Review Article

Hydrobiology of the Mingachevir Reservoir and Ecological Analysis of Zooplankton Communities

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Abstract

This review summarizes the hydrobiological characteristics of the Mingachevir Reservoir, with particular emphasis on the ecological analysis of its zooplankton communities. In this review, the hydrological, biological, and ecological characteristics of the reservoir, as well as the species composition and dynamics of zooplankton communities, are analyzed on the basis of long-term data. The results of the studies carried out from 1960 to 2023 are compared, and changes in zooplankton communities are assessed. It is significant that a considerable number of species found in the works of Likhodeyeva (1963) and Ahmadov (1971) survived until now, and this suggests the relatively stable state of the ecosystem. However, the appearance of new species in the Mingachevir reservoir in 2021–2023 proves the growth of hydrobiological diversity. The relationships between zooplankton species diversity, dominant species succession, and environmental factors are discussed. Comparison with the Varvara reservoir made it possible to formulate necessary conclusions about similarities and differences of zooplankton communities in the cascade reservoirs.

Keywords: zooplankton, Mingachevir reservoir, hydrobiological characteristics, species diversity, ecological assessment

1. Introduction

The Mingachevir Reservoir is known as the first large reservoir built on the Kura River in Azerbaijan. The construction of the facility was completed in 1953 and has been operated for multiple purposes since its commissioning. The reservoir is located at approximately 40°55′30.1″ N latitude and 46°47′44.3″ E longitude and is the largest artificial lake formed in the middle reaches of the Kura River, which crosses the Samukh Valley. The main indicators of the reservoir are quite large: its length is 75 km, maximum width is 20 km (average width is 8.3 km), and the deepest point reaches 75 meters in the section near the dam. The average depth is considered to be 27 meters. The reservoir covers approximately 62,000 ha and has a total storage capacity of water. The dam that creates the reservoir is 1,550 meters long and 80 meters high. The Mingachevir Hydroelectric Power Station, with a total capacity of approximately 402 kW, operates on this dam. Two main irrigation canals, Upper Karabakh (172 km) and Upper Shirvan (128 km), also branch off from the reservoir. Both canals have been in operation since 1958 and have played a significant role in the development of the irrigation system in the region [1].

2. Hydrobiological Characteristics of Mingachevir Reservoir

In addition to being a necessary strategic facility in terms of energy, irrigation, and transportation, the Mingachevir Reservoir is also widely used in the city's drinking water supply, recreation, and tourism sectors. Fishing is also one of the main activities here. Fishing has been conducted in the reservoir area since 1955, and the productivity has been determined to vary between 0.6–4.1 kg per hectare. Scientific studies show that this figure can increase to 7 kg/ha. Under current circumstances, real productivity is likely to be higher than statistical figures. The reservoir is fed by the Kura, Ganikh, Gabyrri, and Ganja rivers. Although the reservoir can be classified as a riverbed type due to its hydrological characteristics, it is characterized as a lake-type reservoir due to the fact that the hydraulic residence time is approximately one year and a considerable proportion of suspended sediments is deposited within the reservoir [1]. As a result of the creation of the reservoir, ancient forests along the Kura, Ganikh, and Gabyrri rivers, as well as part of the Samukh forests located in the Samukh depression, were submerged [2].

These forests were dominated by valuable tree species such as oak, elm, willow, mulberry, and alder. Today, in the upper reaches of the reservoir, it is possible to find the dry remains of those trees, stumps jutting out of the water like "tombstones."

3. Phytoplankton Species Composition and Dynamics

Phytoplankton of the Mingachevir reservoir was first studied by S. Rzayeva in the 1950s–1960s. As a result of the research, a total of 232 algae species were recorded in the reservoir, approximately 150 of which were characterized as typical plankton forms. In terms of species diversity, green algae dominate (94 species), followed by diatoms (88 species) and blue-green algae (29 species). During the initial formation of the reservoir, the density of phytoplankton was quite high. Thus, an average of 9,050 cells were recorded per cubic meter of a 55-meter water column, and the total biomass was 11.9 g/m³. Among the species, Chlorella vulgaris, Coelastrum microporum, and Oocystis borgei are particularly widespread and dominant. However, the development of higher aquatic plants is observed at a relatively weak level.

Phytoplankton constitute the primary producers in the reservoir ecosystem and form the basis of the aquatic food web. Such organisms, which produce the largest share of organic matter via photosynthesis, are the foundation of primary production. Organic matter produced in this way serves as the major nutritional base for zooplankton, fish larvae, and benthic organisms. Mesotrophic-eutrophic features of the Mingachevir Reservoir provide high productivity of phytoplankton that positively impacts the development of higher trophic levels.

Another function of phytoplankton in aquatic ecosystems is the regulation of oxygen content in water. Photosynthesis performed in the daylight period enriches water with oxygen, thus creating the necessary conditions for the existence of fish, zoobenthos, and aerobic microorganisms. Research shows that the maximum activity of photosynthesis is provided mainly in the spring-summer period, when the content of dissolved oxygen in the water significantly increases. Species composition and abundance of phytoplankton serve as a significant bioindicator of the ecological state of the water body. Massive development of phytoplankton is often connected with the increased nutrient content of the water, in particular, nitrogen and phosphorus compounds, suspended particles carried to the water by rivers, and anthropogenic factors. For instance, the intensive development of blue-green algae (Cyanophyta) serves as a necessary indicator of the beginning of the eutrophication process. The excessive growth of phytoplankton leads to alters the physical and chemical characteristics of the water. At this point, the transparency of the water decreases, its color changes, and the light transmission is reduced. Thus, the temperature regimen of the reservoir and light penetration into the lower layers are changed, which influences the life of benthos. The role of phytoplankton in the development of fish populations is also enormous.

Phytoplankton is the first link in the food chain web, and the amount of phytoplankton affects the development of zooplankton, fish larvae, and productivity of fish. The reaction of zooplankton groups, Cladocera and Copepoda in particular, to phytoplankton amount is very sensitive, and a large amount provides the proper conditions for fishing. Moreover, the activity of phytoplankton in self-cleaning of the water body should be noted. They can absorb ammonia, nitrate, phosphate, and some heavy metals and organic substances, also stimulating microbiological degradation processes.

The above-listed characteristics make it possible to describe phytoplankton as a significant component of the biological water filtration system.

In this connection, phytoplankton in the Mingachevir reservoir serves not only as a source of the food chain, but also as one of the basic elements that ensure the stability, productivity, and ecological equilibrium of the aquatic ecosystem.

The roles of phytoplankton in the Mingachevir reservoir can be formulated as follows:

- ensures the normal functioning of the ecosystem;
- serves as a basis of the trophic chain;

- regulates the oxygen regime of the water;
- serves as an indicator of water pollution;
- is an essential factor in creating fish stocks.

Therefore, the analysis of phytoplankton's structure, quantity, and seasonal changes plays an important role in determining the ecological state of the reservoir.

4. Species Composition and Dynamics of Zooplankton

Zooplankton is one of the key biocomponents performing extremely significant roles in the Mingachevir Reservoir ecosystem. Organisms belonging to the primary consumers in the aquatic food web mainly consume phytoplankton and play a predominant role in energy and matter flow transfer processes in the aquatic environment. Since zooplankton serves as a natural link between phytoplankton and fish, the formation of fish populations in a reservoir is entirely dependent on their presence and activities. One more role of zooplankton is controlling water quality and regulating phytoplankton biomass through grazing. Otherwise, the overgrowth of the phytoplankton population will increase water turbidity and affect the oxygen regime negatively, thus creating adverse conditions for living organisms in the aquatic environment. Thus, zooplankton can be considered as a natural regulating system in the ecosystem. Zooplankton is also one of the main food sources for fish and other aquatic organisms. Young fish mainly feed on zooplankton. Therefore, the number of zooplankton organisms is extremely important for the survival of the fish population. The role of these creatures is not only limited to being consumers and contribute to natural water purification processes. Zooplankton aids in increasing water clarity and general sanitation through consumption of organic debris, bacteria, and phytoplankton in excess amounts. Thus, the number and diversity of zooplankton can be considered good indicators of the ecological state of the watershed. Systematic studies of the zooplankton of the Mingachevir Reservoir started in the 1960s, and the infusorians became the focus of research in the 1970s. Infusorians of the reservoir were first systematically investigated by I. Alakbarov (1977). As a result of his study, 50 types of planktonic infusorians were found in the reservoir, including the novel genus Astrostama and its species A. mobilis. In the course of his research from 1977 to 2005, I. Alakbarov described numerous new families, genera, and over 100 types of infusorians.

Although at the beginning of studies on the mesoplankton community of the reservoir there were 22 species discovered, in recent years the number of species has fluctuated between 32 and 38. Rotifers (15 species) and cnidarians are dominant in terms of diversity of species, but copepods lead in terms of numbers and biomass. Zooplankton biomass is in the range of 1.28–3.6 g/m^3, and 93–99.6% of biomass is represented by crustaceans [3].

The first research on the faunistic complex of zoobenthos goes back to the 1950s and 1960s. At the beginning of the research, 66 species were registered, and according to some data, there were almost 100 species. In the process of the research, the species composition of the benthos has changed: despite the fact that some rheophilic species which were present in abundance at the first stages of the research have disappeared, the fauna became richer due to the appearance of limnophilic and pelophilic species.

After the successive construction of the Shamkir reservoir (1982) and Yenikend reservoir (2000) on the Kura River in the upper reaches of Mingachevir, changes in water flow have had a significant impact on both the number and biomass of benthos in the Mingachevir reservoir. Currently, the mass of benthos varies in the range of 4.4–16.2 g/m^2, which is a significant decrease compared to previous periods.

In general, zooplankton and zoobenthos are components that play a key role in the formation of the food chain and biological balance of the Mingachevir reservoir ecosystem, and their changes are one of the most sensitive indicators of the ecological state of the reservoir.

5. Ichthyofauna

It has been continuously studied since the 1950s to the present day. 34 species and subspecies and 2 hybrid fish have been recorded in the Mingachevir reservoir. Among them, 9 species are of national importance. Among the fish inhabiting this area are kulma, cheki, chapaq, Khramulya, usach, sif, nakha, hasham, and shemaya. In recent years, 4 more species of valuable freshwater fish (salmon, agamur, and garasol) have been recorded in the reservoir. The biomass and number of zooplankton in the Mingachevir reservoir vary seasonally [3]. In recent years (2000–2008), the amount of fish caught from the Mingachevir reservoir has decreased significantly - from 39.2 tons (2002) to 94.9 tons (2005). On the one hand, this is due to the improper use of the biological justification prepared for the reservoir, and on the other hand, it is due to illegal fishing, the concealment of a large part of the fish caught, and the failure to record some of them (in statistics).

The metazoan plankton of the Mingachevir reservoir was first studied by Likhodeyeva (1963), and 21 zooplankton species were recorded [4]. Later, Ahmadov (1971) identified 38 species [5]. Both authors noted that A. priodonta, P. vulgaris, D. brachyurum, D. longispina, D. hyalina, B. longirostris, L. kindtii, S. sarsi, A. acutilobatus, M. fuscus, and T. dybowskii are the most widespread and permanent species of the Mingachevir reservoir. Studies conducted by Alekperov in the 1970s on the protozooplankton community (ciliate fauna) of the Mingachevir Reservoir documented 50 species of free-living ciliates (Alekperov, 1987; Alekperov & Tapdygova, 2022) [6]. Subsequent investigations carried out after the commissioning of the Yenikend Reservoir revealed that the species richness of metazooplankton within the reservoir cascade ranged from 26 to 31 species during the period 2001–2005 (Ahmadov, 2003, 2006).

A comparative analysis of zooplankton indicators obtained in the Mingachevir reservoir in 2021–2023 with data from the 1960s revealed that 16 of the 21 species recorded by Likhodeyeva (1964) and 25 of the 38 species recorded by Ahmadov (1971) have maintained their existence for 55–60 years [4], [5]. L. luna, B. bennini, B. falcatus, A. affinis, C. strennus, M. viridis, M. leucarti, and A. crassa, recorded in 2021–2023, are new species for the reservoir.

T. dybowskii, listed as the permanent species by both researchers, maintains its dominance today. In all seasons of 2021–2023, B. longirostris, Ch. sphaericus, and A. acutulobatus dominated the zooplankton complex.

6. Comparative Analysis of the Kura River Cascade Reservoirs

As it moves westward from the Central Lowland zone of Azerbaijan, the cascade of reservoirs of the Kura River begins with Varvara and ends with the Shamkir Reservoir. For the purpose of comparative analysis of zooplankton of cascade reservoirs, the Varvara reservoir was studied in 2019–2021, and 41 metazooplankton species were recorded: 19 species of rotifers, 12 species of cladocera, and 10 species of copepods (Alekperov and Tapdykova 2021) [6].

When comparing with the Sorensen similarity coefficient (1948), it was determined that [7]:

- 1 rotifer species, 4 cladoceran species, and 4 copepod species recorded in the Mingachevir reservoir were not found in the Varvara reservoir.
- 7 rotifer species, 4 cladoceran species, and 3 copepod species recorded in the Varvara reservoir were not detected in Mingachevir.

Similarity coefficients:

- Rotifera: K = 75%
- Cladocera: K = 66.7%
- Copepoda: K = 66.7%

Thus, the highest similarity between the Mingachevir and Varvara reservoirs is observed in rotifers, and lower in cladocerans and copepods. As a result of research conducted after an interval of approximately 60 years, new information has been obtained on the species composition, quantitative parameters, distribution across biotopes, and seasonal development dynamics of multicellular zooplankton (metazooplankton) communities of the Mingachevir reservoir [8]. It was determined that the metazooplankton of the reservoir consists of 36 species belonging to 3 taxonomic groups. Rotifera (36.1%) dominates in terms of species diversity. The most common types in all seasons of the year are:

- Polyarthra vulgaris
- Asplanchna priodonta
- D. longispina
- D. hyalina
- Ch. sphaericus
- Bosmina longirostris

– acutulobatus
– T. dybowskii

These species played a leading role in shaping the structure of zooplankton.

7. Conclusion

Studies confirm that the zooplankton diversity of the Mingachevir reservoir demonstrates both stability and renewal characteristics over time. The fact that a significant portion of zooplankton species recorded in the 1950s–1970s still exist today indicates the long-term sustainability of the ecosystem. However, the discovery of new species in 2021–2023 indicates that the hydrobiological dynamics and ecological conditions of the reservoir are changing. The maintenance of dominance in zooplankton communities by species such as B. Longirostris, Ch. Sphaericus, A. Acutulobatus, and T. Dybowskii ensures the functional stability of the ecosystem. Comparative studies with the Varvara reservoir have shown that there are differences in species diversity in cascade reservoirs and that these differences are formed depending on hydrology, nutrients, and anthropogenic impacts. In conclusion, contemporary ecological studies of zooplankton communities are the scientific foundation that can ensure the sustainability of biological productivity and the food chain, provides a scientific basis for the sustainable management of biological productivity, food-web integrity, and fishery resources.

Author Contributions

The author was responsible for the conceptualization of the study, literature review, data collection and analysis, interpretation of the results, and preparation of the manuscript. Dr. Naila Guliyeva supervised the research, provided scientific guidance throughout the study, critically reviewed the manuscript, and approved the final version for publication.

Conflict of Interest

The authors declare no conflicts of interest.

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