

The impact of pollution on the quality of the Lake Ohrid water and the *Barbus meridionalis petenyi* Heckel

Abstract

This paper presents the results of seasonal research during 2016, which are important for the assessment of littoral eutrophication of the Ohrid Lake. The water quality of the lake was monitored through physico-chemical and bacteriological parameters, as well as histologic markers of the liver (*Barbus meridionalis petenyi* H.). Research was conducted in three locations: Lubanishte, Peshtane, and Metropol. The negative effects of pollutants on aquatic ecosystems are closely related to histopathological lesions of the fish liver. Barbel fish is a typical benthofag, very sensitive to changes in the aquatic environment, and is an ideal organism for assessing the state of aquatic ecosystems. The fish liver is sensitive to toxic substances and metabolic disorders. Histological analysis revealed the presence of parasites and granulomatous inflammation at the level of hepatocellular parenchyma.

Keywords: Eutrophication, Lake Ohrid, liver, *Barbus meridionalis petenyi* Heckel.

Introduction

The Ohrid Lake in the last decades of the last century and this century is experiencing strong pressures from the anthropogenic factor caused by the doubling of the number of inhabitants living near its banks, the negative effects of the industry, and by intensive use of agricultural areas. The use of various artificial fertilizers, insecticides and herbicides leads to slow changes but with consequences not only for the water mass of the littoral eutrophication, but also for the Lake as a whole.¹ Another form of powerful anthropogenic influence over Lake Ohrid is manifested through the pollution of the littoral region, from the fecal waters, into which the sewage of city buildings, hotels, restaurants and industries is poured. Fecal pollution represents a serious problem of freshwater contamination and manifests itself with the phenomenon of intensive coliform bacteria, powerful phytoplankton development and potential eutrophication of affected regions.²⁻⁴ The seriousness of the problem of pollution of water accumulation, which also includes Ohrid Lake, highlights the need for continuous monitoring of the state of the Lake. Ohrid Lake's protection measures and the partial construction of the collector system have considerably reduced the impact of municipal sewage and sewage from industry on the lake's ecosystem, although there are still places showing degree of contamination. This primarily refers to the localities where wastewater from industry and households is discharged, which are not connected to the collector system, which causes many undesirable effects on the water quality of those parts.⁵⁻⁷

Material and methods

There were collected 64 specimens of the barbel fish from three investigated localities: 1-Lubanishte, 2-Peshtane, 3-Metropol (Figure 1) in the period May-September 2016. Out of each specimen was isolated part of the liver, which underwent the standard procedure of histological preparations and microscopic analysis. The water quality of the lake in the three localities was investigated on the basis of physico-chemical and microbiological parameters. Determination of total nitrogen was carried out according to Keldal's method.^{8,9} The total phosphorus was determined by the persulphate digestion.¹⁰ Organic pollution was determined on the basis of oxygen from

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KMnO₄ according to the Kubel-Tieman method.^{11,9} Microbiological parameters were also monitored (total number of coliform bacteria). The total number of heterotrophic bacteria was determined on the nutritional agar, the number of coliform bacteria in the liquefied bases, and *E. coli* was identified in the selective chromogenic substrate (COLI ID) (Figure 1).

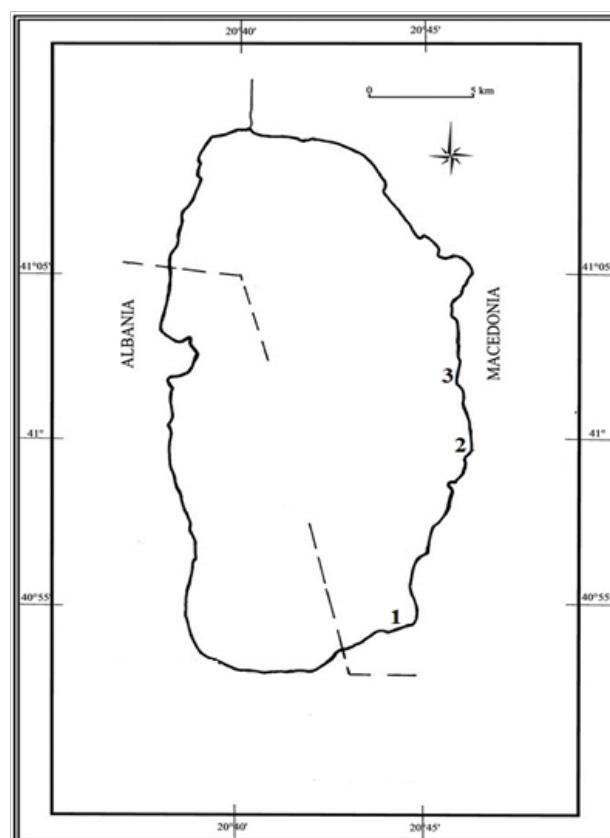


Figure 1 Map of Lake Ohrid with explored locations.

Results and discussion

Microscopic analysis of histological preparations shows the presence of granulomatous inflammation in all researched localities. As a cause of such changes, it was found the presence of parasitic eggs *Capillaria* sp., in the hepatocellular parenchyma of the Barbel fish. Near and around the eggs of the parasite, lymphocyte infiltration was also detected (Figure 2).

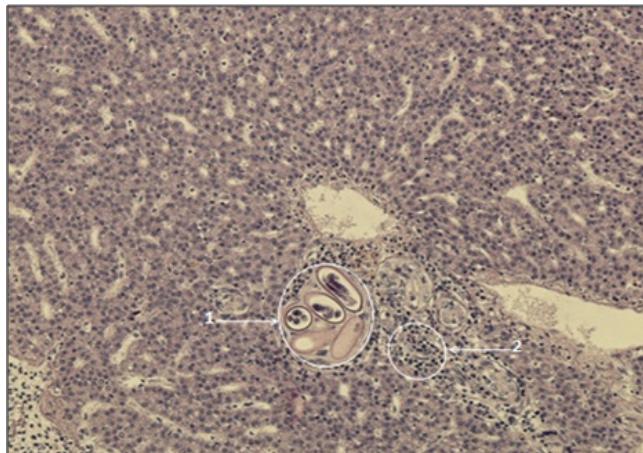


Figure 2 Aggregation of parasitic eggs *Capillaria* sp, Infiltration of lymphocytes into hepatocellular parenchyma (H & E, x400).

The presence of parasitic eggs *Capillaria* sp. in the hepatocellular parenchyma, poses a potential problem for the population of Ohrid Lake. Such pathogenic effects of the eggs of this parasite in the hepatic tissue were evidenced by Sima et al.¹² in the liver of *Cichlasoma urophthalmus* fish in Mexico, as well as by Roganovic-Zafirova et al.¹³ in the Ohrid Lake (*Barbus meridionalis peteneyi* H.). The presence of parasitic eggs in the hepatocellular parenchyma indicates the non-favorable environmental impact of the fish health situation in this Lake. Regions around the lake shore, with a high density of population, are under the greatest anthropogenic pressure, and this is reflected on the population of the Barbels.¹⁴ Balance disorder of the Trophic status through the discharge of sewage into rivers flowing into Lake Ohrid, especially during the tourist season, initially exerts local pressure on the lake ecosystem, and over time this pressure extends into its broader areas. The parasitic infestation of fish depends on the presence and spread of the parasitic host, such as the *Eiseniella tetraedra* (square-tailed worm) ascertained and described by Kakacheva-Avramova¹⁵ on the liver of the Barbel or some representatives of Crustacea,¹⁶ are the intermediate host of parasitic *Capillaria* sp. The parasitological analysis of the Lake Ohrid fish,¹⁷ showed that the lake provides favorable conditions for the development of more parasites in the fish, the inhabitants of the Lake and this contributes to the biological diversity of the invertebral forms that serve as passers-by of parasites. In this paper is also analyzed the water quality from three sites that suffer from anthropogenic contamination, especially during the summer period. These sites were selected because they are not or partially linked to the collector system. The content of dissolved organic matter (Figure 3) reflects this condition. In all three localities, values of organic pollution have been identified, which determine the mesotrophic nature of water in the summer period. The same condition was confirmed by the study of

total phosphorus in (Figure 4) and nitrogen (Figure 5).

According to the total phosphorus concentrations, the water of the investigated localities is oligotrophic, except for the months of June and July when it is mesotrophic (Figure 4).

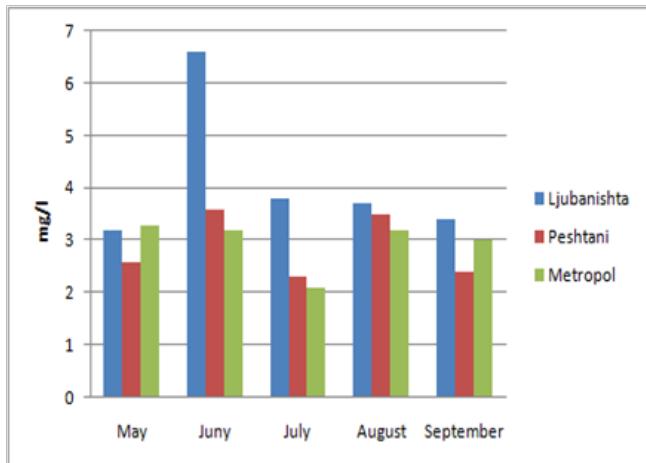


Figure 3 Organic Pollution in Exportable Locations (mg/l KMnO4 spent).

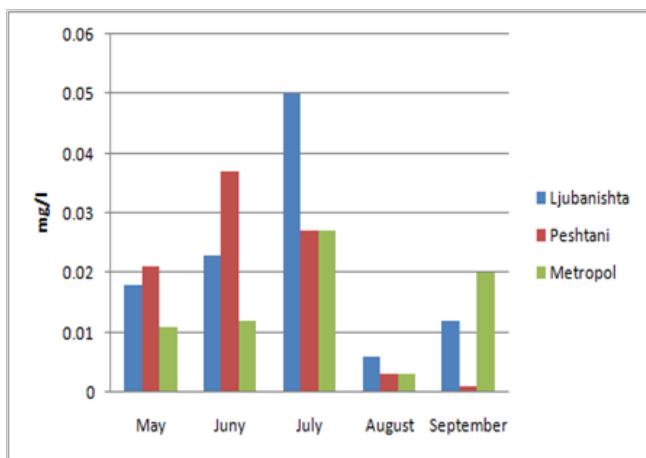


Figure 4 Total Phosphorus in Researched Locations.

The values obtained for the total nitrogen concentration show that the water in the Metropol locality is of better quality, i.e oligotrophic, except in August (mesotrophic), whereas the localities of Ohrid Bay and Peshtani are predominantly mesotrophic (Figure 5). All the maximum values were ascertained in the month of August, which is certainly the result of the atmospheric precipitation at that time and the introduction of nutrients from the ground flushing around. Microbiological analyzes also show the state of water quality. The heterotrophic bacteria are the largest in Peshtani and Ohrid Lake Bay. In Metropol locality the values are relatively small and are responsive to the quality of the first grade water. According to the number of bacterial coliforms, the water from the locality of Peshtani and Ohrid Bay is of first and second class, and on the Metropol locality, such bacteria are missing in May and August, while in the other months the values are relatively small and are on the boundaries of the first class (Figure 6). According to the categorization of Kavka 1994, the

water in Ohrid Bay in July and August is highly polluted, in Peshtani is polluted, whereas in Metropol it is pure during the research period.

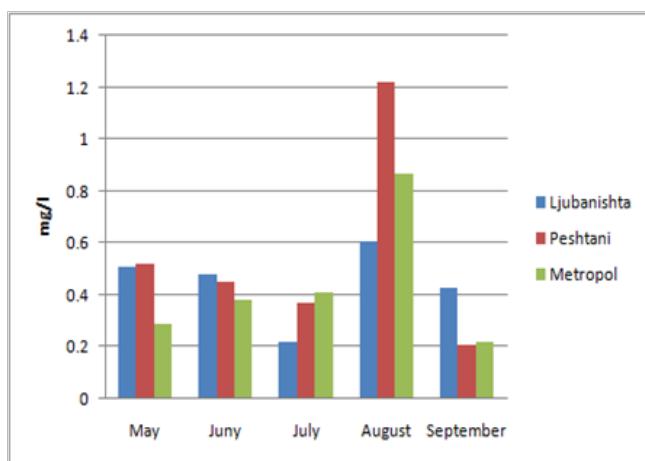


Figure 5 Total nitrogen in researched localities.

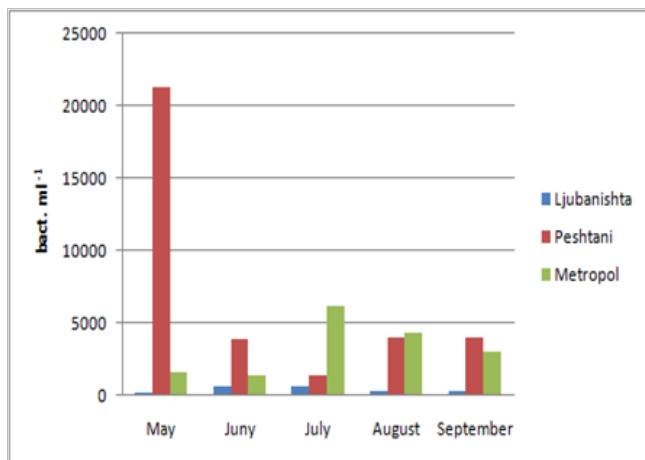


Figure 6 Class boundaries.

Conclusion

Ohrid Lake's water conserves its oligotrophic characteristics, even during the tourist season due to the increased anthropogenic pressure in some localities, the mesotrophic characteristics appear. Anthropogenic pressure on the lake's shoreline is also reflected on the health status of the Barbel fish population. The pollutants from the outside environment negatively affect the immune system in the fish and make them exposed to parasitic infections.

Acknowledgements

None.

Conflict of interest

The authors declare no financial interest or any conflict of interest for the purpose of this work.

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