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Limnological Situations in two Shallow Greek Lakes (Kastoria and Mikri Prespa Lakes)

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ABSTRACT: The shallow Kastoria lake supports an important fishery but the effluent discharges from the local town renders the lake polluted and eutrophic. From a limnological point of view, its water exhibits unstable thermal stratification, dimictic as well as meromictic situations, low concentrations of dissolved oxygen close to its bottom sediments and rather high nutrient concentrations. The internationally important wetland of Mikri Prespa lake belongs to the dimictic lacustrine type. The lake is directly influenced by runoff from nearby agricultural land as well as by the organic matter produced mainly in the luxuriant bank vegetation of reeds.

Introduction

The limited freshwater resources in Greece, less than 4 % of its total area, are in part compensated by the favourable climatic conditions and the morphological characteristics of its lakes, which give rise to high rates of biological productivity. Their irrational exploitation leads to conflicting uses of the water and accelerates the aging of the system. The major factors that pose a serious threat to the future utilization, preservation and protection of lake resources originate in great part from man's activities. These include various types of uncontrolled discharges directly into the basins or their catchment areas, overfishing, selective fishing and enrichment of aquatic organisms.

The excessive levels of nutrients, natural and anthropogenic, usually apparent in the overgrowth of aquatic macrophytes or planktonic algae, have a deleterious effect on water quality and interfere directly with the beneficial uses of lake water for fishery, irrigation and other purposes.

Eutrophication and/or pollution represent the major water quality and fish productivity problems of the Lakes Kastoria and Mikri Prespa as identified recently (Koussouris et al. 1983; 1985).

Results and Discussion

Kastoria lake, with the local town (population over 25,000 inhabitants) developed on a peninsula, entering the main basin, supports an important fishery (Fig 1). The lake covers an area of about 32.4 km^2, has a maximum depth of around 9 m, and a mean depth of 4.4 m. Effluent discharges through surrounding land and building drainage render the lake polluted and eutrophic. Its water exhibits unstable thermal stratification with dimictic and meromictic conditions. Dissolved oxygen concentrations are low during most of the year to the bottom. High levels of dissolved oxygen are recorded near to the surface from June to September as a result of phytoplankton blooms. Based on alkalinity and chloride values, the lake is classified as meso-eutrophic, while its water transparency points to the eutrophic type. The nutrient concentrations of water are rather high for phosphate, nitrate and ammonium, but they vary spatially and with season. Plankton assemblages, to some degree, show the influence of incoming sewage, as well as agricultural runoff and increased soil erosion. The benthic fauna has comparatively few species, but high biomass. Most of species indicate extension of sapropelic communities. During the last 17 years (1965 - 1982), the fish production decreased from 510 t to 160 t annually, while the species structure changed. The summarising characteristics of the lake are presented in Tab 1.

Mikri Prespa lake is a shallow basin occupying an area of c. 48,5 km^2 (Fig 1). Together with the neighbouring Lakes Ohrid, Megali Prespa and Malik, it is the remnant of an old larger lake in the west Pelagonian massif of the Adriatic confluence. During the last decades, various development pro-

Climatic Conditions:
Air temperature, range of mean max. 6.0-28.4°C
range of mean min. 1.0-15.9°C
Precipitation, annual mean - 700mm
Main wind direction - N,NW,NE
Evaporation, annual - 20-25cm

Geology:
Geological characteristics - Meiocene sediments
Limestones

Major Land Uses:
Urban - Residential - Agricultural
Industrial - Commercial

Demography and Human Activities:
Number of inhabitants - 40000
Usage of water - Effluent discharges - Fishery - Irrigation
Main agricultural activities - Appletrees - Cereal

Topography:
Latitude - 38° 34'N
Longitude - 21° 30'E
Altitude - 688m

Lake Morphology:
Surface area, km^2 32.4 Development of shore line-1.67
Max. depth, m 9.1 Development of volume-1.49
Max. length, km 32.5 Volume $X10^6 m^3$-144
Max. width, km 28.3
Mean depth, m 4.45 z:zm 0.49

Hydrography and Limnology:
Ice cover - Every two to three years for 10 days
Lake's type - Temperate dimictic lake
Temperature, range °C - Summer 19.3-25.7
Autumn 9.3-21.6
Winter 5.4- 7.1
Spring 4.7-13.3
Dissolved oxygen, range mg/l - Summer 0.3-12.1
Autumn 0.1-10.4
Winter 5.1-10.2
Spring 2.2-11.5
pH, range - Summer 7.00-8.71
Autumn 6.80-9.50
Winter 5.90-8.20
Spring 7.80-8.30
Conductivity, range uS - 120 -308
Alkalinity, range meq/l - 1.44 - 3.04
Total hardness, range G° - 4.48 - 8.51
Chlorides, range mg/l - 6.80-40.1
$P\text{-}PO_4$, range mg-at/l - 0.09 - 0.71, arithm.mean 0.30
$N\text{-}NH_4$, >> >> - 0.67-12.10, >> >> 3.09
$N\text{-}NO_2$, >> >> - 0.04 - 1.60, >> >> 0.15
$N\text{-}NO_3$, >> >> - 0.02-24.10, >> >> 4.38
Secchi disk transparency, range m - 0.50-2.80
Dom.Phytoplancton Species-
Spring time - **Ankistrodesmus falsatus, Pediastrum** spp., **Scenedesmus** spp. **Tetraedron** spp., **Fragilaria** spp.
Summer - **Lyngbya limnetica, Microcystis** spp., **Cyclotella** spp.
Dom.Zooplankton Species
Spring time - **Polyarthra minor, Keratella quadrata, Tintinopsis lacustris**
Summer - **Polyarthra trigla, P.euryptera, Filinia longiseta**
Dom.Macrophytes (%) - **Phragmites australis** 60%, **Myriophyllum** spp. 15%
Dom.Benthic Animals - **Tubifex tubifex, Chironomus** spp. **Chaoborus crystallinus**
Dom.Fishes - **Cyprinus carpio, Perca fluviatilis, Alburnus albidus, Rutilus rutilus, Tinca tinca, Silurus glanis, Esox lucius**

Tab 1 Lake Kastoria, Greece

Fig 1 Study areas

jects have not only altered the natural environment of the region, but also influenced, directly or indirectly, conditions within the lake itself. The lake, with its luxuriant bank vegetation, dominated by reeds and its extensive marshes and floating islets of thick reed clusters, offer valuable sites for nesting and breeding waterfowl which make Mikri Prespa a site of international interest; especially for pelicans. The lake is situated in a karstic basin and is of a dimictic lacustrine type. Its water shows low Secchi disc transparency, low levels of dissolved oxygen with a clinograde distribution, with average high hardness and alkalinity values. Its nutrient concentrations are rather high for phosphates and low for nitrates, although at times very high values of nitrates, due to agricultural runoff from the area, were observed. The organic matter, produced mainly by reeds on the littoral zone and on the open lake zone by algal blooms, is high and, by accumulating in many areas, disturbs the diversity of habitats, alters the water quality and accelerates the ecological succession. The plankton

Climatic Conditions:
Air temperature, range of mean max. 7.2-22.9°C
range of mean min. 1.0-15.0°C
Precipitation, annual mean - 823mm
Main wind direction - N
Evaporation, annual - 18-22cm

Geology:
Geological characteristics - Pleiocene sediments
Limestones

Major Land Uses:
Agricultural and rural

Demography and Human Activities:
Number of inhabitants - 2500
Usage of water - Fishery - Irrigation
Main agricultural activities - Legumes - Appletrees - Cereal

Topography:
Latitude - 40° 44'N
Longitude - 21° 04'E
Altitude - 853m

Lake Morphology:
Surface area, km^2 48.5 Development of shore line-1.92
Max. depth, m 7.9 Development of volume-2.54
Max. length, km 13.3 Volume $X10^6 m^3$-324
Max. width, km 6.1
Mean depth, m 6.7 z:zm-0.85

Hydrography and Limnology:
Ice cover -Every two years for 3 to 7 days
Lake's type -Temperate dimictic lake
Temperature range°C -Summer 18.3-28.1
Autumn 18.7-22.2
Winter 12.4- 4.9
Spring 8.8-11.1
Dissolved oxygen, range mg/l - Summer 0.6-12.7
Autumn 0.1- 8.7
Winter 2.1-10.8
Spring 1.8- 9.8
pH, range - Summer 7.00-8.70
Autumn 7.10-8.50
Winter 6.40-9.00
Spring 7.50-8.20
Conductivity, range µS - 60 -240
Secchi disk transparency, range m - 1.05- 3.00
Total alkalinity, range meq/l - 1.80- 2.96
Total hardness, range G° - 4.76- 8.96
Chlorides, range mg/l - 5.2 -10.1
$P\text{-}PO_4$, range mg-at/l - 0.09- 0.71, arithm.mean 0.30
$N\text{-}NH_4$, >> >> - 0.67-12.00, >> >> 3.09
$N\text{-}NO_2$, >> >> - 0.04- 1.60, >> >> 0.15
$N\text{-}NO_3$, >> >> - 0.02-24.10, >> >> 4.38
Dom.Phytoplancton Species-
Spring time - **Anabaena** spp., **Chroococcus** spp., **Microcystis** spp., **Scenedesmus** spp., **Elakatothrix** spp., **Pediastrum** spp.
Summer - **Cyclotela** spp., **Melosira** spp., **Asterionella** spp.
Dom.Zooplankton Species
Spring time - **Keratela** spp., **Polyarthra** spp.
Summer - **Polyarthra** spp., **Daphnia** spp.
Dom.Macrophytes (%)-**Phragmites australis** 85%
Myriophyllum spp.2%, **Potamogeton** spp.2%
Dom.Benthic Animals - **Tubifex tubifex, Chaoborus crystallinus** **Chironomus** spp., **Nais variabilis**
Dom.Fishes-
Cyprinus carpio, Alburnus albidus, **Rutilus rubilio, Chondrosoma nasus**

Tab 2 Lake Mikri Prespa, Greece

assemblages also show the influences on the lake environment of agricultural runoff and increased soil erosion. The benthos has few species but high biomass. The fish population of the lake, estimated from total catches and species composition, has changed dramatically during the last 2 decades, from 450 t annually in 1964 to 50 t in 1983. The main characteristics of Mikri Prespa are given in Tab 2.

The agricultural runoff into Lake Mikri Prespa which contributes a considerable amount of plant nutrients, mainly phosphorus, is the principle source of lake eutrophication. The permanent flux of nutrients into the lake will rise serious problems in the near future, because the reduction of a nutrient supply from diffusive sources is operational in terms of decades only.

Conclusions

Lake Kastoria which supports an important fishery contains a high nutrient loading, which is brought about mainly by unpurified sewage outfalls from local towns. The sewage treatment would be essential for the conservation of Lake Kastoria as an important local fishing ground.

References

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