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The species composition of macroinvertebrates and water quality assessment using the macrozoobenthos organisms of the Izhevsk reservoir

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Abstract. The species composition of macroinvertebrates of the Izhevsk Reservoir was specified. Changes in the taxonomic structure of macroinvertebrates on different biotopes were shown. A significant simplification of the bottom-dwelling communities' structures of the rivers Izh and Pazelinka in the deep-water part and increase in species richness at the mouth area, overgrown with macrophytes, was identified. A total of 414 species and taxons of higher macrozoobenthos rank were identified. According to the results of bioindication the upstream and middle part of the Izh reservoir can be classified as a β -mezosaprobic area.

1. Introduction

For more than 20 years, the inhabitants, administration and environmentalists of Izhevsk and the Udmurt Republic are concerned about the water quality of the Izhevsk Reservoir. However, routine surveys of bioresources are extremely non-regular.

In 1991, the laboratory of the State Committee for Nature Protection of Udmurt Republic conducted a study of macrozoobenthos. As a result 32 species of organisms were identified [1]. In 2006, on request of «Izhvodokanal», employees of the Perm Branch of FSBSE «GosNIORH» carried out an assessment of the ecological status of Izhevsk Reservoir and determined the species composition of the invertebrate aquatic fauna. Seventy taxa of benthic invertebrates were found. The highest species richness was noted for the larvae of family Chironomidae (33 species and forms), the oligochaetes were represented by 19 species, molluscs - by 7 species. The total biomass of macrozoobenthos in the reservoir on average was 23.15 g/m^2 , including feed biomass - 9.29 g/m^2 . The feed biomass was basically formed by species of the genus *Chironomus* [2].

Izhevsk Reservoir is an anthropogenic reservoir on the Izh River, located 189 km from its mouth. The volume of the reservoir is 76.3 million m^3 , the water surface is 26.4 km^2 . The maximum length of the reservoir is 11.4 km, the maximum width is 2.3 km. The maximum depth of the reservoir near the dam is 12 m, the average depth is 3.2 m. The area of shallow waters with depths up to 2 m is about 7 km^2 . Reservoir has 35 km of coastline [3]. Izhevsk reservoir is a source of drinking water supply for some districts of Izhevsk.

Pazelinka River is the left tributary of the Izh River (since the dam was built the river flows into Izhevsk Reservoir). The total length of the river is about 10 km. The mouth area is 0.17 km^2 , the depth at this part of river reaches 2.5 m, the bottom sediments are silty sand with detritus. There are floating mats along the banks. The area of overgrowing is 70.544 m^2 , which is 41.5% of the mouth area [4].



At this stage of succession in the overgrowth of the water body such associations as Lemno-Nupharetum luteae, Lemno-Nymphaetum candidae, Nupharetum luteae, Lemno-Ceratophylletum demersi, Lemno-Potamogetonnetum natantis, Potamogetoneto lucentis-Ceratophylletum demersi take a predominant part. The predominance of these associations indicates active successional processes associated with the overgrowth of shallow areas of the Izhevsk reservoir [5].

The aim of the presented work is to specify the species composition of aquatic macroinvertebrates in different parts of the Izhevsk Reservoir and to assess the water quality in its upper and middle parts using macrozoobenthos.

2. Materials and methods

A macroinvertebrates study of the Pazelinsky Bay was carried out from June to August 2010. Samples were taken with a hydrobiological scraper and Macan's sampler. Total amount of zoophytos samples were 192. The abundance and biomass of the macrozoophytos were calculated per 1 kg of wet plant mass.

The macrozoobenthos study in the upper and middle parts of the reservoir was carried out from 2011 to 2014. A total of 147 samples were selected.

Invertebrates samples in the reservoir water area were sampled from a boat using a DAK-100 bottom-grab by triple sediment sampling or from the shore using a hydrobiological scraper. Processing of the material was carried out according to generally accepted hydrobiological methods [6].

According to the analysis of the taxonomic composition and quantitative indicators of macrozoobenthos, the values of the Goodnight-Whitley Index of oligochaetes were calculated [7], Shannon Index [8], Pielou Index [9] and the values of the Woodiwiss biotic index were estimated [10].

3. Results

In the period from 2010 to 2014 a total of 414 species and taxa of a higher rank in the composition of macroinvertebrates of Izhevsk Reservoir were identified.

The communities of benthic invertebrates of the Izhevsk Reservoir can be divided into three groups:

1) the macrozoobenthos of the mouth parts of the tributors and coastal zones of reservoir which are characterized by small depths (up to 2-3 m), silty bottom sediments with detritus, projective cover of macrophytes is 80-100%, the total organic matter content in bottom sediments from 2.22 to 64.72%;

2) the benthos of sand shallow waters with wave mixing and high recreational load, the content of organic matter is 0.98-4.5%;

3) the benthos of the deep-water part with depths up to 6 m, with sandy silty bottom sediments, the content of organic matter in the soil is 0.76-31.03%.

In the upper part of the reservoir 180 species of macrozoobenthos were identified (the chironomid larvae were identified by the subfamily). The prevailing representatives of phytophilous fauna were gastropod molluscs - 22 species (12%), true bugs - 11 species (6%), beetles - 14 species (8%) and dragonfly larvae - 8 species (4%). In addition to these groups, oligochaetes, bivalves, leeches, and insects from the orders Diptera, Ephemeroptera, Trichoptera, and Lepidoptera were found. In numbers, chironomid larvae prevailed - 69.6%; gastropod molluscs formed the basis of biomass - 81%. The average density of macrozoobenthos organisms of these biotopes was 756.95 ind/m², the average biomass was 10.85 g/m².

Dytiscus latissimus L., which is listed in the Red Book of the Udmurt Republic, was found in the area of village Volozhka (the right bank with reed beds).

In the mouth part of the Pazelinka River 371 species of macroinvertebrates were recorded, including the larvae of chironomids and biting midge larvae. Diptera dominated in the number of species - 116 species (31%), beetles - 85 species (23%), gastropods - 37 species (10%), true bugs - 28 species (7.5%). In the Diptera, the Chironomidae family was represented by the largest number of species - 69 species. The most common species among the larvae of the Chironomidae are the following: *Ablabesmyia phatta* Eggert, 1863, *Chironomus plumosus* Linnaeus, 1758, *Endochironomus*

albipennis Meigen, 1830, *Endochironomus tendens* Fabricius, 1775, *Glyptotendipes glaucus* Meigen, 1818, *Parachironomus biannulatus* Staeger, 1939, *Paratanytarsus austriacus* Kieffer, 1924, *Cricotopus* gr. *sylvestris*. The average number of invertebrates in the mouth area of the Pazelinka River varied from 7854.2 to 25463.7 ind/kg, the average biomass varied from 12.1 to 27.9 g/kg.

In the area of the city beach, 12 species of macroinvertebrates were noted. Leeches: *Erpobdella octoculata*, *E. testacea*, *E. lineata*, *Glossiphonia complanata*, *Helobdella stagnalis*; mollusks: *Bithynia tentaculata*, *Lymnaea auricularia*, *Sphaerium corneum*; Chironomidae larvae: subfamilies Orthoclaadiinae и Chironominae. Also common representatives of this biotope are the oligochaetes of the Tubificidae family: *Tubifex tubifex* and *Limnodrilus hoffmeisteri*. The density of macrozoobenthos did not exceed 600 ind/m², the average biomass was 0.45 g/m².

In the deep-water part of the reservoir, a total of 26 species and genera were noted. Eight species were dipterous larvae, 8 - oligochaetes, 2 species of bivalve molluscs, 3 species of beetles, and 1 species of dragonflies, caddis flies, alderflies, leeches and nematods of the Mermitida order.

In the profundal benthic fauna the prevailing organisms were the larvae of the genus *Chironomus* (75% of the number and 81% of the biomass), oligochaetes *Limnodrilus hoffmeisteri* and *Tubifex tubifex*. In addition to chironomids, the fauna of Diptera was represented by horsefly larvae, biting midges, and predatory plankton larvae of *Chaoborus*. The average density of macrozoobenthos of profundal zone was 2398.4 ind/m², and the average biomass was 10.3 g/m². In the channel part of the reservoir, on the sandy silty soil, large bivalve molluscs, *Unio pictorum*, *Unio protractus*, were also encountered. In some samples, benthos was absent [11].

4. Discussion

The fauna of the reservoir consists mainly of phytophilous and pelophilous species. The greatest faunal diversity was reached by diptera larvae (118 species, 69 of them were the chironomids larvae). Also a large number of species were represented by beetles (88 species), true bugs (31 species) and caddisflies (32 species). The fauna of molluscs were represented by 41 species, of which 14 were bivalves and 27 were gastropods.

The most favorable conditions for macrozoobenthos in the Izhevsk Reservoir are formed in the coastal overgrown zone, at a depth of 2 m. The maximum indices of biodiversity (the Shannon Index, Pielou Index, the total number of taxa) of aquatic macroinvertebrates were noted in the Pazelinsky Bay (table 1). With a similar type of overgrowing, the upper part of the reservoir is characterized by less species diversity. We associate this with water pollution from the Izh and Luke rivers.

Table 1. Indicators of macrozoobenthos in different parts of the Izhevsk Reservoir.

Biotope Indicators	The upper part of the reservoir, the influence of the River Izh	The Pazelinsky Bay	Sand littoral	Deep-water part
The number of taxa	180	371	12	26
Shannon Index	2,10	3,2	1,42	0,81
Pielou Index	0,78	0,91	0,63	0,65
Woodwiss Index	7,5	9	4	1,8
Goodnight-Whitley Index, %	46,6	-	16,2	35,6
Biomass, g/m ²	10,85	20,0*	0,45	10,26
Density, ind/m ²	757,0	16658,0**	600,0	2398,4

* - g/kg plant mass, ** ind/kg plant mass.

Findings indicate the maximum accumulation of silty detrital sediments in the shallow waters of the reservoir, which contributes to the development of pelophilic oligochaetes (Goodnight-Whitley Index is 46.6%).

According to the Woodiwiss Index, the upper part and the coastal thickets of the reservoir can be classified as clean zone, the sandy littoral zone can be classified as polluted, and the deep water part - as dirty. However, the Goodnight-Whitley Index shows moderate pollution of the upper part, overgrown zone and profundal zone. Sandy soil is unfavorable for the oligochaetes, so they make up 16.2% of the total benthos. This corresponds to clear waters.

Simplification of the macrozoobenthos structure in the profundal zone of the Izhevsk Reservoir may be associated with eutrophication, which leads to a lack of oxygen in the bottom layers and pollution of bottom soils with heavy metals and petroleum products.

According to the S.P. Kitaev's trophic scale [11], the upper and middle parts of the reservoir belong to the category of the β -mesotrophic zone, and some stations with high density of large molluscs can be classified as α -eutrophic zone.

5. Conclusion

Thus, in the Izhevsk Reservoir 414 species and taxa of a higher rank of macroinvertebrates were specified. The representatives of the order Diptera were prevailed, and the Chironomidae reached the greatest species richness. In the deep-water part of the reservoir, there is a significant simplification of the structure of benthic communities and an increase in species richness in the estuarine, overgrown with macrophytes parts of the Izh and Paselinka Rivers. According to the results of bioindication, the upper and middle parts of the Izhevsk Reservoir fall into the category of β -mesosaprobic zone, the 3rd class of water. It is environmentally friendly waters, which can be used for drinking after pre-treatment, for fish farming and irrigation. Some coastal stations with delayed water exchange can be attributed to the α -mesosaprobic zone.

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