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Analysis of the Impact of Anthropogenic Activities on the Biochemical Parameters of Water and Hydrobiont Diversity in the Heydar Aliyev Reservoir in Nakhchivan

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Abstract. *In this study, the hydroecological state of the Heydar Aliyev reservoir, located in the Nakhchivan Autonomous Republic, was comprehensively assessed with consideration of ongoing anthropogenic impacts. Water samples were collected and analyzed to determine key biochemical indicators, including nutrient levels, dissolved oxygen, and pH, as well as hydrobiological components such as phytoplankton and zooplankton communities. The study revealed that agricultural activities in the surrounding areas, particularly the use of mineral fertilizers, significantly influenced the reservoir's water quality. Surface runoff from cultivated lands carried excess nutrients into the reservoir, resulting in increased concentrations of nitrogen and phosphorus compounds. These nutrient enrichments triggered alterations in the planktonic structure, including shifts in species composition and abundance, which may have further implications for the overall aquatic ecosystem. Seasonal variations were also observed, indicating periods of higher vulnerability to eutrophication. The findings highlight the strong link between land use practices and the ecological health of freshwater systems. Effective management strategies, including controlled fertilizer application and the implementation of buffer zones, are recommended to mitigate these anthropogenic pressures and preserve the reservoir's ecological balance.*

Keywords: *reservoir, anthropogenic impact, hydrobiology, ecosystem, biochemical*

Introduction

Inland water bodies are of great importance in terms of ecosystem services and are considered to be among the most sensitive natural systems to the impacts of human activity. In addition to providing numerous services such as water supply, fisheries, agriculture, tourism and recreational opportunities, these basins play a key role in protecting biodiversity and ensuring ecological balance. However, in modern times, industrialization, urbanization, intensive agriculture and other anthropogenic activities put serious pressure on inland water bodies.

Anthropogenic pollutants, especially nitrogen and phosphorus compounds, accelerate the eutrophication process by causing trophic changes in the aquatic environment. Eutrophication is characterized by the massive development of phytoplankton and algae in water bodies as a result of an increase in nutrients. This process leads to a decrease in water transparency, limited illumination at depths and a disruption of the oxygen regime of the aquatic ecosystem. As a result, the living conditions of fish and other aquatic organisms in water bodies deteriorate, and in some cases, mass fish deaths are observed.

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Biochemical indicators are the main indicators for assessing the sanitary and ecological state of water. For example, BOD_5 (biochemical oxygen demand) and dissolved oxygen levels reflect the degree of organic pollution. A high BOD_5 level indicates the presence of a large amount of organic matter in water and the need for microorganisms to decompose these substances through oxygen consumption. Nitrate and phosphate ions indicate an increase in anthropogenic nutrients entering water bodies, which is associated with agricultural waste, sewage discharges and industrial emissions.

In addition, monitoring the quality indicators of water bodies is important not only for assessing ecosystem health, but also for protecting public health, sustainable management of water resources and the formation of environmental policy. Modern scientific research shows that an integrated assessment of various physico-linear and biochemical indicators allows for a more accurate and comprehensive determination of the ecological state of water. In this regard, the protection of inland water bodies and the prevention of their pollution are considered one of the main priorities of sustainable environmental management.

Materials and Methods

The object of the study is a reservoir located in a semi-desert climate zone. The area is characterized by high summer temperatures, limited precipitation, and strong evaporation (Guliyeva et al., 2025). Agricultural activity in the reservoir basin area is intensive, which increases the risk of agrochemicals (nitrogen and phosphorus fertilizers, pesticide residues, etc.) entering the aquatic environment. Soil erosion products, suspended particles, and mineral fertilizer residues are transported to the water body through surface runoff resulting from rainfall and irrigation. This can lead to a change in the trophic state and an increase in the concentration of biogenic elements (Paerl & Otten, 2013).

Sampling was carried out during the growing season, which is characterized by a maximum level of biological activity. Samples were selected from three main zones covering the hydrological and ecological characteristics of the reservoir (Ansarova, 2017):

- River inflow area – the main inflow point of foreign substances and nutrients;
- Central aquatorium – a more homogeneous part of the water mass;
- Coastal zone – an area more sensitive to anthropogenic impacts and coastal processes.

In each zone, samples were taken from the surface layer (0–50 cm depth) in sterile glass containers and delivered to the laboratory at a temperature of +4 °C until analysis. Preservation and storage of samples were carried out in accordance with the requirements of international standards (Dodds & Smith, 2016).

Within the framework of the study, the main biochemical and physicochemical indicators of water samples were determined based on international standard methods. The pH indicator was measured electrometrically using a calibrated pH-meter. The concentration of dissolved oxygen (O_2) was determined by the classical Winkler titrimetry method. This method allows to determine the exact amount of oxygen in water and is widely used in assessing the oxygen balance of the aquatic ecosystem.

Biochemical oxygen demand (BOD_5) was calculated based on the 5-day incubation method at a temperature of 20 °C. The difference between the initial and final oxygen indicators reflects the amount of oxygen consumed by microorganisms for the decomposition of organic matter (Wetzel, 2001).

Nitrate (NO_3^-) and ammonium (NH_4^+) ions were determined by spectrophotometric analysis. This method is based on measuring the color intensity formed as a result of the reaction of ions with specific reagents. The amount of phosphate ions (PO_4^{3-}) was determined by the molybdate method;

in this case, the optical density of the complex formed in the reaction with ammonium molybdate was measured.

Results

The results obtained were statistically processed, and average values and standard deviations were calculated. This methodological approach allowed for an objective and reliable assessment of the sanitary and ecological state of the reservoir.

Table 1
Analyses were conducted based on international standard methodologies
(Salmanov & Ansarova, 2018)

Indicator	Method
pH	electrometric
Dissolved O_2	Winkler style
BOD_5	5 days incubation
Nitrate, Ammonium	Spectrophotometric
Phosphate	Molybdate method

Hydrobiological analyses. Plankton samples were collected with a plankton net, and the species composition was determined under a microscope. Biodiversity was calculated using the Shannon index. Plankton samples were collected using a plankton net within the scope of the study. The species composition of the samples was determined under a microscope in laboratory conditions and the presence of each species was recorded. Plankton biodiversity was calculated based on the Shannon index, which allowed assessing the structural diversity and stability of the ecosystem. The main biochemical indicators determined during the study and their evaluation were as follows (Ansarova, 2020):

• pH: was in the range of 7.6–8.3, which indicated that the water was slightly alkaline from neutral.
• Dissolved oxygen (O_2): was recorded in the range of 6.1–8.5 mg/L, which is at a satisfactory level according to the assessment.
• BOD_5 (5-day biochemical oxygen demand): was between 3.2–5.6 mg/L, indicating an average level of pollution (Carpenter et al., 1998).
• Nitrate: The nitrate level of the water was found to be high, which indicates the presence of anthropogenic impacts.
• Phosphate: The phosphate content was high, and this situation was associated with the risk of eutrophication of the water.

These results allow us to determine the state of the ecosystem in terms of both hydrobiological and chemical indicators and assess the degree of anthropogenic impacts (Salmanov & Huseynov, 2013). Hydrobiological indicators. Green algae and diatoms dominated the species composition of phytoplankton. An increase in cyanobacteria was observed in some areas, which is associated with high nutrient levels. A decrease in zooplankton diversity was recorded. The Shannon index was at an average level, which indicates that the ecosystem is under some degree of stress (Smith et al., 1999).

Disscussion

The results of the study conducted in the Heydar Aliyev reservoir show that the biochemical indicators and hydrobiological diversity of the water were mainly affected by anthropogenic impacts, especially agricultural activities and surface runoff. The increase in nitrate and phosphate concentrations is directly related to the leaching of agricultural fertilizers and soil erosion.

Table 2
Biochemical indicators (Salmanov & Ansarova, 2018)

Parameter	Average value	Assessment
Ph	7.6–8.3	Neutral–weakly alkaline
It's done	6.1–8.5 mg/l	Satisfactory
Bod_5	3.2–5.6 mg/l	Moderate pollution
Nitrate	Elevated	Anthropogenic impact
Phosphate	Elevated	Risk of eutrophication

This has led to a change in the trophic status of the water, especially an increase in phytoplankton biomass (Ansarova, 2016). Green algae and diatoms predominate in the species composition of phytoplankton. This indicates that the amount of nutrients in the aquatic environment is high in certain areas. The growth of cyanobacteria in certain zones indicates potential water bloom tendencies. The decrease in zooplankton diversity is a sign that the trophic chain in the ecosystem is disrupted and some species may be under stress (Ansarova, 2014).

Looking at biochemical indicators, the moderate level of BOD_5 indicates that organic matter has entered the water, but dissolved oxygen has not yet fallen to a critical level. This means that the oxygen regime in the reservoir is still stable, but in the future, if the amount of nutrients increases and the temperature rises, the problem of oxygen deficiency may arise (Ansarova, 2016). The research results show that the anthropogenic impact is mainly stronger in the river inlet area and the coastal zone. This indicates that some parts of the reservoir are more ecologically sensitive. If this situation continues, the change in plankton structure will become more widespread and the accumulation of high nutrients will negatively affect ecosystem functions (Salmanov & Huseynov, 2013). These results also indicate that there are potential ecological risks in irrigation and domestic water use in the surrounding areas. Therefore, continuous water monitoring, keeping nutrient levels under control and managing runoff from agricultural areas is important (Ansarova, 2014).

Conclusion

This has led to a change in the trophic status of the water, especially an increase in phytoplankton biomass. Green algae and diatoms predominate in the species composition of phytoplankton. This indicates that the amount of nutrients in the aquatic environment is high in certain areas. The growth of cyanobacteria in certain zones indicates potential water bloom tendencies. The decrease in zooplankton diversity is a sign that the trophic chain in the ecosystem is disrupted and some species may be under stress.

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Declaration of Competing Interests

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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