Ecosystem of Morinje Bay (Adriatic Sea, Croatia): Aspects of the Sediment/Water Interface

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Abstract: During the 4.6 ka long depositional history of the Morinje Bay ecosystem, organic-rich sediments have accumulated, indicating a higher trophic level. At present, the sediment/water interface is characterized by a sharply delineated anoxic sediment/oxic water column interface zone, indicating most recent shift to moderate eutrophication.

Key words: Trophic level, biology, palynofacies, hydrogeology, sedimentology, geochemistry, anthropogenic pollution

Introduction

Morinje Bay (3.5 km^2) represents an restricted, shallow marine (<2m) ecosystem which communicates with the open Adriatic Sea through the 150-350 m narrow and 2.5 km long Morinje channel (Figure 1). The depth of the channel at the open sea is 23 m, and at the entrance into the Bay 2 m. During the Late Pleistocene and especially the Holocene, both the depression of the Bay and the channel were formed in Cretaceous-Palaeogene carbonates and clastics, both being tectonically predisposed to erosion by the Dabar torrential stream. According to Filipčić (1992), due to global sea-level rise the transgression into the Morinje channel begun approx. at 8 ka B.P.,

During 4.6 ka some 4.5 m of sediments have been deposited in Morinje Bay, indicating a relatively high sedimentation rate estimated at 1.0 m/1 ka. The Morinje Bay ecosystem is characterized by varying seawater temperatures (0-35 ^{o}C), as well as fluctuating salinities (up to 42.0 ‰) caused by seasonally enhanced evaporation, a continuous freshwater supply through on shore and submarine springs and significant surface runoff episodes. Until recently, before freshwater regulation in the catchment area (103 km^2), the Dabar stream during rainy periods provided

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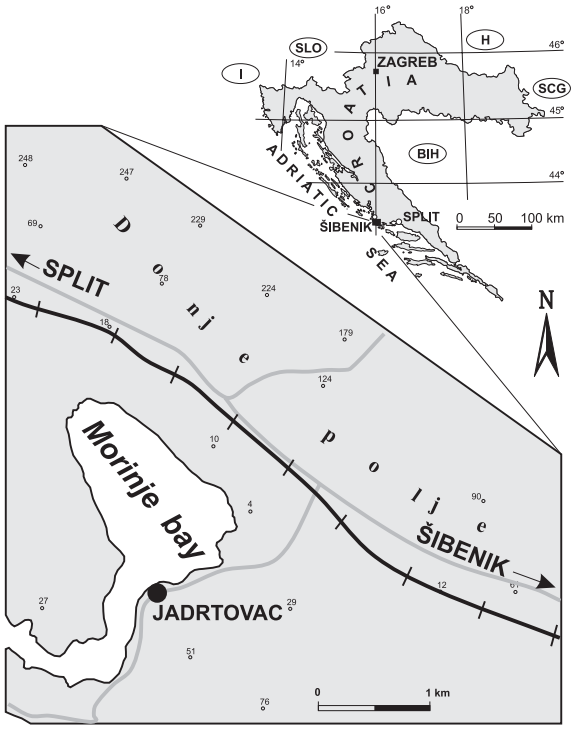

Figure1. Location of study areaand into the Bay approx. at 4.6 ka B.P., which is in accordance with the values of the Adriatic sea-level rise presented in Cattaneo et al. (2003).

freshwater to the Bay with a maximum 5-year discharge of 46 m^3/s. These ecological conditions were conducive for enhanced primary bioproduction, resulting in accumulation of mostly organic-rich sediments during the Bay's depositional history.

RESULTS AND DISCUSSION

The abundance, structure and diversification of the microphytoplankton assemblage, as well as the ratio of physiological groups (measured in April and June), indicate that the ecology of Morinje Bay favours the formation of a specific microphytoplankton assemblage, reflecting extreme, unstable and stressed environmental conditions. The abundance of microphytoplankton is moderate and the assemblage is dominated by diatoms, lower concentrations of dinoflagellates and very low concentrations of coccolithophorids. The subfossil phytoplankton assemblage of diatoms, coccolithophorids and organic walled dinoflagellate cysts, as well as the assemblage of opportunistic foraminifera of the surficial sediments, indicate a sufficient but variable nutrient supply, whereas the higher concentrations of coccolithophorids may indicate either stronger open sea influence or diagenetic changes within the sediment. As a consequence of the entire ecology, mostly organic-rich sediments were deposited. The rather high content of organic matter of the sediments indicates the higher trophic level of the Morinje Bay ecosystem

during its depositional history, which was at least seasonally induced by Dabar runoff episodes providing nutrient supply.

Palynofacies and the composition of organic carbon stable isotope $\delta^{13}C$ values show that 70-90 % of organic matter is lipid- and hydrogen-rich (predominantly amorphous type), with on average 2/3 of marine (mostly phytoplankton, bacteria and marine macrophyts) and 1/3 of terrestrial (mostly woody tissue) origin. Gas chromatograms indicate that the qualitative composition, i.e. organic compounds, of the extractable low molecular weight organic matter is always the same, but differs in relative quantitative distribution. The quantitative variations of the organic matter composition are a function of environmental and distributional factors within the sedimentary basin.

Lipid- and hydrogen-rich organic matter, pyrite, Eh and pH measurements, as well as relatively high concentrations of sulfur organic compounds (indicated by the gas chromatogram peaks) indicate reductive depositional conditions. The portion of sulfur ions is higher than the input of heavy metal ions (for example Fe) and is therefore partly incorporated into organic molecules by the action of anaerobic bacteria. Eh measurements show that, in spite of obvious benthic activity, the sediment was highly reductive even in the uppermost segment at the sediment/water interface which sharply delineates the oxygen-depleted sediment from the oxic water column. This is consistent with the well preserved lipid- and hydrogen-rich organic matter of the surficial sediments and is explainable in terms of cyanobacteria (widely distributed in shallow marine ecosystems with periodically increased but fluctuating salinities) which may have formed mat structures which reduce the vertical permeability of the sediments, retaining reducing conditions.

According to their mineralogical composition and distribution of major elements, the sediments of Morinje Bay are classified as sandy-clayey silt.

The distribution and concentration of most of the chemical elements positively correlate with the mineralogical composition of the clayey silt. The deeper sediment layers are characterised by enrichments of the redox-sensitive trace minerals As, Mo, U and V, whereas Mn is enriched in the oxic/anoxic interface zone. Co, Cr, Ni, La, Ba and Zn reflect the geogenic background when normalized to Sc. Redox-sensitive trace metal enrichments have been linked to high concentrations of dissolved sulphide; reactions at mineral surfaces, including pyrite and the amount and type of organic matter present.

Gas chromatograms of the surficial sediments near a ash waste disposal site located in the NW part of the Bay show the presence of some organic pollutants (petroleum, plastics, detergent) indicating anthropogenic influence on the Morinje ecosystem. It has been also demonstrated that erosion of the ash containing high heavy metal concentrations does not contribute appreciably to total concentrations of metals in surficial sediments and the influence is almost undetectable at distances of more than 100 m off-shore. Increased, but not anomalous values of Pb and Cu may also be interpreted in terms of regional atmospheric deposition (Pb) and local vine-yard activity (Cu) in the catchment from which sediment is transported to the Bay.

CONCLUSIONS

Organic-rich sediments of Morinje Bay reflect a higher trophic level during the 4.6 ka long deposition history. Its recent ecological state reflects moderate eutrophic conditions as exemplified by a sharply delineated anoxic sediment/oxic water column interface zone which was in the past placed somewhat higher within the water column. Anthropogenic influence of Morinje Bay ecosystem is indicated by some organic pollutants which have been detected in the Northwestern part of the Bay. Somewhat increased concentration of Pb and Cu are interpreted as a results of atmospheric deposition (Pb) and vineyard activity (Cu).

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