INFLOWS AND ANTROPOGENIC INFLUENCE ON THE WATER QUALITY OF LAKE PRESPA

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ABSTRACT

Lake Prespa is at an altitude of 856,45 m. From total area of 319, 90 km^2, 189,20 km^2 belong to Macedonia, while 130,79 km^2 are shared between Albania and Greece.

In the period 2007-2009, within the project "Interdisciplinary assessment of water resource management in two transboundary lakes in about Eastern Europe" we carried out monitoring of Lake Prespa, which practically closed ten years of research for the second largest lake in the Republic of Macedonia.

Economic development of the country is connected with the construction of commercial facilities, modernization in agricultural production, development of tourism etc. Result is sudden development of urban units. All these changes result in a disproportionate burden on the environment by industrial, utility and wastewater from agricultural surfaces that carry contaminants used in modern agriculture. Most contaminates are carried through river systems and finally in the lake system.

To illustrate the effects of anthropogenic impact and water lake quality, we made comparative studies river-littoral-pelagic zone. In order to define the water quality we investigated following physico-chemical parameters: temperature, transparency, pH, dissolved oxygen, organic matter, total phosphorus and total nitrogen, while the biological parameters were monitored by state of chlorophyll *a*.

The purpose of this paper was to reflect the impact of inflows and anthropogenic impact on the water quality of Lake Prespa. Categorization was performed according to OECD fix boundary system and legal regulations of the Republic of Macedonia.

Key words: *Lake Prespa, monitoring, anthropogenic influence*

INTRODUCTION

Second largest lake in Macedonia's Lake Prespa, settled in the Prespa valley at an altitude of 856,45 m. Of the total area of 319,90 km^2, 189,20 km^2 belong to Macedonia, while the rest of 130,79 km^2 shared Greece and Albania. Economic development of the country is connected with the construction of commercial facilities, modernization of agricultural production, development of tourism etc. Result is sudden development of urban units. All these changes result in a disproportionate burden on the environment by industrial, utility and drainage water from agricultural surfaces carry contaminants from the assets used in modern agriculture. To minimize problems with municipal sewage, the lake was constructed collection system from which wastewater is accepted at the mouth of Big River.

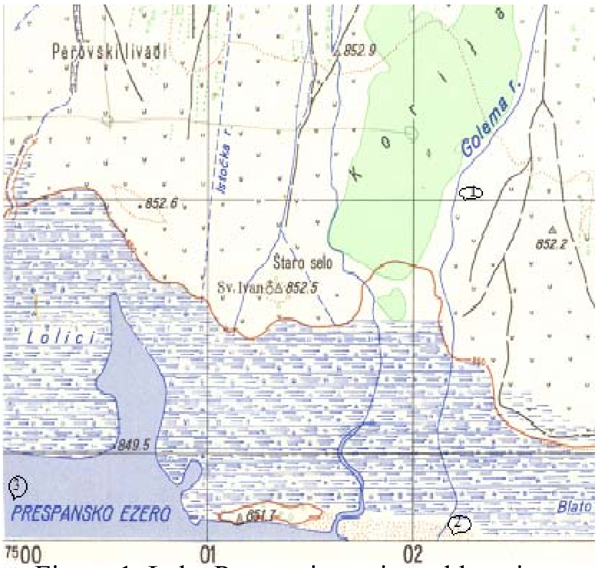

Figure 1. Lake Prespa- investigated location

Another big problem is the enormous use of water for irrigation from the three countries out of the Prespa Lake.

Water quality is monitored in the period 2007-2009 by selected physic-chemical and biological parameters.

For this purpose investigated temperature changes, pH of water, state of oxygen, organic load as permanganate support, total nitrogen and phosphorus and chlorophyll *a* situation.

Based on the obtained results is carried categorization of water, and the condition is a good basis for future interventions.

MATERIALS AND METHODS

Comparative investigations in River Golema, littoral area before it (littoral Golema) and in the pelagic zone of Lake Prespa were carried out.

Water samples were taken with Ruttner bottles.

For determination of dissolved oxygen is used the method of Winkler [1, 2]. Organic load expressed as oxygen demand from permanganate work with boiling in acidic condition and titration by the method of Kubel-Tieman [3, 4].

For determination of dissolved oxygen is used the method of Winkler [1, 2]. By digestion with acid and persulfat all forms of phosphate, including organic, moving into orthophosphate [1, 6, 8, 11]. Using ammonium molybdate and antimonil-potassium tartrate, ortho-phophosfate build complex reacts with ascorbic acid thus creates molybdate blue complex whose intensity is measured at 885 nm wavelength. Reading is performed on spectrophotometer brand Spekord, model S-10, the company Carl Zeiss Jena.

The Kjeldahl method [1, 10.11] are assessed for organic and ammoniacal nitrogen. Nitrates, first reduced to nitrite using a Cd-roms sawdust and then, together with nitrites are determined by sulfanil amide and ethylene diamine [1, 6, 8], intensity is measured spectrophotometric of 530 nm wavelength.

The water transparency is determined by Secchi Disc (Welch, 1948).

Determination of chlorophyll *a* concentration was carried out spectrophotometricaly after extraction in 90% ethanol [15].

RESULTS AND DISCUSSION

Lake Prespa ecosystem is researched extended period. For this purpose, there were two national projects in the period up to year 2006 and continuously until 2009, an international project funded by the Norwegian government. The period of research ensures the correctness of the conclusions on the situation in this ecosystem.

Temperature, pH

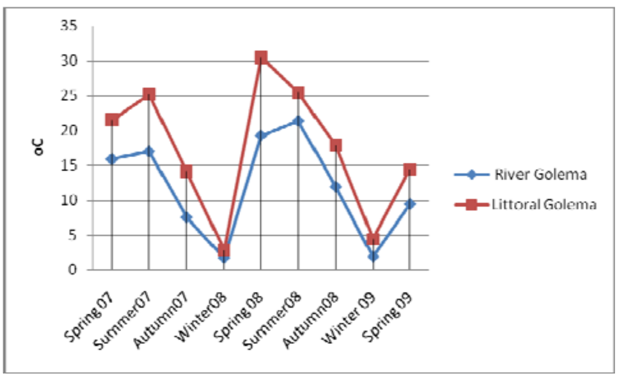

Figure 2
Temperature conditions in river and littoral area before it

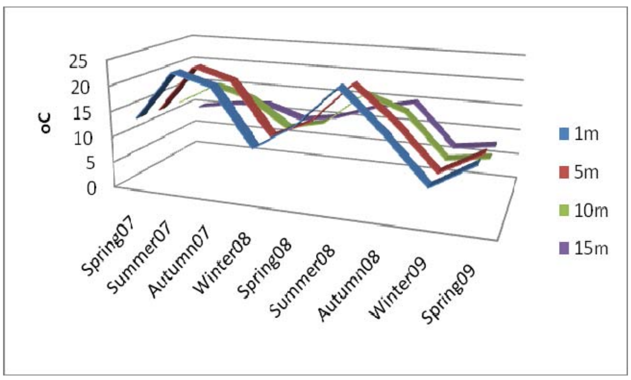

Figure 3
Temperature conditions in pelagic zone

Measured relatively high maximum temperatures in the littoral zone (Fig.2) indicate that it is quite shallow area that is rapidly heated (summer period), but quickly cools in the winter. The river water temperatures were recorded in the range of 21,40 C in the summer 2008 to 1,8^{o} C in winter 2009.

In the pelagic zone of the lake (Fig.3) were registered temperatures in the range of 6,5^{o} C, in winter 2009, at 15 m depth, to 22,5^{0} C, the surface layer in summer 2007.

As a measure of relative acidity or alkalinity of water is investigated pH. Acid-base character of the water is very dependent factors. The research period was recorded somewhat larger values for pH in littoral Golema (10.08 / summer '07; 10.09 / summer '08; Fig.4).

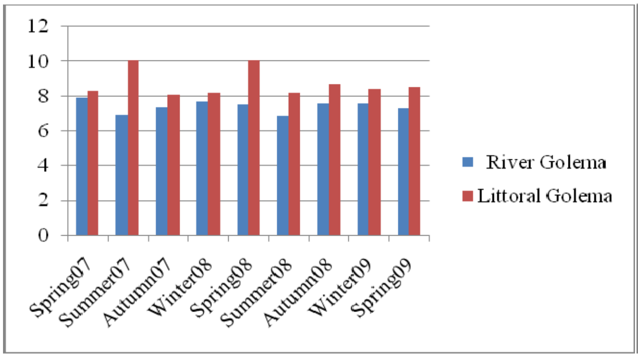

Figure 4
pH in the River Golema and littoral Golema

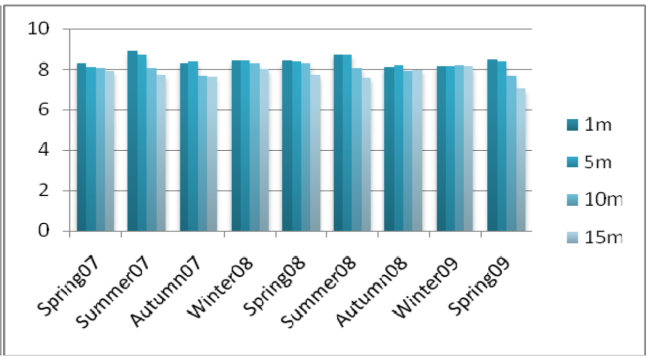

Figure 5
pH in the pelagical zone in the Prespa Lake

During the summer months in the upper layers of lake pelagial (Fig.5) registered relatively higher values, up from deeper layers, where they registered slightly lower values.

Oxygen parameters

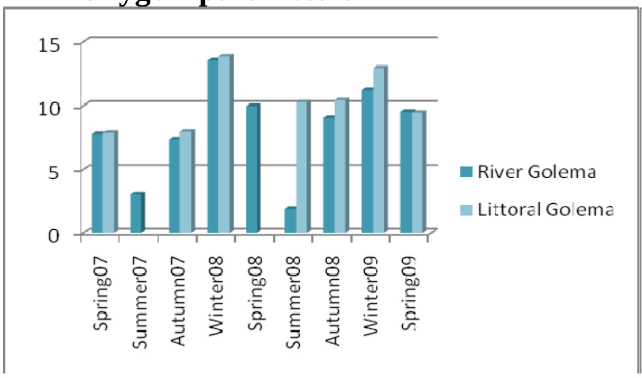

Figure 6
Dissolved oxygen in the River Golema and littoral Golema

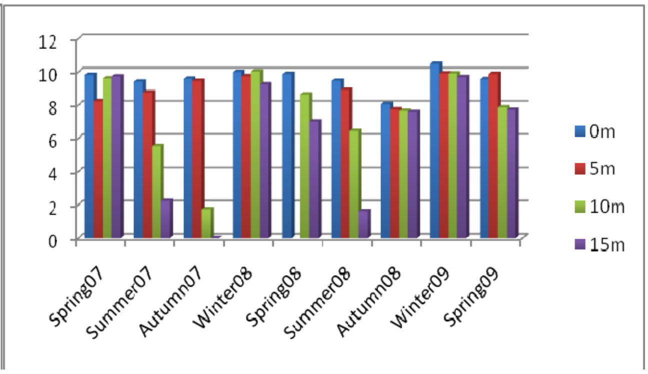

Figure 7
Dissolved oxygen in the pelagical zone in the Prespa Lake

The most important dissolved gas in water is because oxygen is necessary for biota in the aquatic environment and is essential for defining water quality.

Reaeration and consumption (biological and chemical) of oxygen are the two basic reactions in the selfcleaning and are the basis for determining the spatial and temporal distribution of dissolved oxygen or oxygen balance. The paper shows the results for dissolved oxygen (Fig. 6 and 7) and oxygen consumption, expressed as oxygen consumed from permanganate (Fig. 8 and 9).

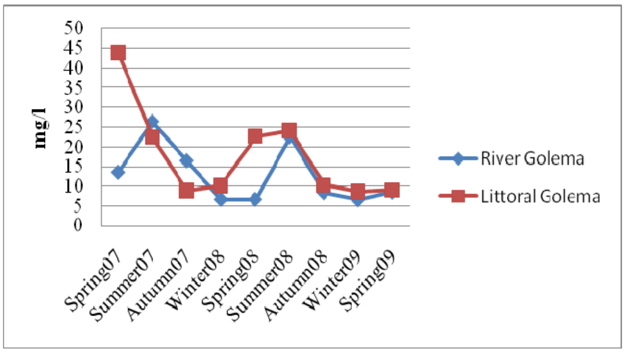

Figure 8
Oxygen demand (by KMnO4) in the River Golema and littoral Golema

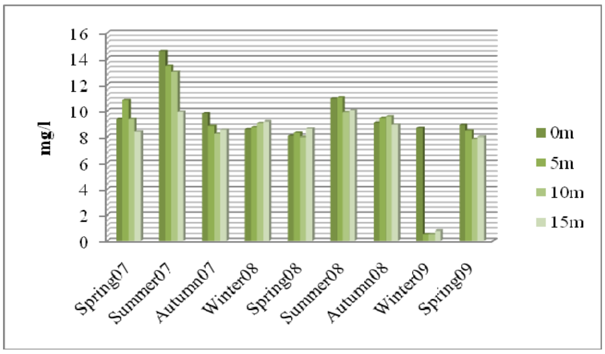

Figure 9
Oxygen demand (by KMnO4) in the pelagical zone

Given the inflow of river water and relatively shallow litoral registered relatively high concentrations of dissolved oxygen from 11,26 mg.l-1 / winter '09-river and 13,87 mg.l-1 / winter '08- litoral; fig.5. In summer the lowest concentrations of dissolved oxygen in the river (1,9 mg.l-1, summer '08) were registered as expected from the minimum amount of water in the river and minimal aeration, because it is virtually standing water.

The the pelagic section has caracteristic to have minimal amounts of dissolved oxygen in the deepest zones (1, 62 mg.l-1, summer '08, at 15 m depth).

Quantitative determination of organic load is by determining the oxygen consumption of potassium permanganate. Although permanganate, under certain conditions can oxidize nitrite, Fe^{+2} and H_2S, and some paraffins and their halogen derivatives react poorly, but as a parameter is quite accepted the definition of organic load of water ecosystems. Maximum values for the parameter is registered in the spring-summer periods, namely, 26,46 mg.l-1, summer '07 and 43,9 mg.l-1, spring '07 (Fig. 8).

The organic load is not spared either in pelagic zone of the lake. In the researched period, the maximum value for COD consumption (Fig. 9) is registered in the summer of 2009 (11,02 mg.l-1, 5 m depth). According oxygen parameters in accordance with OECD-regulation of the European Union and the Regulation on classification of waters of the Republic of Macedonia, ranging from oligotrophic (winter period), to eutrophic (summer-autumn).

Phosphorus loading

Phosphorus load is investigated by phosphorus quantities. The results obtained for the concentration of phosphorus in selected measuring points indicate high phosphoric load (Fig. 10 and 11) what is the result of unresolved problems with municipal wastewater, drainage water from agricultural, industrial wastewater etc. The maximum values for total phosphorus ranging from 469,22 µg.l-1 in the Golema River (summer 2008), 117,49 µg.l-1 littoral Golema (spring 2008) and 103 µg.l-1st pelagial of 10 m depth.

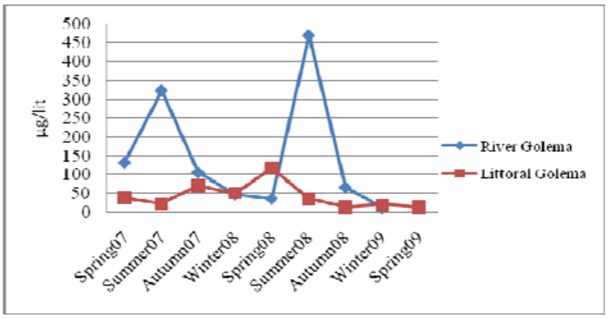

Figure 10
Total phosphorus concentration in the River Golema and littoral Golema

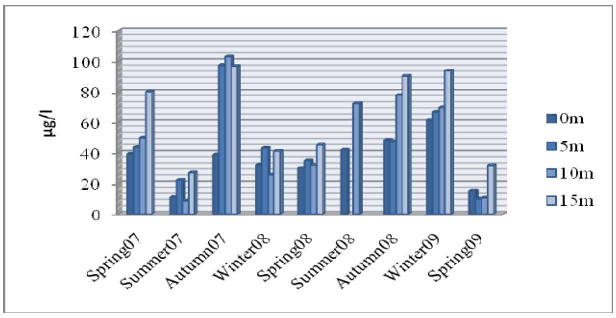

Figure 11
Total phosphorus concentration in the pelagic zone

From the results obtained for total phosphorus in the pelagic zone can conclude that spared neither this lake segment.

Nitric loading

The present nitrogen, total nitrogen as the sum of reduced and oxidized forms of nitrogen (ammonical, organic, nitrite and nitrate nitrogen). Within the project made all nitrogen forms, but the paper will give a presentation as total nitrogen (Fig. 12 and 13). The research question period registered maximum values for total nitrogen by 3847 µg l^{-1} (summer 2007), River Golema 1020 µg l^{-1} in the spring of that year and 906 µg l^{-1} in summer 2007 in the pelagic zone on 10 m depth.

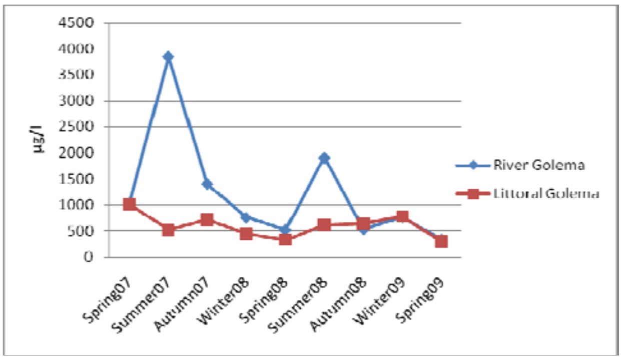

Figure 12
Total nitrogen concentration in the River Golema and littoral Golema

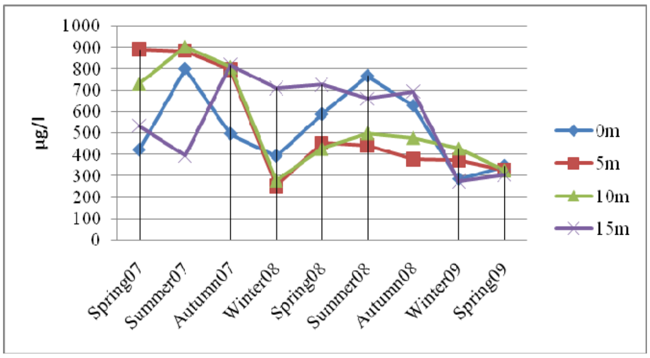

Figure 13
Total nitrogen concentration in the pelagica zone

Transparency

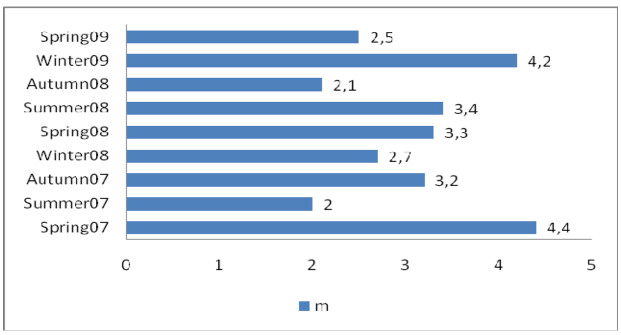

Figure 14
Water transparency in the pelagical zone

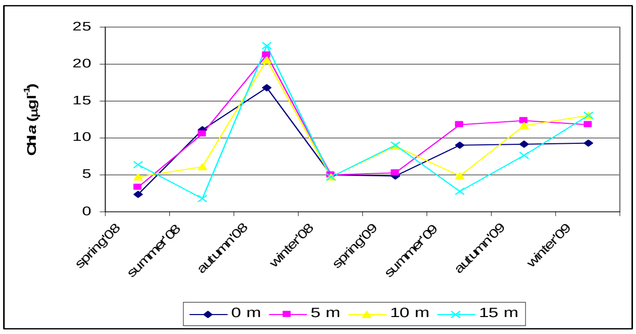

Figure 15
Chlorophyll a concentration in the pelagic zone of Lake Prespa during 2008 and 2009

Important parameter for the trophic state is water transparency. The distance from the coastline buffers the impact of suspended sediment that enters the inflow of water of lake tributaries. On the other hand, transparency is pho function of planktonic communities, particularly in the vegetation period, and of course the movement and flows of lake water and atmospheric effects (rain, etc.). Maximum recorded value of transparency in the Lake pelagic in this research period is 4,4 m in the spring of 2007 (Fig.14).

Chlorophyll *a* concentration

Chlorophyll *a* as a photosynthetic pigment integrating all type of algae is a measurable parameter for whole algal production. Chlorophyll *a* concentration and Secchi depth are both the most significant measures of the lakes trophic state. Chlorophyll *a* represents the biological response of the lake, all other factors being equal.

Our investigations in Lake Prespa showed significant difference of the chlorophyll *a* distribution between different seasons. The highest chlorophyll *a* concentration was observed in winter and in summer period except for 2008 when was observed the lowest values in the winter period (Fig. 15). Contrary, the lowest chlorophyll *a* concentration was observed in spring and autumn period. In the summer months chlorophyll *a* concentration was high in all of investigated years especially in the surface layer that due to the maximal growth of the phytoplankton.

During the investigated period in Lake Prespa was obtained tendency to increase the chlorophyll *a* concentration. Average annual chlorophyll *a* concentration during 2008 was more than 2 µg l^{-1} higher than in 2001-2003 and the average summer chlorophyll *a* concentration in 2008 was almost duplicated as to 2002 and 2003 [14]. This is a strong argument that in Lake Prespa were happened negative processes in the last several years that result in increase of the lake's trophic state.

Using Cha criteria, according to the classification which are regard to summer period, Lake Prespa in 2008 was in eutrophic and in the 2009 in mesotrophic state.

Using Cha criteria according to the fix boundary system of OECD, during the period 2008-2009 Lake Prespa was on the boundary between meso and eutrophic state.

CONCLUSIONS

The quality of river water ranges from class l, according to the Regulation on classification of waters of the Republic of Macedonia [12] or oligotrophy character by OECD [9], to strongly eutrophic condition (Class lV) during the different season.

Unresolved problems with municipal wastewater, wastewater from farms that directly flow into rivers, and solid waste (mostly of organic origin, and certainly should not be neglected inorganic waste) are primary sources of organic loading of the lake ecosystem.

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Prespa Lake is a lake in the three countries, Macedonia, Greece and Albania. From that aspect extraction are important to predict and urgently taken to remedy the situation with the quality of water entering the lake.

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