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Biological mediation of sediment erosion: Can we account for tidal effects?

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Coastal dynamics have traditionally been seen as the field where physical and chemical processes dominated. Even when biological processes have been recognised in tidal flat landscape, focus has been almost entirely on vegetation (e.g., salt marshes, mangroves) or sometimes, on microbenthos (e.g., crabs, corophiums). However, microbial communities living on top of, and within coastal sediments can significantly modify the physical and chemical properties of the sediments. Biofilms, consisting of microorganisms and their secreted extracellular polymeric substances (EPSs), are commonly observed in intertidal zones. Bio-sedimentary matrix in intertidal zones exhibit more complex characteristics than abiotic systems, sensitively responding to different sedimentary environments, particularly the hydrodynamic conditions. Changes in shear stress due to tidal effects may lead to repeated cycles of biofilm erosion, and regrowth, very different from the steady-state conditions examined in the laboratory. To recreate more natural conditions, cycles of incubation and erosion were conducted in the laboratory. Comparisons were then made between the one-cycle of growth-erosion experiments and repeated-cycles aimed at understanding the effects of spring-neap tidal modulation. Diatom biofilms were incubated on a non-cohesive sediment bed under low shear (0.06 Pa). After 5-days of incubation (without nutrient limitation), the bed was eroded using a stepwise increment of shear force, and then allowed to re-develop for 5 days before being eroded again. This was then followed by experimental runs of three repeated cycles (5 days of growth and bed erosion). For the one-cycle scenario, bio-destabilisation occurred at the first stage (5 days)that the bed was more easily eroded than the clean sediment. Biostabilisation occurred only when a relative long growth period was provided. However, surprising results came to the repeated-cycles of frequent disturbance (i.e. only 5-days of incubation followed by erosion). The cyclic disturbance did not degrade the system stability but favoured biostabilisation and increased the homogeneity of bio-sedimentary beds. This indicated while bio-sedimentary matrix was disrupted during repeated disturbance events and effects were cumulative, EPS contributed to the rapid increase of bed stability in recovering beds during the next calm cycles. A conceptual framework is hence put forward to highlight the dynamic variation regularities of bio-sediment under the influences of repeated-cycles. The influence of tidal effects on bio-sedimentary bed stability under field conditions will be the subject of further research.