l	0.331	3.3	ISO 10304-1:2007
Nitrates		0.832	45	
Phosphates		0.025	3.5	
Ammonium		0.388	0.39	ISO 7150-1:2010
Summer				
Nitrites	Mg/l	0.481	3.3	ISO 10304-1:2007
Nitrates		0.235	45	
Phosphates		0.233	3.5	
Ammonium		0.454	0.39	ISO 7150-1:2010
Autumn				
Nitrites	Mg/l	0.255	3.3	ISO 10304-1:2007
Nitrates		1.553	45	
Phosphates		0.222	3.5	
Ammonium		0.497	0.39	ISO 7150-1:2010

Table 2. Parameters of concentrations of biogenic elements in the Alazani river (2024)

River Alazani (Akhmeta)					
№	**Testing parameters**	**Unit**	**Result**	**MPC**	**Method used**
Spring					
1	Nitrites	Mg/l	0.038	3.3	ISO 10304-1:2007
2	Nitrates		0.657	45	
3	Phosphates		0.220	3.5	
4	Ammonium		0.342	0.39	ISO 7150-1:2010
Summer					
1	Nitrites	Mg/l	0.059	3.3	ISO 10304-1:2007
2	Nitrates		0.426	45	
3	Phosphates		0.188	3.5	
4	Ammonium		0.425	0.39	ISO 7150-1:2010
Autumn					
1	Nitrites	Mg/l	0.076	3.3	ISO 10304-1:2007
2	Nitrates		0.729	45	
3	Phosphates		0.115	3.5	
4	Ammonium		0.476	0.39	ISO 7150-1:2010

Table 3. Total nitrogen content in fish samples (2023)

Fish samples						
Sample name	**Sampling time**	**Test Parameters**	**Unit**	**Result**	**Method used**	**Note**
Alazani river fish	September	Total nitrogen	%	2.78	GOST 7636-85	Analytical weight 350 gr.

Table 4. Total nitrogen content in fish samples (2024)

Fish samples						
Sample name	**Sampling time**	**Test Parameters**	**Unit**	**Result**	**Method used**	**Note**
Alazani river fish	September	Total nitrogen	%	3.26	GOST 7636-85	Analytical weight 350 gr.

Fish, as one of the main links in the aquatic trophic chain, are sensitive to excess biogenic elements. Their accumulation in fish tissues is not only an indicator of ecosystem stress, but also poses a direct risk to human health (Plessl et al., 2017). Determination of biogenic elements in fish is particularly relevant, as fish act as bioindicators of chemical pollution in aquatic ecosystems. Accordingly, studying biogenic elements in fish provides a more complete assessment of ecological status and is important for water quality monitoring (Hedayati, 2019).

The results of the study of total nitrogen content (the sum of organic and mineral nitrogen, expressed as a percentage) determined in fish samples from the Alazani River are presented in the tables below.

Determining total nitrogen is important because nitrogen compounds are one of the main biogenic elements of aquatic ecosystems, and their concentrations directly affect water quality and the state of ichthyofauna (Camargo & Alonso, 2006). Fish, as bioindicators, accumulate both organic and mineral nitrogen in their bodies, providing an objective picture of anthropogenic pollution and ecological stress (Dodds & Welch, 2000). Such research data play an important role in monitoring and managing aquatic ecosystems, which is especially important for protecting the ecological stability of the Alazani and Aragvi rivers and ensuring sustainable development.

Comparative analysis of the research data indicates that in September 2024, total nitrogen content in fish samples from the Alazani River increased compared to the same period in 2023. In particular, total nitrogen levels in the river was 2.78% in 2023, and 3.26% in 2024, representing a 17.3% increase. Although the total nitrogen content does not exceed the established maximum permissible concentration (MPC), the upward trend may reflect a growing anthropogenic impact on the river. Such dynamics could serve as an early warning of ecosystem degradation and underscore the need for intensive hydrochemical and biological monitoring of the Alazani.

These findings emphasize the importance of effective water resource management and systematic ecological monitoring, which are essential for mitigating anthropogenic pressures and maintaining the stability and biological diversity of the river ecosystem.

Conclusions

Seasonal monitoring conducted in 2023-2024 showed that the concentrations of biogenic elements – nitrates (NO_3^-), nitrites (NO_2^-) and phosphates (PO_4^{3-}) – remained within the maximum permissible concentrations.

In contrast, ammonium ion (NH_4^+) concentrations increased notably during summer and autumn, reflecting the application of ammonium- and ammonia-based fertilizers to agricultural fields during these periods.

The 17.3% increase in total nitrogen (TN) concentrations in fish samples in September 2024 compared to 2023 serve as an early warning of ecosystem degradation and suggests a rising anthropogenic impact on the Alazani River. These findings underscore the importance of regular ecological monitoring of fish populations in the River.

The results of the 2023-2024 study indicate the need for systematic and complex monitoring of biogenic elements, both to assess the ecological status of the Alazani River and to evaluate their concentrations and biological effects on fish organisms.

ეკოლოგია

ბიოგენური ელემენტების კონცენტრაცია მდინარე ალაზნის წყალში და საერთო აზოტის შემცველობა თევზის ორგანიზმში

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ანთროპოგენური ფაქტორების ზემოქმედება უარყოფით გავლენას ახდენს მდინარე ალაზნის წყლის ხარისხსა და ეკოსისტემის მდგომარეობაზე, რაც ზრდის გარემოსდაცვით რისკებს. წყლის ეკოლოგიური მდგომარეობის შეფასების მიზნით, აქტუალურად ჩავთვალეთ მდინარე ალაზნის წყალში 2023-2024 წლებში, სეზონურად, ბიოგენური ელემენტების (NO_2^-, NO_3^-, NH_4^+, PO_4^{3-}) განსაზღვრა და თევზებში, როგორც ბიოინდიკატორში, საერთო აზოტის კონცენტრაციის დადგენა. სინჯები აღებულ იქნა მდინარე ალაზნიდან, ახმეტის მუნიციპალიტეტის ტერიტორიაზე (სოფელი ალავერდი). წყლის ნიმუშებში ბიოგენური ელემენტები (NO_3^-), (NO_2^-), (PO_4^{3-}) განისაზღვრა იონ-ქრომატოგრაფიული მეთოდით (ISO 10304-1:2007); (NH_4^+) კი – პექტროფოტომეტრული მეთოდით. თევზის საანალიზო ნიმუშში საერთო აზოტი განისაზღვრა გოსტ 7636-85 შესაბამისად. ორწლიანი მონიტორინგის შედეგად დადგინდა, რომ ნიტრატების, ნიტრიტებისა და ფოსფატების კონცენტრაციები მერყეობდა ზდკ-ს ფარგლებში. ამონიუმის იონის კონცენტრაციამ კი ზაფხულსა და შემოდგომაზე გადააჭარბა ზდკ-ს. ამონიუმის მატება ემთხვევა სასოფლო-სამეურნეო სავარგულებზე სასუქების შეტანის პერიოდს, რაც ტოქსიკურია თევზებისა და ჰიდრობიონტებისთვის. მდინარე ალაზნის თევზის ნიმუშებში ნაჩვენებია, რომ საერთო აზოტის შემცველობა 2024 წლის სექტემბერში 3,26%-მდე გაიზარდა, რაც 2023 წლის 2,78%-თან შედარებით 17,3%-იანი ზრდაა. მიუხედავად იმისა, რომ მონაცემები ზდკ-ს ფარგლებშია, ეს დინამიკა მიუთითებს ეკოლოგიური სტრესის ზრდის რისკზე, რაც მოითხოვს მდინარის მუდმივ მონიტორინგს და კომპლექსურ შეფასებას. ბოლო ათწლეულის განმავლობაში მსგავსი კომპლექსური კვლევები არ განხორციელებულა. კვლევის შედეგები საფუძველს ქმნის იმის დასადგენად, რამდენად შესაძლებელია აზოტოვანი ნაერთების შეღწევა, აბსორბცია და შემდგომი აკუმულაცია თევზის ორგანიზმში. ასეთი კომპლექსური მიდგომა უზრუნველყოფს წყლის ეკოლოგიური მდგომარეობის მართებულ შეფასებას, ბიოგენური დაბინძურების დონის განსაზღვრას და მის გავლენას ეკოსისტემის სტრუქტურასა და ფუნქციონირებაზე.

REFERENCES

Camargo, J. A., & Alonso, Á. (2006). Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment. *Environment International, 32*(6), 831-849. https://doi.org/10.1016/j.envint.2006.05.002

Dodds, W. K., & Welch, E. B. (2000a). Establishing nutrient criteria in streams. *Journal of the North American Benthological Society, 19*(1), 186-196. https://doi.org/10.2307/1468291

Gałamon, T., Paszkiewicz, Z. (1989). Determining the levels of selected pesticides, nitrates, nitrites, ammonium ions, sulphates, chlorides, and urea in surface and underground waters. *Polish Journal of Environmental Studies, 40*(4-6), 297-301.

GOST 7636-85. Fish, marine mammals, invertebrates and products of their processing. Methods of analysis.

Hedayati, A. (2019). Fish biomarkers, suitable tools for water quality monitoring. *International Journal of Veterinary and Animal Research.* https://ijvar.org/index.php/ijvar/article/download/61/54

ISO 10304-1:2007. Water quality. Determination of dissolved anions by liquid chromatography of ions. https://doi.org/10.3403/30171464

ISO 7150-1:2010. Water quality. Determination of ammonium – spectrophotometric method.

Mchedluri, T. (2009). *Monitoring and bioindication of processes of microbe self-clearing of open bodies of Eastern Georgia.* Universal.

Mchedluri, T., Makharoblidze, N., & Vepkhvadze, A. (2016, October). *The impact of pesticides on ecological condition of the river Alazani.* Ganja.

Plessl, C., Otachi, E. O., Körner, W., Avenant-Oldewage, A., & Jirsa, F. (2017). Fish as bioindicators for trace element pollution from two contrasting lakes in the Eastern Rift Valley, Kenya: Spatial and temporal aspects. *Environmental Science and Pollution Research, 24*(24), 19767–19776. https://doi.org/10.1007/s11356-017-9518-z

Sinyakova, M. A., & Krylova, Yu. V. (2023). Biogenic elements in the water and bottom sediments of Lake Ladoga. *Russian Journal of General Chemistry,* 93, 3383-3390.

Received December, 2025