Microbial biostabilization – an important ecosystem service at microscale

Sabine U. Gerbersdorf[1], Moritz Thom[1], Holger Schmidt[1], Silke Wieprecht[1]

[1]Institute for Modelling Hydraulic and Environmental Systems, University Stuttgart, Pfaffenwaldring 61, 70569 Stuttgart, Germany

Phone: +49-(0)-711-685-64739
E-mail: sabine.gerbersdorf@iws.uni-stuttgart.de

Introduction: Sediments and the associated microbial communities (biofilms) feature to a great extend the essential functionality of marine and freshwater habitats and provide important "ecosystem services" such as nutrient (re)-cycling or self-purification. This paper addresses the ecosystem function "biostabilisation" where the microorganisms modify the response of the aquatic sediments to erosive forces (flow velocity, turbulence) by the secretion of extracellular polymeric substances (EPS). That way, biostabilisation of fine sediments helps to contain the formerly deposited and buried old pollutants. However, this functionality is threatened by the increasing load of anthropogenic micropollutants or trace compounds (ATCs). ATCs originate from our modern life style and are often designed to act antimicrobial thus leading to microbial death and finally, biofilm dissolution with consequences for sediment erosion. This paper addresses the newest findings in biostabilisation research in lotic waters that, in the long-term, should be implemented in sediment transport models to enhance their prediction power further.

Methods: Natural biofilm were grown in novel flumes (DFG project GZ GE 1932/1) on glass beads (resembling fine sdiments) under controlled conditions of light, temperature and turbulence. During the experimental time, biostabilization was closely monitored measuring biofilm adhesion and sediment stability by MagPI (Magnetic Particle Induction) and the SETEG flume, respectively. In the end, the sediments with biofilm were eroded by the Gust Chamber/Microcosms and the resuspended flocs investigated for their floc characteristics and settling velocities. In parallel, biofilm parameters such as extracellular polymeric substances (EPS), microalgal biomass, bacterial cell numbers and microbial community (both eukaryotic and prokaryotic) were determined.

Results: Firstly, an intra- and interflume comparison of the microbial and functional parameters revealed the suitability of the newly designed flumes for biofilm experiments. Secondly, biostabilisation has been proven highly significant in lotic waters (increase of up to 50 in adhesive capacity). Thirdly, biostabilisation differed largely between seasons and was highest in spring and early summer. Presumably, this is explained by the differences in biofilm architecture resulting in mechanically diverse responses to the critical bed shear stress. There is evidence that these differences in the biofilm matrix are related to varying species composition in the natural microbial community.
Fourthly, the abiotic parameters light and hydrodynamic were highly influential in biofilm adhesion and growth. Thereby, medium to highest light intensities and lowest to medium flow velocities resulted in highest biostabilization. Topography measurements visualized the close interaction of the biofilm with the flow field to shape its environment and possibly, maximize biostabilization.
Fifthly, the results on the floc characteristics indicate distinct differences in size, shape, strength and settling velocity due to the history of the sediment.

Discussion: Biofilm cultivation at controlled boundary conditions demonstrated the importance of biostabilization (known to be substantial in marine areas) within lotic habitats for the erosion and transport as well as deposition of fine sediments. Apparently, the mutual interactions between environmental parameters and the composition of the microbial community play a decisive role for biofilm architecture to impact its functionality and thus, inter alia, the ETDC (erosion, transport, deposition, consoldiaion) cycle of fine sediments.

Conclusions: The stabilizing effect of biofilms upon lotic fine sediment is currently unaddressed despite its broad range of economic and ecological implications. Our results underpin the need to better recognize biofilm as ecosystem engineers and to value biostabilisation as one important ecosystem service of biofilms. While we only begin to understand the phenomenon biostabilisation, we have no idea how biofilm will behave under the increasing anthropogenic forcing. Yet, the current and the future influence of biostabilisation cannot be neglected in morphological modeling any longer.