

# Influence of unreasoned economic activity on the condition of macrophytes of the Bol'shoje Goluboye Lake

O V Palagushkina, N R Zaripova, N M Mingazova and T O Yarutkin

Kazan Federal University, Institute of management, economics and finance,  
Kremlevskay str.,18, 420008, Russia  
E-mail: opalagushkina@mail.ru

**Abstract.** The ecosystem of Lake Bolshoye Goluboe had undergone a strong anthropogenic impact in 2013 as a result of the implementation of the dam reconstruction project. Studies in 2014 have shown that the implementation of the project for the reconstruction of the Bolshoye Goluboe dam has negatively affected on the species richness of macrophytes. The total species composition of the lake and species richness of the water core decreased twofold, *Hippuris vulgaris* L., *Zannichellia palustris* L., *Ceratophyllum demersum* L., and the species listed in the Red Book of the Republic of Tatarstan - *Batrachium circinatum* (Sibth.) Spach disappeared from the species composition. The area occupied by macrophyte communities has decreased by 55%.

## 1. Introduction

Unique natural objects require careful treatment in the implementation of measures for their improvement and verified environmentally decisions. Bolshoye Goluboe Lake, which is characterized by a special blue color of water, refers to the type of "blue", karst cold-water sulphate lakes are extremely rare for the Middle Volga Region. Special features are also the properties of the Great Blue Lake therapeutic sapropel silt. Silts of the lake used to Kazan sanatoriums [1,2].

## 2. Study site and the problem statement

Lake Bolshoye Goluboe is located in the Vysokogorsky district of the Republic of Tatarstan and is part of the State Nature Reserve of the regional importance "Blue Lakes". The name of the lake is associated with the blue color of water combined with high transparency. By origin lake is oxbow-karstic with complex elongated shape, is located in the rear part of the floodplain terrace of the River Kazanka. The lake's area is 4.60 hectares, the maximum depth is 15.7 m, and the water volume is 59.8 thousand m<sup>3</sup>. Underground power of Bolshoye Goluboe Lake is due to the discharge of deep aquifers Permian two sinkholes located in its northern part. The chemical composition of the water in the lake is neutral, very hard, sulfate-calcium with a mineralization about 2.2-2.5 g / l (brackish).

The water level in the lake is 5 m above the water's edge in the Kazanka River to the low water, the width of the jumper separating the lake and the river in the narrowest part is 20 m. The lake does not have permanent tributaries, but from it flows a stream that flows into the Kazanka River 10.6 km from the mouth. The water flow in the stream varies from 0.6 to 0.9 m<sup>3</sup> / s by seasons. The main type of modern anthropogenic impact on Lake Bolshoye Goluboye is recreation. Also in the coastal zone of the lake, there is an irregular grazing of livestock, which introduces about 126 kg / year of nitrogen and 13 kg / year of phosphorus [2,3,4].



In November 2013, the ecosystem of the Lake Bolshoye Goluboe had undergone strong anthropogenic impacts resulting from the project for the reconstruction of the dam that separates the lake from the river Kazanka and strengthen the banks drain the water from the lake. At the time of the implementation of the project, old dam, that maintained the water level in the lake destroyed, in the place below the drain (Crystal Waterfall), the excavator sank. The flow of water from the lake was reoriented into a new ditch with unsettled shores and without a retaining dam. As a result of a temporary change in the hydrological regime, the level of water in the lake dropped sharply, with water retained only in the karst volcanoes (Bolshaya and Malaya Puchini), through which groundwater is discharged. Sapropel silt in winter conditions froze and dried up. After the reconstruction of the dam, the water level in the lake restored, but the water drain led to the disruption and disappearance of the habitats of many species of aquatic plants and animals, to the loss of large amounts of sapropel silt. In connection with this, the main goal of the research was to identify the current state of macrophytes in Lake Bolshoye Goluboe in comparison with investigations of previous years.

### 3. Results and discussion

Detailed studies of the vegetation of Lake Bolshoye Goluboye, conducted in 1998-2000, attributed it to the macrophyte type [5,6].

Production of organic matter of such reservoirs is created mainly due to the photosynthetic activity of immersed plants characterized by rapid growth, intensive metabolism, increased requirements for the content of minerals in water and soils and represented by charofities and green algae, green mosses, and *Hippuris vulgaris* and other species. The formation of vegetation of brackish karst lakes affects not only natural factors, such as the transparency and salinity of the waters, but also anthropogenic eutrophication. Moderate anthropogenic eutrophication and high transparency of water favored the development of submerged vegetation of the lake Bolshoye Goluboye to 2013, the lake characterized by underwater meadows of green water plants and mosses and charophytes [2,7].

Research in 1998-2000 allowed identifying in the Bolshoye Goluboye Lake 29 species of macrophytes of 18 families. Hydrobotanical studies were carried out using conventional methods. The investigated plants were determined at the site of collection and laid in the herbarium for further clarification. Only dominant species were considered. In the course of the road surveys, the boundaries of the location of the associations were visually marked, and they were recorded on the map charts. The evaluation of the degree of overgrowth was given by the classification of V.M. Katanskaya [5]. Such special hydrophysical properties of the lake as cold water, high transparency, fluidity of waters, increased mineralization caused the presence of communities of stenobiotic species in it. Among the higher vascular plants, the communities of submerged attached, tall and small-leaved plants with dominants *Myriophyllum verticillatum*, *Potamogeton pectinatus*, *Hippuris vulgaris*, *Utricularia vulgaris* were most common. Were widely distributed, but occupied small areas of the community, formed by representatives of the family *Lemnaceae*. The important role-played charophytes - in autumn happening death of most of the vascular plants and charophytes continued to actively vegetate and bear fruit, often replacing edificator species. Floating and submerged algal clusters formed by macroscopic green filamentous algae from the genus *Cladophora* played a large role. As a species-edificator, forming almost monodominant communities along the slopes of karst funnels of Lake Bolshoye Goluboye, the water moss *Fontinalis antipyretica* appeared. In the lake, there was a lack of a vegetation belt with floating leaves. The belt of wetland vegetation, located along the coast, was weakly expressed. 12 species of the "water core" were identified for Lake Bolshoye Goluboe. In the reservoir, there was an uneven type of overgrowth with a degree - excessive, more than 70% [2].

Geographical and ecological analysis of the flora showed that the flora of brackish-water karst lakes is composed of various geographic elements with a predominance of species with a wide range wide of distribution area, which indicates the relative youth of this flora and its immigration character.

The geographical structure of the flora of the "water core" of Lake Bolshoye Goluboe is typical for cold-water lakes in the central part of Russia. Among the higher vascular plants, communities of immersed, tall and small-leaved plants with dominants *Myriophyllum spicatum*, *Potamogeton*

*pectinatus*, *Hippuris vulgaris*, *Urticularia vulgaris*. Quite widespread, but occupy small areas of the community, formed by representatives of the family *Lemnaceae*.

Great is the role of floating and submerged algal clusters, which are often the edificators of communities. In autumn, when the majority of vascular plants die, the cows continue to actively vegetate and bear fruit, often replacing the edifying species. In many brackish water mineralized reservoirs, the role of edificator belongs to water moss *Fontinalis antipyretica*, having a wide ecological amplitude and form monodominant or mixed communities on the slopes of karst holes and craters. Especially noted the absence in such lakes of the vegetation belt with leaves floating on the surface. Belt of wetland vegetation along the coasts is often poorly expressed [8,9].

Species of the "water core" in 1998-2000: *Lemna minor* L., *Lemna trisulca* L., *Potamogeton pectinatus* L., *Zannichellia palustris* L., *Ceratophyllum demersum* L., *Myrophyllum spicatum* L., *Hippuris vulgaris* L., *Batrachium circinatum* (Sibth.) Spach., *Cinclidotus fontinaloides* (Hedw.) P.beauv., *Fontinalis antipyretica* Hedw., *Cladophora glomerata* (L.) Kutz., *Chara contraria* A.Br.

Species that exist only in brackish-water karst lakes in the Middle Volga Region probably do not exist, but they form a plant complex with species with intensive growth, metabolism, and a high demand for mineral content in water and soils [1].

Summer studies in 2014, conducted according to the standard procedure [10], found only 14 species of macrophytes belonging to 10 families. The vascular plants represented by the families *Alismataceae*, *Lemnaceae*, *Potamogetonaceae*, *Halagaraceae*, *Ranunculaceae*, *Solanaceae*, *Umbelliferae* and were mainly confined to the belt of wetland vegetation along the shores. Charophytes algae were represented by the species *Chara contraria* A.Br. and formed a small area community in the southern part of the lake. Green filamentous algae of the genus *Cladophora* formed clusters in the coastal shallow water zone. Amblystegiaceae and Fontinaliaceae mosses were noted on the slopes of funnels.

According to the 2014 "water core" species of the lake composed of 6 species: *Lemna minor* L., *Lemna trisulca* L., *Potamogeton pectinatus* L., *Myrophyllum spicatum* L., *Fontinalis antipyretica* Hedw., *Chara contraria* A.Br.

The degree of overgrowth of the lake bottom by macrophytes was no more than 15%.

The similarity index of the macrophyte species composition of the two study periods was 65.1% [11,12]. Thus, the conducted studies showed that the implementation of the project for the reconstruction of the dam of Lake Bolshoye Goluboye negatively affected on the species richness of macrophytes.

#### 4. Conclusion

The total species composition of the lake and species of the water core decreased twofold, *Hippuris vulgaris* L., *Zannichellia palustris* L., *Ceratophyllum demersum* L., and the species listed in the Red Book of the Republic of Tatarstan [13] *Batrachium circinatum* (Sibth.) Spach disappeared from the species composition. The area occupied by macrophyte communities has decreased by 55%.

Taking into account that the project of dam and drain reconstruction passed state ecological expertise, it is obvious that the environmental consequences during the examination were not taken into account.

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