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The effect of bedforms (crest and trough systems) on sediment erodibility on a back-barrier tidal flat of the East Frisian Wadden Sea, Germany

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Abstract

The erosion potential over bedforms in a tidal flat of the East Frisian Wadden Sea was studied by conducting erosion and physical and biological sediment property measurements on the crests and troughs of bedforms. Five stations along a cross-shore transect of 1.5 km length from immediately below the salt marsh to the mid tide-level of the tidal flat were visited during two field campaigns in June and September 2002. Measurements of sediment erodibility were made on both crests and troughs using an EROMES erosion device and quantified in terms of critical erosion shear stress and erosion rate. Surface sediment scrape samples (upper 1 mm layer) were taken from crests and troughs to determine various physical and biological properties of the sediment. The results show that crests are generally more stable (i.e. higher critical erosion shear stresses and lower erosion rates) than troughs. In general, crests contained more chlorophyll *a*, colloidal carbohydrate, and EPS (extracellular polymeric substance) than troughs. Median grain-size, water content and wet bulk density of the crests showed no statistically significant difference from those of the troughs with the exception at the most landward station immediately below the salt marsh margin, where crests had significantly lower water content and higher wet bulk density than troughs.

Two different processes were identified for the difference in erodibility between crests and troughs: (1) At stations with emersion times less than 6 h, the higher benthic diatom biomass (measured as chlorophyll *a* concentration) on the crests increases the amount of EPS, which is likely to stabilize the sediment surface of these features; (2) in a saltmarsh transition area (most landward station), physical processes such as surface drying and compaction seem to enhance in a synergistic way the sediment stability on the crests.

Keywords: tidal flat; erodibility; erosion rate; bedforms; microphytobenthos; biostabilisation; Wadden Sea; Germany

1. Introduction

Bedforms of various sizes occur in most coastal sedimentary systems (Dyer, 1986). These can be broadly classified as (a) channels, creeks, and gullies; (b) ridge-runnel system; (c) ripples and other micro-topography; (d) cliffs (Dyer, 1998). Structure and size of intertidal bedforms have a significant impact on the overall flow in an estuary by increasing the bottom roughness length (Ke et al., 1994). Crests and troughs max redirect flows and wave propagation at very shallow water depths (Whitehouse et al., 2000), cause localised near-bed concentrations of sediment (Roberts et al., 2000) and control the drainage export of sediments from the flats (Bassoullet et al., 2000; Le Hir et al., 2000).

For granular, non-cohesive bed materials, bedform generation, shape and size is generally understood as resulting from instability of bed-flow interaction, which may start from a plane seabed and horizontally uniform flow exceeding the threshold for sediment transport (Dronkers, 2005). Fine cohesive sediments, which prevail on intertidal flats, on the other

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