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PHYTOPLANKTON COMMUNITY AS BIOINDICATOR OF WATER TROPHIC STATE IN LAKE PRESPA

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Abstract

Lake Prespa is a very unique ecological and hydrological system shared by Macedonia, Greece and Albania that over the past years, has faced serious environmental challenges such as eutrophication and water level declination. Phytoplankton species represent the most sensitive biological components of water ecosystems that respond first to changes in nutrient concentrations. Regarding this fact, phytoplankton is a very good indicator of water trophic state in aquatic ecosystems Phytoplankton samples were taken seasonality during 2023 at one pelagic and seven littoral sampling points in the Macedonian part of Lake Prespa. The phytoplankton community in the pelagic zone was dominated by diatoms and cyanophytes and rare occurrences of the groups dinoflagellates, chlorophytes and chrysophytes. The diatoms dominated in winter, spring and autumn periods while cyanophytes dominated in the summer. The total abundance of phytoplankton was considerably higher in summer than in other seasons which is characteristic for meso-eutrophic lakes. According to the trophic state index (TSI) based on chlorophyll a concentration two points of Lake Prespa are categorized as oligotrophic and all other points as mesotrophic.

Keywords: Lake Prespa, phytoplankton community, trophic state.

INTRODUCTION

The transboundary Lake Prespa basin, situated in the Balkan Peninsula is an ecosystem of global significance. This becomes even more important in the case of systems of great importance such as ancient world lakes (estimated age between 2 and 35 million years) which are about a dozen and have long been recognized as unique ecosystems in terms of their exceptional high biodiversity and levels of endemism [1].

In the past, periodical oscillations of the lake level were in the range of one to three metres, depending on the amount of rain in the season. After the mid 80's, a steady decrease of the water level has been recorded that disturbs the ecological balance of the lake and the watershed area resulting in serious consequences for the water trophic state, biodiversity and ecosystem health. A topographic map from the 1940s indicates that the present water level is 5–6 m lower than in the 1940s. As Lake Prespa is relatively shallow compared to its large surface area, wind and convective mixing lead to completed stratification of the entire water column from September to April/May and consequently all dissolved substances are homogenized annually [2]. In addition to this, the industrial activities as well as the over use of the herbicides in agriculture activities raised the problem of pollution of the water in Lake Prespa.

Phytoplankton is one of the most sensitive indicator of the water trophic state in lakes. Changes in environmental conditions related to anthropogenic load, climate change, nutrients, water depth and chemistry can affect the phytoplankton community structure and diversity. The EU Water Framework Directive [3] includes phytoplankton as one of four biological elements to be used in the assessment of the ecological status of surface waters.

In the last two decades, there were many investigations of the phytoplankton and trophic conditions that suggested process of eutrophication of Lake Prespa as result of anthropogenic pressure [4–10].

MATERIALS AND METHODS

The surveys of the phytoplankton in the Macedonian part of Lake Prespa were carried out at seven sampling points in the littoral zone and one in the pelagic zone at three depths of 0 m, 7 m and 13 m. The phytoplankton samples were collected seasonality during four sampling campaigns. The samples were collected with a Niskin water sampler and preserved immediately at the sampling site by adding 4% formaldehyde. The identification of phytoplankton taxa and quantitative analyses (enumeration of individuals per volume of water) were done according to Utermöhl [11], using an inverted microscope LW101–2 trinocular, with epi-illumination module and camera OmniVID, 8.0 MP.

Chlorophyll a was analysed according to ISO 10260 [12], using a spectrophotometer UV–VIS SPECORD 10 (Zeiss) after an extraction with 90% ethanol. Total phosphorus (TP) was measured spectrophotometrically wavelength 885 nm, after digestion of the water sample with peroxodisulfate [13,14]. The Trophic State Index (TSI) was calculated based on values of chlorophyll *a* concentration and total phosphorus concentration [15].

RESULTS AND DISCUSSION

A total number of 75 phytoplankton taxa were collected in Lake Prespa during the winter, spring, summer and autumn campaigns of 2023. The taxa belonged to eight divisions: Cyanophyta (Cyanobacteria), Bacillariophyta, Chlorophyta, Chrysophyta, Charophyta, Pyrrophyta, Cryptophyta and Euglenophyta. Most of the phytoplankton taxa identified belonged to Bacillariophyta (42 taxa), followed by Cyanophyta (12) and Chlorophyta (11). The other groups of algae are represented by a small number of taxa Chrysophyta (3) Charophyta (3) Pyrrophyta (2), Cryptophyta (1) and Euglenophyta (1).

Table 1 *The number of phytoplankton species in each of the sampling points in Lake Prespa*

	Pelagic zone	**Stenje**	**Oteshevo**	**Pretot**	**Krani**	**Slivnica**	**Nakolec**	**Dolno Dupeni**
Cyanophyta	7	7	5	4	5	5	2	3
Bacillariophyta	11	24	27	25	28	17	22	24
Chlorophyta	6	6	3	3	5	3	5	3
Charophyta	3	2	2	2	2	2	2	2
Chrysophyta	2		1		2	1	1	
Pyrrophyta	2	1	1	1	1	1	1	1
Cryptophyta		1	1	1	1			1
Euglenophyta		1						
Total	**31**	**42**	**40**	**36**	**44**	**29**	**33**	**34**

The number of taxa at the littoral points was higher than in the pelagic zone because their phytoplankton communities contain species that usually live on the bottom and on macrophyte vegetation. The highest number of taxa (44) characterized littoral sampling point

Krani, followed by Stenje (42) and the lowest number of taxa was recorded at Slivnica (29) and at the pelagic zone (31) (Table 1).

During the investigations it was determined that Cyanophyta was the dominant phytoplankton group in the summer period, and the species *Planktolyngbya limnetica* dominated in terms of its abundance. Other species of cyanobacteria that may be potentially toxic were represented with low or insignificant abundance or were not recorded at all in the phytoplankton. In the rest of the seasons, the pelagic zone was dominated by the diatom *Cyclotella ocellata* and in the littoral points, in addition to this species, which was dominant in all seasons with high abundance, the species *Navicula sp.* was represented with significant abundance and in the autumn period the species *Aulacoseira sp.* was dominant species.

The total abundance of phytoplankton was considerably higher in summer than in other seasons and the lowest phytoplankton abundance was observed in autumn. In summer, the highest abundance of phytoplankton was recorded in Pretor with 7,720,000 ind/l, and the lowest density was in Slivnica (1,664,000 ind/l) and Nakolec, where it was 1,776,000 ind/l. In the other seasons, there were no significant differences in the abundance of phytoplankton between different points (Figure 1).

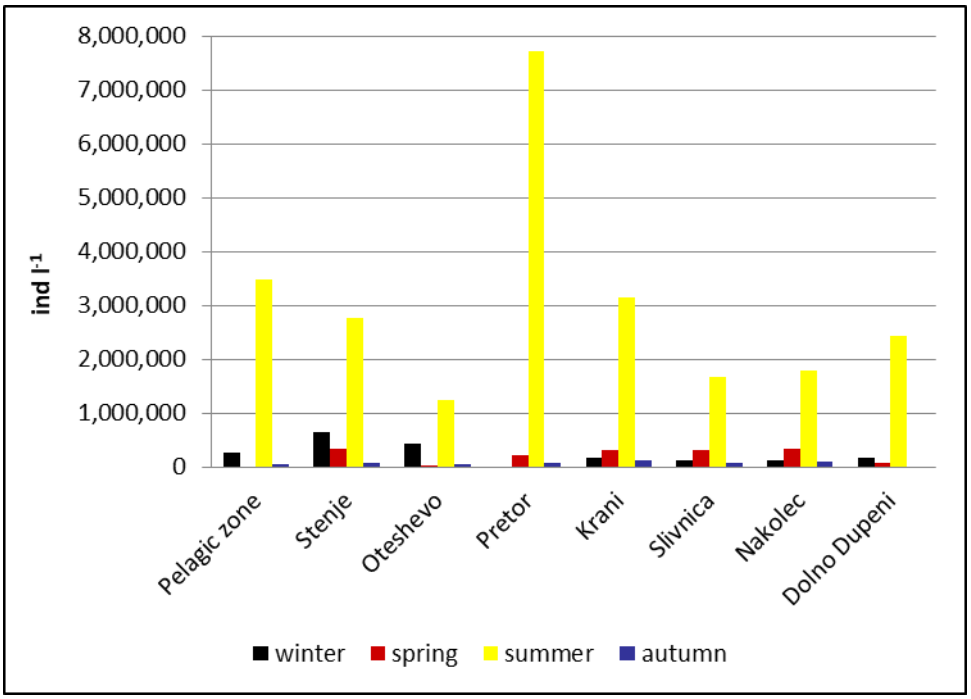

Figure 1 Total phytoplankton abundance at sampling points of Lake Prespa

Chlorophyll *a* is a photosynthetic pigment that integrates all types of algae and serves as *a* measurable indicator for the entire phytoplankton production, that is, the phytoplankton biomass, and therefore it is a very significant parameter for determining the trophic state of the lake water. The average annual values of chlorophyll *a* concentration at the all sampling points during 2023 were below 5.1 µg l^{-1} and there were no significant differences in the values of different sampling points. The average value of chlorophyll *a* concentration in the pelagic zone was slightly lower than in the littoral zone and recorded 2.56 µg l^{-1}, the highest values were observed in Pretor (5.04 µg l^{-1}) and Slivnica (4.78 µg l^{-1}) (Figure 2).

The average annual total phosphorus concentration in the pelagic zone was 28.87 µg l^{-1}, while in the littoral zone the highest value of 57.74 µg l^{-1} was recorded in Pretor, in Dolno Dupeni was 31.82 µg l^{-1} and at all other points were below 30 µg l^{-1} (Figure 3).

The obtained results showed that the anthropogenic impact, especially expressed in the littoral zone of the lake near the rivers inflows, agriculture areas and touristic complexes have significant influence on the water trophic state.

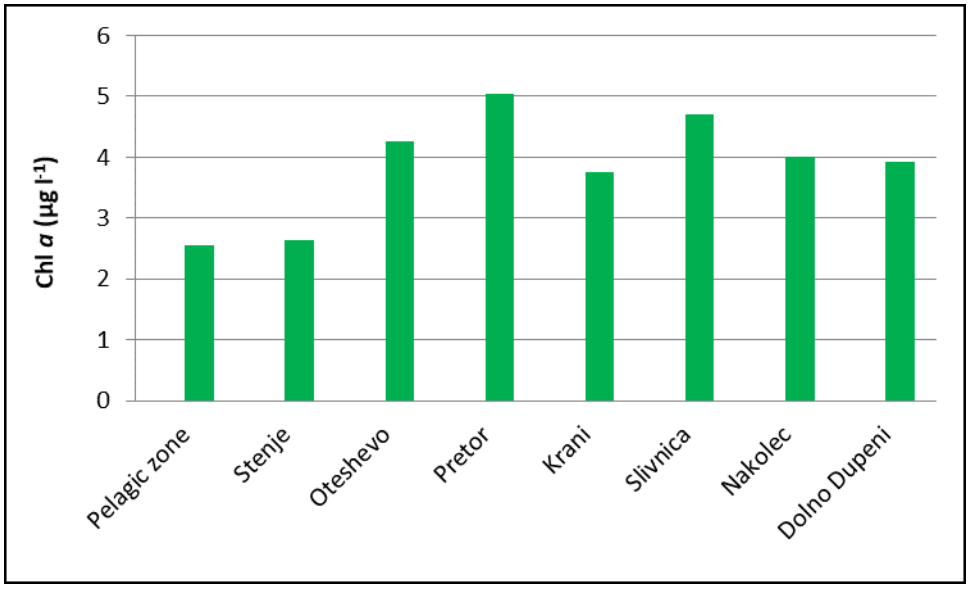

Figure 2 Average annual chlorophyll a concentration at sampling point of Lake Prespa

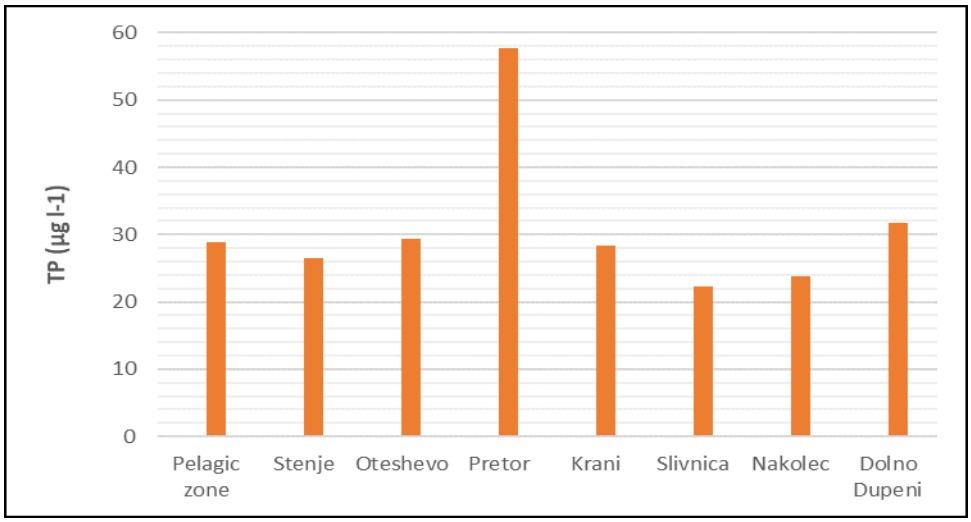

Figure 3 Average annual total phosphorus concentration at sampling points of Lake Prespa

The trophic state index (TSI; Carlson, 1977) is an indicator of water trophic level and provides a basis for relating chlorophyll *a* levels and transparency to total phosphorus, which tends to promote algal production. According to the values of the trophic state index (TSI) based on the concentration of chlorophyll *a*, during 2023, the lake water at pelagic zone and Stenje was categorized as oligotrophic, and at all other points of littoral zone of Lake Prespa were categorized as mesotrophic (Figure 4).

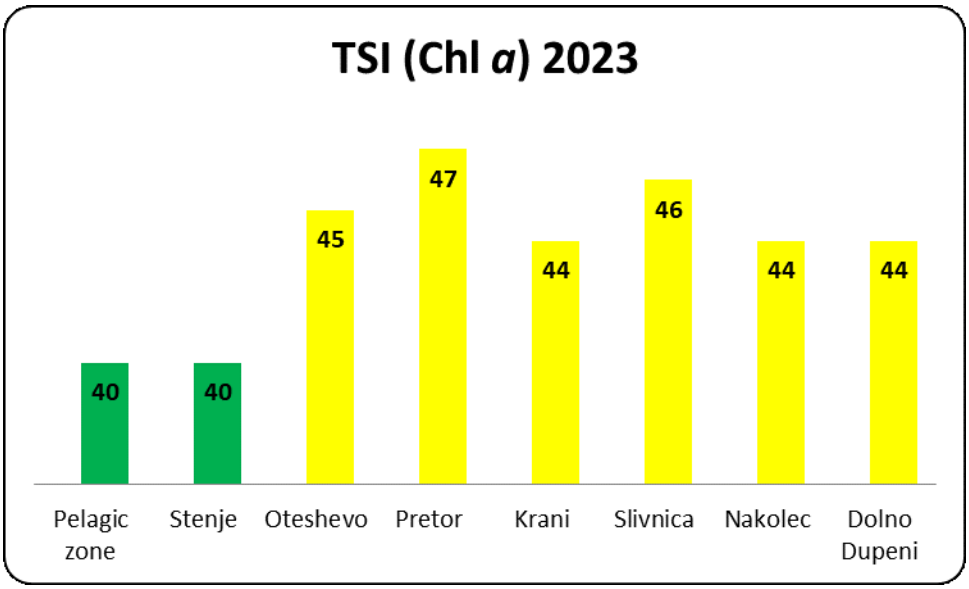

Figure 4 Trophic state index based on chlorophyll a concentration

According to the values of the trophic state index (TSI) based on the concentration of total phosphorus, during 2023, the lake water at Stenje, Krani, Slivnica and Nakolec were categorized as mesotrophic, pelagic zone and Oteshevo was categorized as meso-eutrophic, Pretor and Dolno Dupeni as eutrophic (Figure 5).

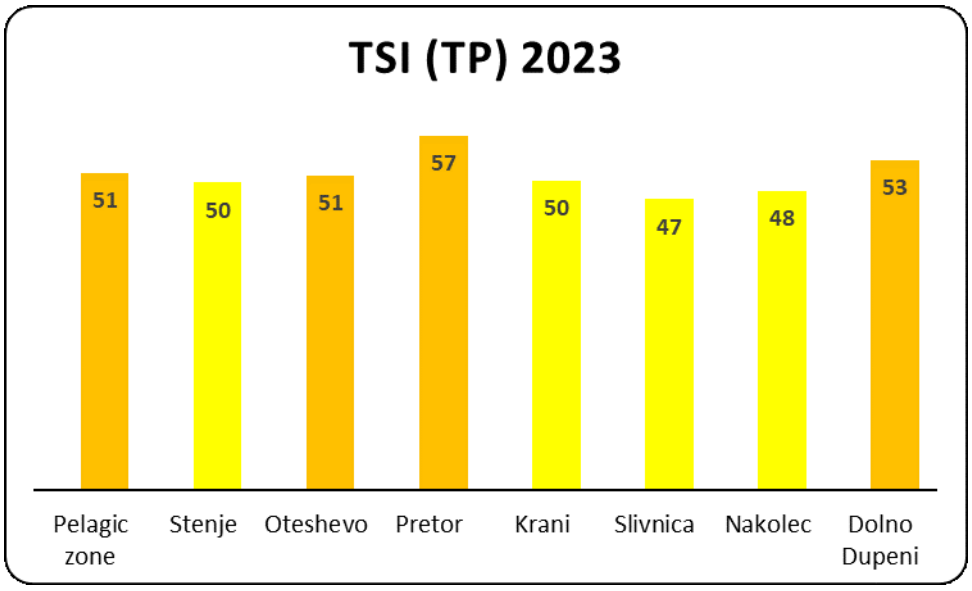

Figure 5 Trophic state index based on total phosphorus concentration

CONCLUSION

Phytoplankton diversity and abundance is a very important tool in the monitoring of the seasonal changes in Lake Prespa, showing process of eutrophication especially during the summer season. Most phytoplankton species identified belong to the Bacillariophyta. Investigations showed distinct seasonal differences in phytoplankton composition. Bacillariophyta were the dominant group in spring, autumn and winter. In summer Cyanophyta was the dominant algal group at all sampling points

Phytoplankton composition as well as spatial and temporal distribution of phytoplankton in Lake Prespa is typical for mesotrophic lakes.

The trophic state index based on chlorophyll *a* concentration and total phosphorus was the highest in littoral sampling point Pretor as a consequence of the negative influence of River Golema that flows into the lake at that point.

ACKNOWLEDGMENTS

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