SEASONAL VARIABILITY OF NUTRIENT AND CHLOROPHYLL A CONCENTRATIONS IN THE KARSTIC COASTAL LAKE VELIKO JEZERO (MLJET ISLAND, ADRIATIC SEA)

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Abstract

Vertical and seasonal distribution of nutrients and chlorophyll a (Chl a) were analyzed in relation to thermohaline conditions in a coastal karstic lake on the south-eastern Adriatic island of Mljet during 1987 and 1988. The water column through most of the year was thermally or saline stratified. Haline stratification was greatly influenced by the rainfall regime and freshwater input through underground springs. Trapped saline water of relatively high salinity was found in the deeper layers. Most of the nutrients did not exhibit a statistically significant difference between different seasons in the relation to the entire water column. The lowest nutrient concentrations were found in the layer above the pycnocline and the highest in the layer below it. Veliko jezero is an ecosystem characterized by separate water types in vertical profile during all the seasons.

Key-words: hydrography, vertical profile, stratification, Adriatic Sea

Introduction

The south-eastern Adriatic island of Mljet, with its dense forest vegetation and two picturesque coastal lakes, Veliko jezero and Malo jezero, has been proclaimed a national park in 1960 (Fig.1). The lakes were filled by the Holocene ingression of the Adriatic Sea during the Atlantic period ca. 5000 years BC. Paleohydrology of these lakes seems to be a suitable instrument for the reconstruction of climatic changes in the Mediterranean (1). Both lakes are highly isolated from each other and from the sea by narrow passages and shallow (1 respectively 2 m deep) sills. Veliko jezero is 2.5 km long, up to 1 km wide, with a maximal depth of 46 m and a volume of 0.036 km^3. The coastal line is 9.2 km long. Occasional subsurface decreases in salinity are caused by the so-called "vruljas"-subsurface springs, which are a characteristic karst phenomenon. The aim of this paper is to determine seasonal variability of nutrient and Chl a concentrations in relation to the hydrodynamic properties of the water column.

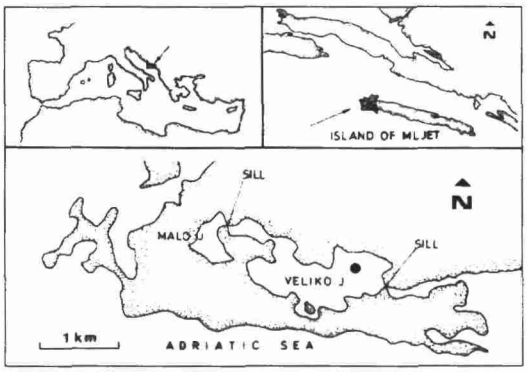

Fig. 1. Location of the Vrbovacka station in Veliko jezero (Mljet lakes).

Materials and methods

Water samples for the analyses of the nutrients and Chl *a* were collected at the Vrbovacka station (46 m max. depth) in the deepest basin of Veliko jezero. Four sampling cruises were carried out in December 1987, March, June and August 1988. The samples were taken by Niskin bottles every five meters from the surface to the bottom, except in the pycnocline where the samples were taken at every two meters. The nutrients and Chl *a* concentrations were determined by standard oceanographic methods (2, 3). Salinity and oxygen were measured using standard titration methods. Temperature was measured using inverted thermometers. Data were subjected to analysis of variance (ANOVA) and SNK-multiple range test (4).

Results and conclusion

This is the first report of Chl *a* concentration data for Veliko jezero. Thermohaline properties, oxygen saturation and Chl *a* concentration in the water column are presented in Fig. 2. Vertical distribution of the nutrient salts is presented in Fig. 3. In December 1987, the surface layer (from 0 to 10 meters) was relatively homogenous for most of the sampled parameters. Temperature was 12.8°C and salinity ranged from 37.41 to 37.59 psu. A temperature increase started at 13 meters depth to reach a maximum increase of 2.5° C between the 15 and 27 meters. At 13 meters depth salinity increased to 38.12 psu. Variation in density followed the temperature and salinity variations.

In the layer of increased temperature, an interesting distribution pattern of nutrient concentration was observed. The highest concentrations of reactive phosphorus and ammonia were recorded at 10 meters depth, namely, in the layer above the temperature increase. NO_3 with unusually high values within the increased temperature layer formed three peaks: at 13 m (50.4 μmol dm^{-3}), at 15 m (49.18 μmol dm^{-3}) and at 24 m (24.02 μmol dm^{-3}). In the drainage area dominated by pine forests, it is possible

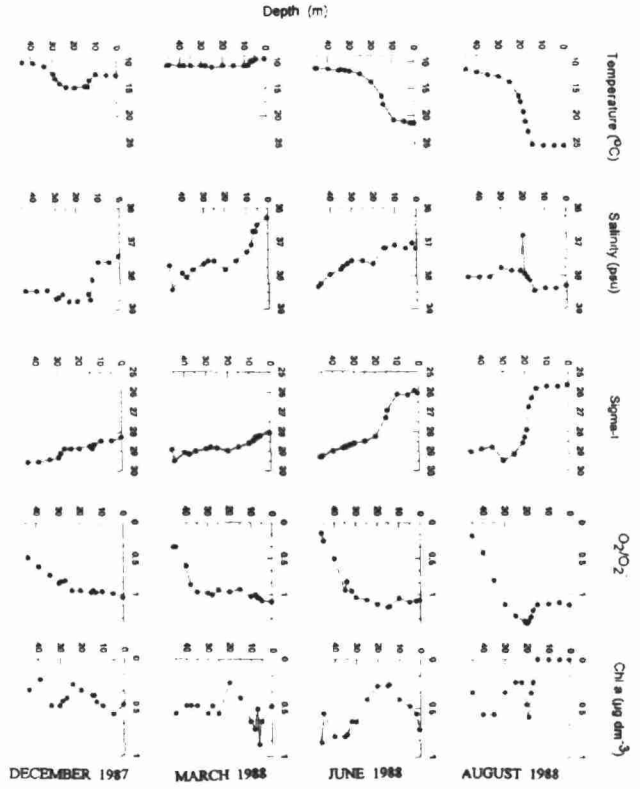

Fig. 2. Vertical distribution of temperature, salinity, density, oxygen saturation and chlorophyll *a* concentrations at Vrbovacka station.

that the amount of humic substances entering the water of Veliko jezero can be considerable. It seems that humic substances were utilized by bacteria both as a carbon and nitrogen source, and that nitrogen was incorporated in bacteria and later regenerated as inorganic nitrogen due to the activity of bacterial grazers and other grazers of higher tropic levels (5, 6). This is presumably the reason for the high NO_3 concentration levels which will be the topic of our future research.

Chl *a* has two maxima within the water column: the first maximum was recorded from the surface to 10 meters depth, and the second between 27 and 35 meters. The highest nitrite concentrations were concurrent with those recorded for Chl *a*. The dissolution of biogenic silica caused the increased reactive silicate concentrations registered at 27 meters and in the layer between 30 meters depth and the bottom. The results of the investigated parameters confirmed the existence of dynamic processes along the lines of contact as well as in the layer of the increased temperature. The increased temperature in between the 13 and 27 meter depths may probably be ascribed to a number of factors: the remnant summer temperatures after the winter cooling of the surface layer; suspended particles which absorb more intensively the energy coming from the sun than the water molecules, and to an intensified bakterioplankton activity (7).

The inverse temperature stratification was recorded to 10 meters in March. The warming of the sea in June and especially in August leads to the increase in the surface layer temperature and the formation of a sharp thermocline between 15 and 20 meters depth. Surface salinity values differed in March and June 1988 (*e.g.*, March 36.29-37.56; June 37.19-37.65), but not