Biostabilisation – consequences for sediment stability and floc entrainment & transport

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Introduction: There is now a consensus that the natural biota often provides the important ecosystem function of "biostabilisation" for many depositional habitats. For example, microalgae - mainly diatoms - stabilise natural sediments through the secretion of extracellular polymeric substances (EPS). Recent work has shown the influence of polymeric substances in floc formation and in determining floc characteristics, such as size and shape. The improved understanding of the functional capacity of the biota is necessary to improve models of sediment dynamics and optimize coastal management strategies.
Despite the increasing numbers of papers in recent years, there are still significant gaps in the fundamental understanding of the role living organisms play in biostabilisation. Whilst microalgae are recognised as ecosystem engineers, the effects of another significant part of the benthic assemblage, the heterotrophic bacteria, have been largely overlooked. Bacteria are regarded as decomposers of the natural sediment organic matrix, yet they also secrete copious amounts of EPS that contributes to biostabilization. Hence, the present paper investigates the stabilisation potential of a natural benthic bacterial assemblage in comparison with an axenic diatom assemblage. Additionally co-existing bacteria and microalgae were observed for synergistic or antagonistic responses affecting sediment stability. Furthermore, the influence of the different microbial assemblages on floc characteristics is assessed.

Methods: Sediment stability and adhesion was analysed by CSM (Cohesive Strength Meter) and by MagPI (Magnetic Particle Induction). Various substrates were eroded by the Gust Chamber/Microcosms and the resuspended flocs investigated for size, floc strength and settling velocity. EPS was extracted and quantified as colloidal carbohydrates and proteins [mg g^{-1} sediment]. The biomass and assemblages of microalgae and bacteria were determined by flow cytometry, microscopy and in situ fluorescence hybridization (FISH).

Results: The bacteria + diatom assemblage showed the highest sediment stabilisation and adhesion (x 9.0 by CSM, x 7.5 by MagPI) followed by pure bacterial assemblages (x 8.2 and 5.9, respectively) and axenic diatom cultures (x 6.4 and 5.2, respectively). Substratum adhesion and stability correlated positively with higher bacterial / diatom biomass and EPS concentrations. The flocs originating from diatom cultures were the biggest and thus reached the highest sinking velocity in an undisturbed water column, followed by flocs from the mixed assemblages and pure bacterial cultures. Floc strength was highest in pure bacterial flocs while diatom flocs were rather fragile.

Discussion: Synergistic stabilisation effect of the mixed assemblage (bacteria + diatom) could be due to nutrient re-cycling, but also due to species-specific interactions. The results on the floc characteristics indicate distinct differences in size, shape, strength and settling velocity due to the biological origin (bacteria or microalgae or mixed). The data suggest that the interaction of proteins and carbohydrates provide the binding force within the EPS matrix to influence substratum stabilisation and floc characteristics.

Conclusions: The current study data showed that bacterial assemblages cannot be neglected when considering microbial sediment stabilization and floc characteristics. The interactions within natural microbial assemblages have been positive for EPS secretion and subsequent binding forces in the present study; but depending on population structure and possible shifts within, the bio-engineering potential might vary significantly. This will have severe consequences to suspended sediment transport and –deposition. Thus we need to enhance our understanding on the ecosystem function biostabilisation and the effects of expected forcing due to climate change.