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Influence of microbial mats on heavy metal interstitial water gradients in versicolored tidal flat sediments of the North Sea

S. Sachsenberg, T. Klenke and W. E. Krumbein

Institut für Chemie und Biologie des Meeres (ICBM) an der Universität Oldenburg
Postfach 2503, D-2900 Oldenburg, Germany

Abstract

In the Wadden Sea certain microbial mats occur in the sandy versicolored tidal flat sediments (e.g., SW' Mellum Island). Gradients of Fe, Cd, Cu and Pb in interstitial water indicate a succession of different bioinduced physicochemical environments from the surface to the buried mats, which causes a transfer of heavy metal species amongst different host minerals and carriers downcore.

Introduction

In distinct supra/intertidal regions of the Wadden Sea, certain microbial mats exist in the sandy versicolored tidal flat sediments (Farbstreifen-Sandwatt) (GERDES et al. 1985). Microbial mats influence the fixation and remobilization of metals in the sediment column (DYER et al. 1989). This influence results in gradients of metal concentrations in interstitial water, which reflect the microbiological processes (GAUDETTE and LYONS 1984, LYONS et al. 1988). Focusing here on the sandy versicolored tidal flat sediments (Farbstreifen-Sandwatt) the question arises as to the possible influence of microbiological activity on metal geochemistry. Gradients of different heavy metals (iron, cadmium, lead, and copper) in interstitial water were obtained from versicolored, sandy and muddy tidal flat sediments.

Material and methods

Vertical profiles were taken from the lower supratidal of the Island of Mellum (versicolored and sand flat) and the Jade Bay (mud flat) (Wadden Sea, German Bight, North Sea) (Fig. 1). Microbiological and sedimentological framework studies have been carried out in detail by STAL et al. (1984) and GERDES et al. (1985).

Generally, tidal flat sediments have an oxic layer at the sediment surface. Below this layer, anoxic conditions prevail. This demands specific requirements at the pre-analytical sampling and preparation stages. A specially developed inert-gas-shallow-corer was used for simultaneous interstitial water and sediment sampling. Sub-sampling was carried out in the field. In the laboratory the interstitial water was separated gravitatively.

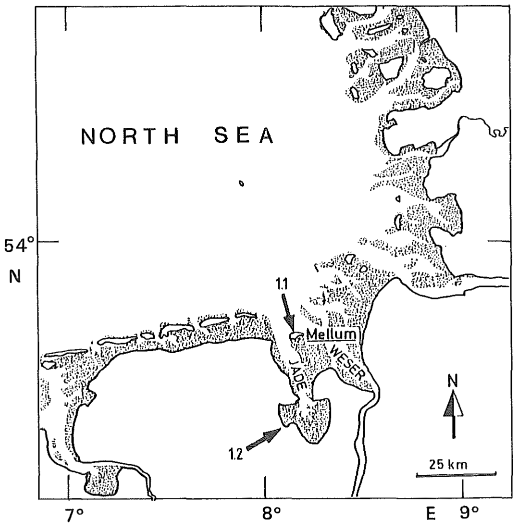

Fig. 1. Regional setting and sampling areas (Mellum Island 1.1; Jade Bay 1.2).

Since high salinity matrices, like interstitial water, cause severe interference to GF-AAS-analysis, a thiocarbamate extraction/back-extraction of the metals was necessary prior GF-AAS-determination.

Results and discussion

The interstitial water chemistry of iron, cadmium, lead and copper shows a marked difference in both the individual concentration range and the obtained gradients downcore. The highest concentration range in interstitial water can be observed for iron (mg/l level) (Fig. 2). The maximum concentrations appeared at the sediment surface layer (0-50 mm) with 2-3 mg/l. Since seawater concentration of iron is much lower (2-50 µg/l) the high interstitial water concentrations may result from the bio-liberation of iron containing organic detritus. The deeper sediment layers are influenced by different heterotrophic microbial communities inducing a precipitation of iron-monosulfides, or trapping by siderohores and other mechanisms of the microbial mat compounds, resulting in much lower iron interstitial water concentrations.

The lead and cadmium interstitial water concentrations are in the µg/l range. This is only a factor of 10 to 20 higher than in seawater during high tides (Fig. 3, 4). Both elements show a high variability of interstitial water concentrations as a function of depth as well as the sediment types.

The chemistry of copper in interstitial water is of special interest, because it is well known that microorganisms prefer to accumulate this element. The copper gradient in the versicolored sediments shows a significantly lower concentration compared to other sediment types (Fig. 5). The concentrations in interstitial water of the versicolored tidal flat sediments shifted downcore to slightly higher concentrations.

Our results indicate that the high variability of concentrations in interstitial water are limited by a succession of different bio-induced physico chemical en-

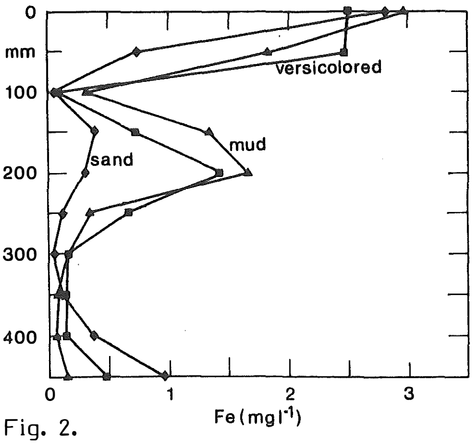

Fig. 2.

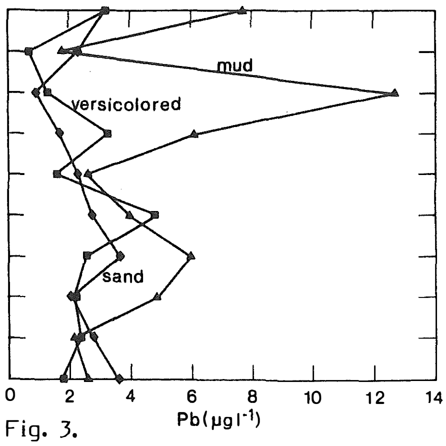

Fig. 3.

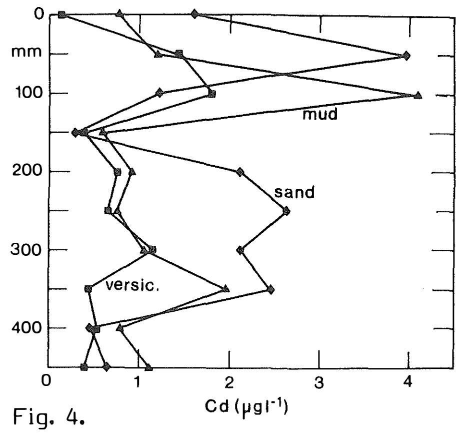

Fig. 4.

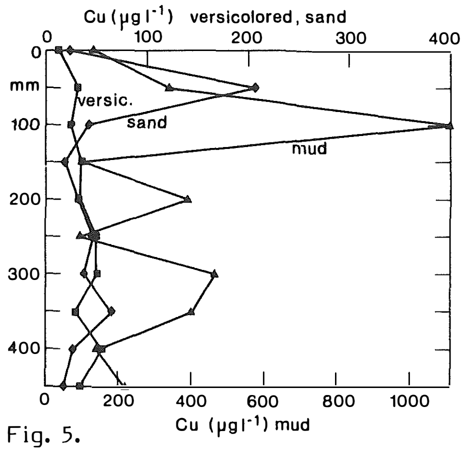

Fig. 5.

Fig. 2. Gradients of iron in interstitial water from different sediment types.
Fig. 3. Gradients of lead in interstitial water from different sediment types.
Fig. 4. Gradients of cadmium in interstitial water from different sediment types.
Fig. 5. Gradients of copper in interstitial water from different sediment types.

vironments from the surface to the deeper layers, which causes a transfer of metals amongst different host minerals and microbiologically influenced domaines and carriers downcore. For example, the relatively low copper concentrations in the interstitial water near the top of the profile give evidence that this element is selectively stripped from the aqueous phase and trapped by the cyanobacteria dominated microbial mat at the surface. This correlates with the known potential of cyanobacteria in terms of the sorption and enrichment of certain metals. However, in comparison to similar types of tidal sediments, no significant bulk enrichment of heavy metals can be observed in the sediment column. Identifiable enrichments are restricted to the microbial mat layers only.

Acknowledgements

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