

DISTRIBUTION OF NUTRIENTS AND PHYTOPLANKTON IN THE KARSTIC ESTUARY (THE ZRMANJA RIVER, EASTERN ADRIATIC SEA)

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Abstract

The abundance of phytoplankton and concentration of nutrients were determined in the highly stratified Zrmanja Estuary, eastern Adriatic coast, Croatia, in the period from June 1998 to October 2000. Marine phytoplankton was more abundant in the middle than in the upper reach of the estuary. The Zrmanja river and the estuary are oligotrophic, and orthophosphate was detected as a limiting growth factor in the estuary.

Key-words: Estuary, nutrients, phytoplankton, stratification, Adriatic Sea

Highly stratified estuaries are maintained in areas where a high volume of river discharge is combined with low tides. Such phenomena are well known along the karstic, eastern Adriatic coast. The Zrmanja River (69 km long) discharges into the eastern-central Adriatic Sea (Fig. 1) forming highly stratified estuary. The average outflow equals 38 m³/s, but may be as high as 456 m³/s and as low as 0.09 m³/s. The upper reach of the estuary is mostly about 5 m deep, while the middle and lower reaches are up to 40 m deep. The surrounding area is scarcely inhabited. The settlement Obrovac in the upper reach of the estuary counts 1200 inhabitants. We present the first data on physico-chemical and ecological characteristics of the Zrmanja Estuary.

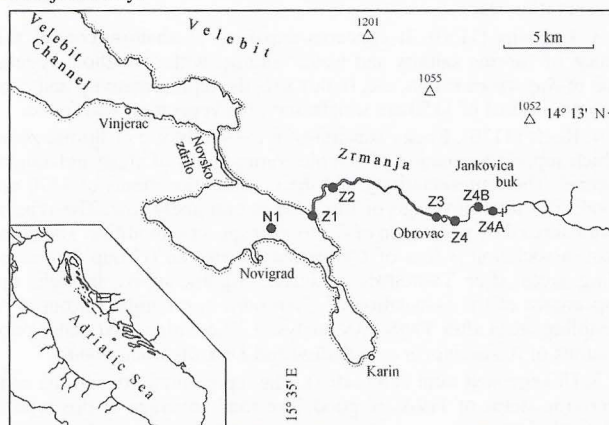


Fig. 1. Position of stations in the Zrmanja River estuary

Materials and methods

This study shows the results about environmental conditions in the middle (Stations N1) and upper (Stations Z1, Z2, Z3, Z4, Z4B, Z4A) reach of the Zrmanja Estuary, in the period from June 1998 to October 2000. Phytoplankton and nutrients were sampled using 5-liter Niskin bottles at one-meter intervals of the water column. Salinity and temperature were determined using a conductivity, temperature and depth profiler (SEA Bird Electronics Inc., USA). The 0–1 m layer was always above the sharp halocline. Halocline, except for station N1, was less sharp and closer to the surface in summer. Phytoplankton was preserved in a 2 % neutralized formaldehyde solution and counted by the inverted microscope method (1). Nutrient concentrations were measured using standard methods (2, 3).

Results and discussion

The concentrations of orthophosphate were low (mostly below 0.1 μmol l⁻¹), slightly increased below the halocline and shortly downstream the Obrovac settlement (Fig. 2). The Zrmanja River was an important source of total inorganic nitrogen (TIN), probably due to the influence of pasture upstream the river. The river was the source of silicates. Most frequent Redfield ratios (TIN/PO₄) were considerably higher than 16, especially at lower salinities, indicating phosphates as the limiting growth factor of phytoplankton. The water column was well oxygenated.

Phytoplankton was mostly composed of marine species (diatoms) below the halocline (Fig. 3). Maximum abundances of diatoms (not higher than 2x10⁶ cells l⁻¹) and micro-dinoflagellates (not higher than 6x10⁵ cells l⁻¹) were detected at N1 and Z1, in the area where marine influences abruptly increase, and just below the halocline, due to the more favorable nutritive and light conditions, and currents below the outflowing surface brackish layer. However, nanoplanktonic dinoflagellates and cryptophytes (mostly mixotrophic species), as well as naked ciliates were more abundant in the area of slight anthropogenic influence. The euphotic layer ceased by the bottom, mostly about 5 m

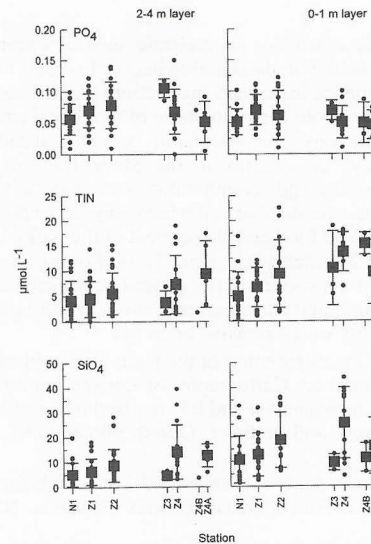


Fig. 2. Distribution of nutrients along the Zrmanja Estuary (1998–2000).

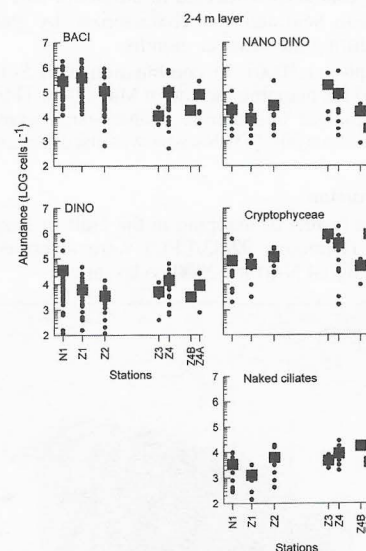


Fig. 3. Distribution of phytoplankton along the Zrmanja Estuary (1998–2000).

deep in the upper reach of the estuary. The presented results indicate the Zrmanja Estuary as an oligotrophic, coastal environment, with a slight anthropogenic impact.

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