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Evaluation of the lake Lyabiazhie (Kazan, Russia) state by indicators of communities of hydrobionts

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Abstract. The article presents the results of studies of zooplankton and zoobenthos communities of Lake Lebyazhye (Kazan, Russia) performed in 2015-2016. Over the past decades, under the influence of anthropogenic and natural factors, the level of water decreased and the area of Lake Lebyazhye decreased. Now the water level in the lake is artificially maintained by the supply of groundwater, which led to a change in the type of water, an increase in mineralization. As a result, species composition of zooplankton decreased, a complex of dominant species changed, and quantitative indicators of zooplankton and zoobenthos communities decreased. The results of studies of the zooplankton and zoobenthos communities of Lake Lebyazhye can be used to justify measures for the lake's eco-rehabilitation.

1. Introduction

The problem of preserving water bodies located in urban areas is becoming increasingly urgent. Lake Lebyazhie is located in the urban forest park "Lebyazhye" (Kazan, Russia). Earlier the lake was a system of four reservoirs: Great, Small, Light, and Dry Swan, connected by ducts. Now there is only one lake left, and the others have dried up. Talking of the origin of the lake, it is supposedly dune or deflation-karst [1]. The water level is artificially maintained by the supply of groundwater from wells in Small Lebyazhye Lake. According to estimations in 2015, the area of Lake. M. Lebyazhye is 3.38 hectares, the volume of the water mass is 31 thousand m3, the maximum depth is 2.9 m, the average depth is 0.92 m, the water volume is 31 thousand m^3, the length of the coastline is 1630 m, the catchment area is 73.7 hectares.

Previously, the water in the Lebyazhye Lake was a hydrocarbonate-calcium type, it was "very soft", with "medium" mineralization. Submission of groundwater to the lake led to an increase in mineralization of water (from 151.5 mg/l to 975.2 mg/l). Indirectly, the content of salts in water can be recognized from the value of the electrical conductivity of water. Its magnitude in different years was 121-410 μS/cm in Small Lebyazhye Lake. In 2015, this indicator was 1030-1280 μS/cm, and in 2016 it was 730-1500 μS/cm, which characterizes the mineralization as "medium-high". The sulfate content was 21.8 mg/l earlier; 513.7 mg/l in 2015, then sulfates prevailed from the anions in 2015. The water in the lakes was observed previously as hydrocarbonate-sulphate-calcium type, medium mineralization, 'very soft'. At the present time it is 'very hard', with high mineralization.

The lake is a valuable recreational facility, therefore it is necessary to take measures to preserve the lake and maintain high water quality. Currently, the project of eco-rehabilitation of Lake Lebyazhye has been developed and is being implemented. It is planned to restore the Great and Light Lebyazhye lakes within their former borders. It is planned to deepen the lakes up to 3-4 m, to restore the waterproof layer and also to build a pumping station and a pipeline to supply water from the Emerald lake. Conservation of the Lake Lebyazhye includes an assessment of the state of the zooplankton and zoobenthos communities in the complex of actions. It is an important and necessary element, since it will allow selecting the most optimal strategy for the conservation and restoration of the reservoir.

The purpose of the work was to assess the state of Lake Lebyazhye (Kazan, Russia) according to the indicators of the communities of hydrobionts.

There are many methods to assess the water quality, each of them has its own advantages and disadvantages. The abundance of species of living creatures that live in water bodies and the complexity of their interaction with the environment and other organisms made it possible for emergence of methods for biological assessment of the state of natural waters. Hydrobiological analysis is an important element and allows determining the ecological state of water bodies and the consequences of their contamination [2]. The driver to use bioindication as a method for assessing water quality is close relationship between environmental quality and the structure of benthic and plankton communities of aquatic ecosystems. Biological indicators are a promising element of the monitoring system for surface water pollution and allow to determine the ecological status and trophic status of water bodies; to assess the quality of waters as habitats of organisms; determine the combined effect of the combined effect of pollutants; localize the source of pollution; to establish the type of pollutants and the occurrence of secondary water pollution [3, 4].

Zooplankton in aquatic ecosystems that carry out a huge process of transferring the energy of primary production to subsequent trophic levels, participate in the processes of natural self-purification and creation of secondary products [5]. Some characteristics of zooplankton are recommended for bioindication, such as the index of species diversity, the average individual mass of zooplankton, the ratio of crustacean and rotifer biomass, biomass of filter feeders and predators, etc. [6-11]. All these characteristics of zooplankton vary due to contamination and eutrophication. The dynamics of changes in the qualitative and quantitative composition of zooplankton and data on the dominance of various species will allow us to conclude the change of water quality over a certain period of time. Therefore, the greatest interest in environmental studies is the long-term and repeated observation of zooplankton [12].

According to many experts [13], zoobenthos is one of the most informative and reliable bioindicators of the state of the environment and its anthropogenic changes. Benthic invertebrates and their communities are sensitive indicators of pollution with nutrients and toxic substances, acidification and eutrophication of water bodies [14, 15]. The duration of life cycles of zoobenthos organisms is much higher in comparison with planktonic organisms. Consequently, the state of zoobenthos communities can reflect the level of chronic pollution. In addition, generally benthic invertebrates lead a sedentary lifestyle, therefore the state of zoobenthos communities clearly characterizes not only the ecological state of the reservoir as a whole, but also its individual areas [14, 15].

2. Material and methods

Samples of zooplankton and zoobenthos were collected at Lake Lebyazhye during the period from May to September of 2015 and 2016. Samples were collected every 10-14 days from 1-4 stations.
Zooplankton samples were collected by filtering 50 liters of water through an Apstein network with a mesh size of 100 μm. Cameral processing was conducted according to generally accepted methods [12]. The values of the abundance of zooplankton were calculated for each station. Biomass was calculated from the equations connecting the length of organisms with their mass. Assessment of water quality by zooplankton was carried out using saprobity indices.

Features of the community structure were identified using the Shannon and Simpson indices. Sampling of zoobenthos was carried out at stations measuring 20x20 cm using a scraper. Fixation and cameral processing were carried out using conventional techniques. Individual weights of organisms were found by weighing on scales. Assessment of water quality by zoobenthos was performed using the Woodiviss and Mayer indexes.

3. Results and discussion

Zooplankton. Zooplankton of Lake Maloe Lebyazhye in 2015-2016 was characterized as follows: 68 species of zooplankton were identified, including 43 species of rotifers- (63%), 17 species of cladocera (25%), 8 species of copepods (12%). 44 species of zooplankton were identified in 2015, and 43 in 2016. The index of similarity of Serensen-Chekanovsky was 64%. Thus, there is certain variability in species composition. Partly the reason for this could be the low number of individual species and zooplankton in general, which may cause short-term species representation in the community. Another reason could be the fact that their presence, due to low numbers, is not always detectable.

The composition of the dominant species reflects the state of the community. In 2015, *Asplanchna priodonta* (Gosse, 1850), *Chydorus sphaericus* (O.F. Muller, 1785), *Keratella cochlearis* (Gosse, 1851) dominated most of the population. The composition of the dominant complex in different periods formed from 2 to 4 species of zooplankton. Biomass was dominated by 1 to 6 species, constantly, including *A. priodonta*, often *C. sphaericus* and *Thermocyclops oithonoides* (Sars GO, 1863). Average number of dominant species was 2.8.

In 2016, *Brachionus calyciflorus* Pallas, 1766, *Polyarthra dolichoptera* Idelson, 1925, *C. sphaericus* and *A. ptiodonta* dominated most. The rotifer *A. ptiodonta* was predominant in biomass in most cases, *C. sphaericus* and *T. oithonoides* were less frequently included in the dominant complex. The average number of dominant species, both in number and in biomass, was 3.5.

The abundance and biomass of the community are important characteristics of its condition. They differed slightly in Lake Lebyazhye (Table 1). Rotifers predominated in numbers and biomass. In terms of zooplankton biomass, the reservoir is α-oligotrophic (according to the classification of S.P. Kitaev (1984).

Table 1. The abundance (N, thousand ind./m^3) and biomass (B, g/m^3) of the zooplankton of the lake Lebyazhye.

Group	2015 (n=12)		2016 (n=11)	
	N	B	N	B
Rotifera	22,71±9,75	0,048±0,031	15,31±5,26	0,017±0,008
Cladocera	3,71±0,94	0,012±0,003	0,90±0,16	0,003±0,001
Copepoda	16,26±4,29	0,050±0,017	6,73±1,78	0,032±0,011
Total	42,68±13,14	0,111±0,038	22,95±5,60	0,054±0,014

Due to unfavorable conditions there were low quantitative indicators of zooplankton. The most important for zooplankton, in our opinion, is the high mineralization of water due to the artificial supply of groundwater to the lake in order to maintain the water level. The peak of zooplankton numbers in 2015 and 2016 was observed in the second half of May and was mainly caused by Rotifera. The second largest peak was observed in June in 2015 and in the second half of August in 2016. The biomass peak was observed in May and in the second half of August in 2015, and in late August and early July in 2016 (dominated by Copepoda) (Figure 1).

The index of saprobity, characterizing the level of contamination with organic substances, corresponds to the β-mesosaprobic zone, moderately polluted waters, III class of water quality. The index of the species diversity of Shannon characterizes the alignment of the community structure. The index values were relatively high and amounted to 2.65 ± 0.13. The community is relatively aligned, i.e. species are represented by approximately the same number of individuals, however, with the small number. The absence of a concentration of dominance is also indicated by the values of the Simpson index (0.74 ± 0.05 in 2015 and 0.77 ± 0.03 in 2016).

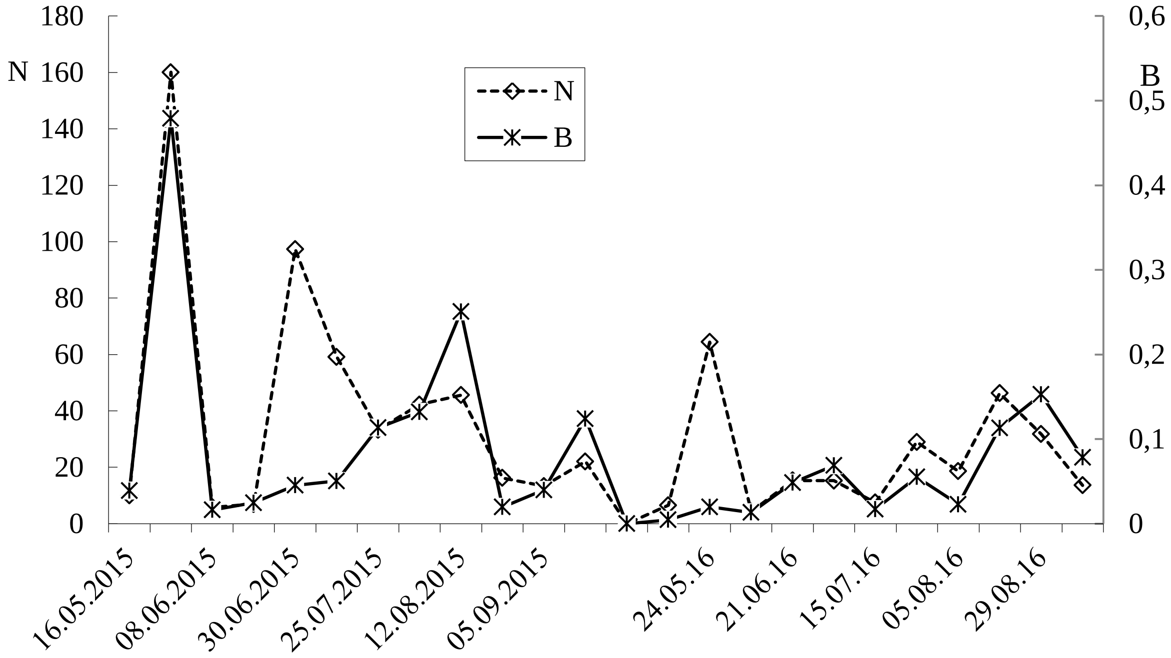

Figure 1. Number (N, thousand ind./m^3) and biomass (B, g / m^3) of zooplankton in 2015-2016.

Zoobenthos. Benthic organisms in 2015-2016 were represented by seven taxa: Lymnea, Oligochaeta, larvae fam. Chironomidae, Agabus (fam. Corixidae), dragonfly larvae (Odonata), Diptera larvae, Ephemeroptera larvae. In 2015, there were 6 taxa, in 2016 - 2.

Larvae fam. Chironomidae (in 92% of samples) and worms (Oligochaeta) (in 30% of samples) were most frequently encountered in the samples in 2015. The remaining groups of organisms were found in no more than two samples. In 2016, all samples contained larvae of family Chironomidae and only in July there were Ephemeroptera larvae. The species richness of zoobenthos is estimated as "low".

Reduction of species diversity in 2016 may be associated with a decrease in the water level in the lake. From May to July 2016, the lake was not replenished with groundwater due to pump failure. Exposure of the bottom areas previously covered by water could lead to the death of inactive benthic organisms, especially the inhabitants of macrophyte thickets.

Very low quantitative indicators of zoobenthos were observed in 2015. The maximum values of abundance and biomass were recorded in May and amounted to 175 ind/m^2 and 116.6 mg/m^2 respectively; the minimum values were observed in September (5 ind/m^2 and 6.8 mg/m^2). The average abundance was 39 ± 16 ind/m^2, and average biomass was 45.1 ± 10.1 mg/m^2 (Figure 2).

In 2016 the abundance and biomass of the zoobenthos were higher; the maximum values of abundance and biomass were 1225 ind/m^2 and 1837 mg/m^2 respectively. The average abundance and biomass were 234 ± 116 ind/m^2 and 351 ± 173 mg/m^2. The greatest contribution to the total abundance and biomass of zoobenthos was made by the larvae of mosquitoes (fam. Chironomidae), especially in 2016.

Some features of the structure of zoobenthos can be caused by a change in the type of water and the value of mineralization, which is associated with the artificial replenishment of the lake with groundwater. So, for example, earlier in the lake there was an abundance of mollusks-vivipar (*Vivivarus contectus* (Millet, 1813)), who prefers soft water. At present, the zoobenthos of these mollusks are not found.

According to zoobenthos, the water in the Lebyazhye Lake is characterized as "dirty" to "very dirty": in 2015 the average value of the Mayer index was 1.91 ± 0.27, and the Woodiviss index had values of 1.33 ± 0.21 (Figure 3). In 2016, the values of the indices were higher and amounted to 1.6 ± 0.4 and 1.8 ± 0.5 respectively. In general, the benthic community was represented by a small number of species, which may be due to changes in the chemical composition of the water, the unstable water level in the lake, the use of insecticides in the recreational area and active recreational loads on the lake.

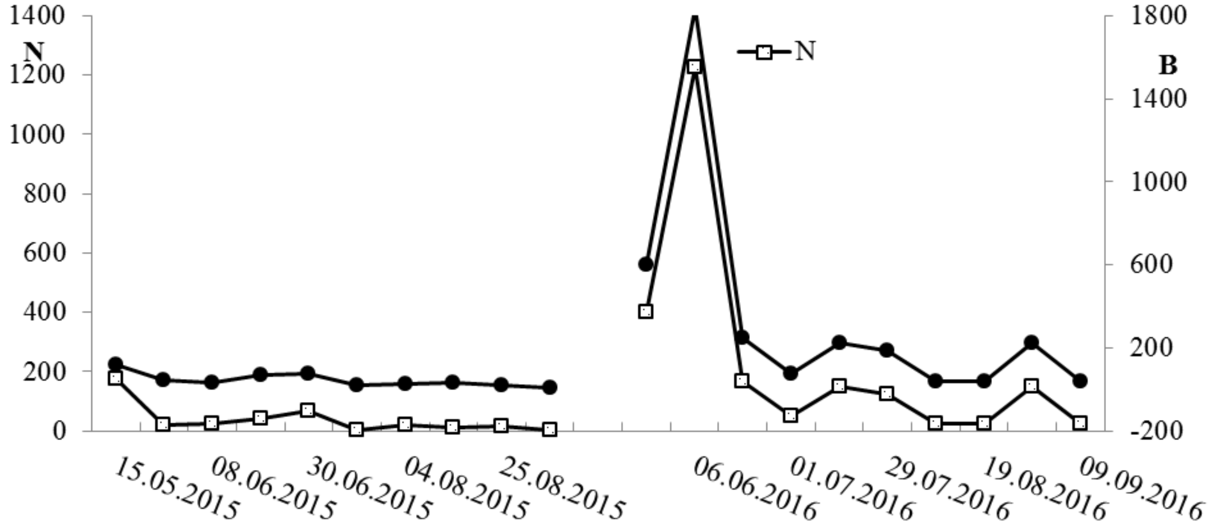

Figure 2. Dynamics of abundance (N, ind./m^2) and biomass (B, mg/m^2) of the zoobenthos of Lake Lebyazhye.

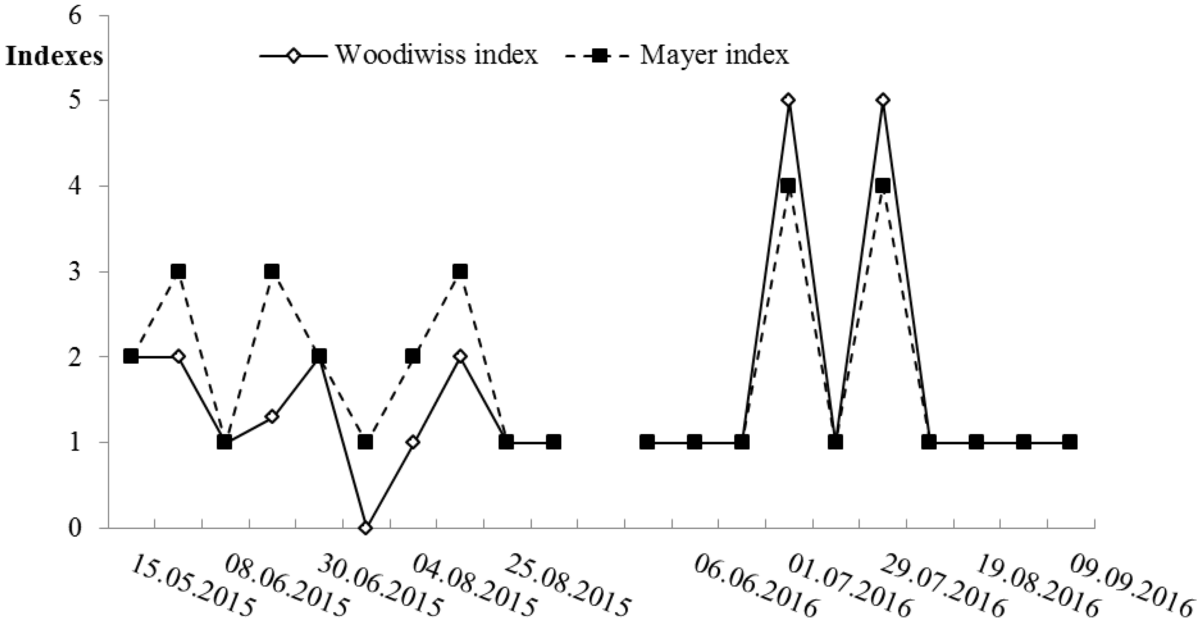

Figure 3. The values of the Mayer and Woodywiss indices in 2015-2016.

Thus, as a result of the studies, 68 zooplankton species were found. Zoobenthos was represented by seven taxa. The composition of zooplankton was dominated by *A. priodonta, B. longirostris, T. oithonoides, P. vulgaris, P. dolichoptera, C sphaericus.* Larvae of family Chironomidae predominated in most cases in the zoobenthos. Quantitative indicators of zooplankton and zoobenthos were low. Indicators of zooplankton estimated water of the Lebyazhye lake as "moderately polluted", which corresponds to the third class of water quality. The state of the zoobenthos communities characterizes the reservoir as "very dirty".

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