SPATIOTEMPORAL CHANGES IN THE WATER QUALITY OF LAKE VEGORITIS AND INTERACTIONS WITH THE LAND USES IN THE CATCHMENT AREA

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Introduction

During the last decades the surface and underground water bodies are under high pressure, mainly due to human influences, the most important of which, are farming, urbanization, industrial and tourism development.

The purpose of this study was to understand the interactions between land uses and water quality in Lake Vegoritis, Macedonia, North Greece and the catchment area. In addition, this study aimed to capture changes over time in the quality of the lake's water and understand the main factors that affect negatively these changes.

As a result, the temporal trends of these parameters and the main influencing factors, for the period 1983-2011, with emphasis on land use, were presented in this study.

Materials and methods

In order to achieve the purpose of this study we have collected available environmental and hydrological data for Vegoritis Lake. Data related to quality characteristics such as pH, electrical conductivity, dissolved oxygen, nitrate, ammonium, chlorophyll and phosphorus were retrieved from Hellenic Ministry of Rural Development and Food, the Hydroeconomics department of Florina Prefecture and research projects. Hydrometeorological data such as water level, temperature and rainfall were retrieved from hydroelectric station of Agras and Amyndaion weather station.

Land cover data were retrieved from the Hellenic Statistical Authority database for the year 1991 and from Corine Land Cover Map datasets, after processing with GIS software, for the years 2000, 2006 and 2012. The Carlson classification system (Carlson 1977) was used to assess the nutritional status of Lake Vegoritida. Processing of data was carried out with statistical analysis software.

Results and discussion

The annual mean values of water volume exhibits overall decreasing trends for the period 1896-2016 (R^2 = 0.424 ; R = - 0.6512 ; p = 0.00001 ; α = 0.05). The minimum water volume was 507.54m in 2002, following by an increasing trend reaching to 517.37m

in 2016. These results could be connected with changes in water balance: Annual rainfalls were higher after year 2004 and at the same period, the local public hydroelectric station interrupted consuming water from lake Vegoritida (fig. 1).

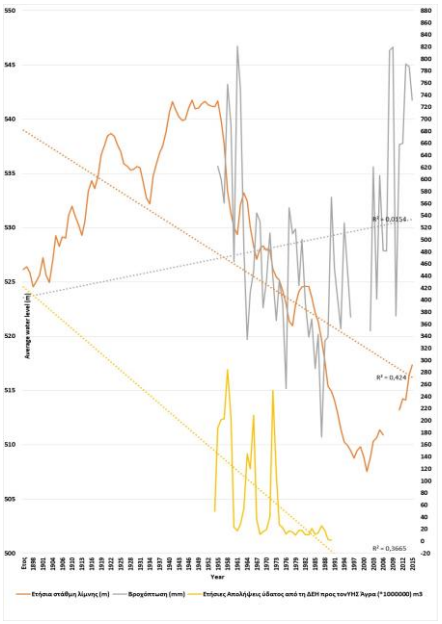

Figure 1- Changes over time in water level, rainfall and water consumption from local public hydroelectric station

Changes in the urban fabric land cover in Vegoritida catchment area, associated with fluctuations in ammonia ions, nitrate ions and total phosphorus concentrations respectively, affecting also water quality (fig. 2). Indeed, other studies revealed that Urbanization affected water quality in terms of nitrogen and phosphorus (Ding et al 2015 [1]; Schuster and Grismer 2004 [2]).

Increase in irrigating areas resulted in larger ammonia ions, nitrate ions and total phosphorus concentrations. On the contrary, the less the irrigating areas exist, the smaller the nutrients concentrations can be (fig. 3).

Intensive agriculture negatively affected the water quality because of the use of fertilizers. However, after year 2006, the concentrations of the referred elements showed a decreased trend, because of the Lake volume increase, the adoption of good agricultural practices by farmers and the new Sewage Treatment Plant operation.

Finally, when the forest areas decreased, the concentrations of ammonia ions increased, possibly due to erosion and water leaching from empty land, the transfer of ammonia ions by runoff, and the new land cover with deciduous fruit trees with the consequent increase for fertilizers (fig. 4).

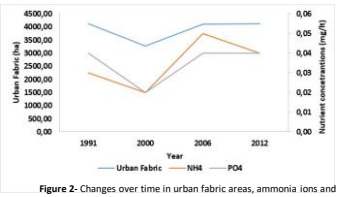

Figure 2- Changes over time in urban fabric areas, ammonia ions and total phosphorus concentrations

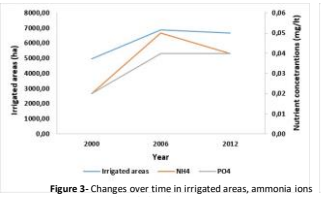

Figure 3- Changes over time in irrigated areas, ammonia ions and total phosphorus concentrations

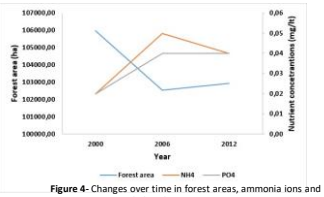

Figure 4- Changes over time in forest areas, ammonia ions and total phosphorus concentrations

In order to determine the status of eutrophication and water quality levels in lake Vegoritida, we used the Carlson' trophic status index (TSI). Our findings revealed that the trophic status of the lake depends on the selected time period. In year 1981, the Lake was in an intermediate category between oligotrophic and mesotrophic. The year 1993 was characterized as eutrophic, the year 2006 mesotrophic and in 2008 oligotrophic to mesotrophic. These changes in the classification of the Lake may be due to the Lake volume increase, the local fertilizer industry operation and the later shutdown, the positive effect of Sewage Treatment Plant operation and the adoption good agricultural practice codes by farmers.

Index / Year	TSI(TP)	TSI(Chl_a)	TSI(SD)
1981	46	33	37
1993	67	50	54
2006	48	43	51
2008	45	38	45

Table 1- Carlson values for Vegoritida Lake: Dark red = Eutrophic to Hypertrophic, Light red= Eutrophic, Yellow=Mesotrophic, Green = Oligotrophic to Mesotrophic

Conclusions

The land use in the hydrological basin must be planned carefully to protect the wetland system from water quality deterioration. Sewage Treatment Plants construction and Systematic control of the existing, would further improve water quality. Irrigation systems that minimize water loss and nutrient leaching, such as drip irrigation are expected to protect lakes from nutrients accumulation that cause eutrophication. The foundation of a water and fisheries resources association would provide information and supporting for the sustainable use of water resources of this area. Thus, a long-term management plan of the Lake Vegoritis is needed to eliminate the pollution pressures and restore its ecological balance.

References

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