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Biostabilization of fine sediments in reservoirs – a manipulative experiment to address the hydraulic impact

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Background and Methods

Reservoirs, in particular those providing access to clean water and green energy, will become more important in the near future due to demographic and climate changes. Profound knowledge on the erosion, transport, deposition and consolidation cycle (ETDC cycle, Fig. 1) of fine sediments will greatly assist in exploiting, tackling and minimising the effects of ongoing siltation within reservoirs.

Recent studies confirmed the importance of organic compounds and in particular of the microbially-produced mucilaginous matrix of extracellular polymeric substances (EPSs) in changing the erosional response to hydraulic forcing within cohesive and mixed intertidal as well as riverine sediments (Gerbersdorf and Wieprecht 2015). Nevertheless **microbial biostabilisation** is hardly addressed within reservoirs.

This paper concerns the first manipulative experiment to show the biostabilisation potential of microbial communities within reservoirs under varying hydrodynamic conditions. Natural biofilms were grown in novel flumes under controlled conditions. The adhesive capacity (as determined by **Magnetic Particle Induction**, Fig. 2) is a measure of the biostabilisation capacity and the results have been related to **EPS quantities** as well as **microbial biomass** (bacteria and microalgae).

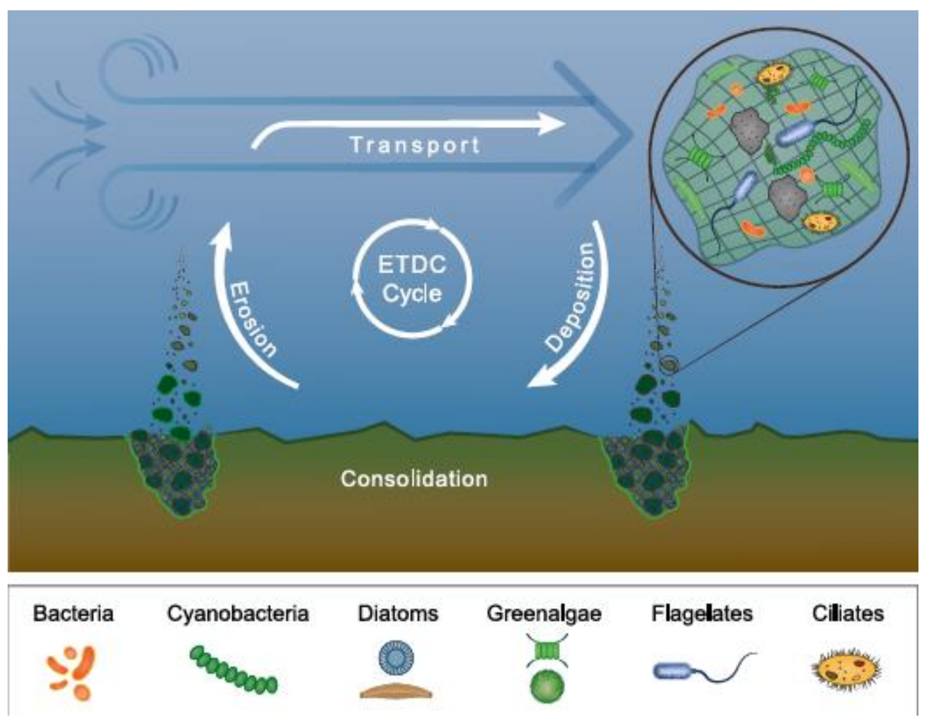


Fig. 1: The influence of biostabilization on the ETDC cycle of fine sediments (source: Gerbersdorf and Wieprecht 2015, Geobiology, Review Article)

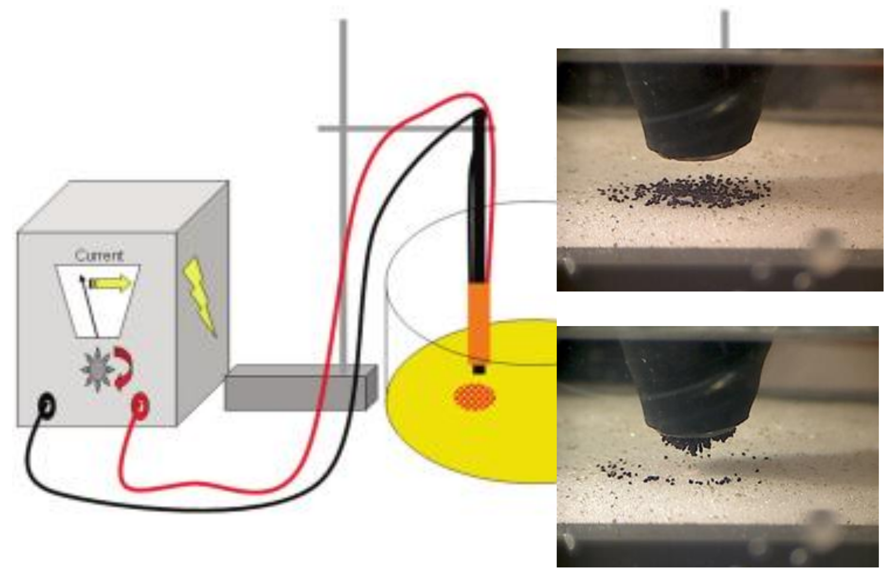


Fig. 2: The original MagPI system: the electromagnet (left) positioned above the biofilm surface attracts ferromagnetic particles. The force needed to retrieve those particles is a direct measure of adhesion (source: Larson et al. 2009, LO Methods).

First Results and Discussion

I. Biofilm Adhesiveness

Biofilms were all grown under moderate low flow conditions (0.51 ± 0.06 L sec^{-1}) for 41 days. Afterwards, weak and strong cartridges were equally distributed over all six flumes. For the next phase of 28 days, three flumes maintained low flow conditions while the other three flumes were exposed to a high discharge rate (2.25 ± 0.04 L sec^{-1}).

Under constant low flow conditions, all biofilms showed an ongoing moderate growth and increase in biostabilisation (Fig. 3). Exposed to high discharge, a significantly enhanced growth rate as well as adhesive capacity could be determined in the formerly weak cartridges. In contrast, the strong cartridges were almost immediately sloughed-off by the increased flow – which resulted in an alloverall net decrease in biostabilisation over the following 28 days.

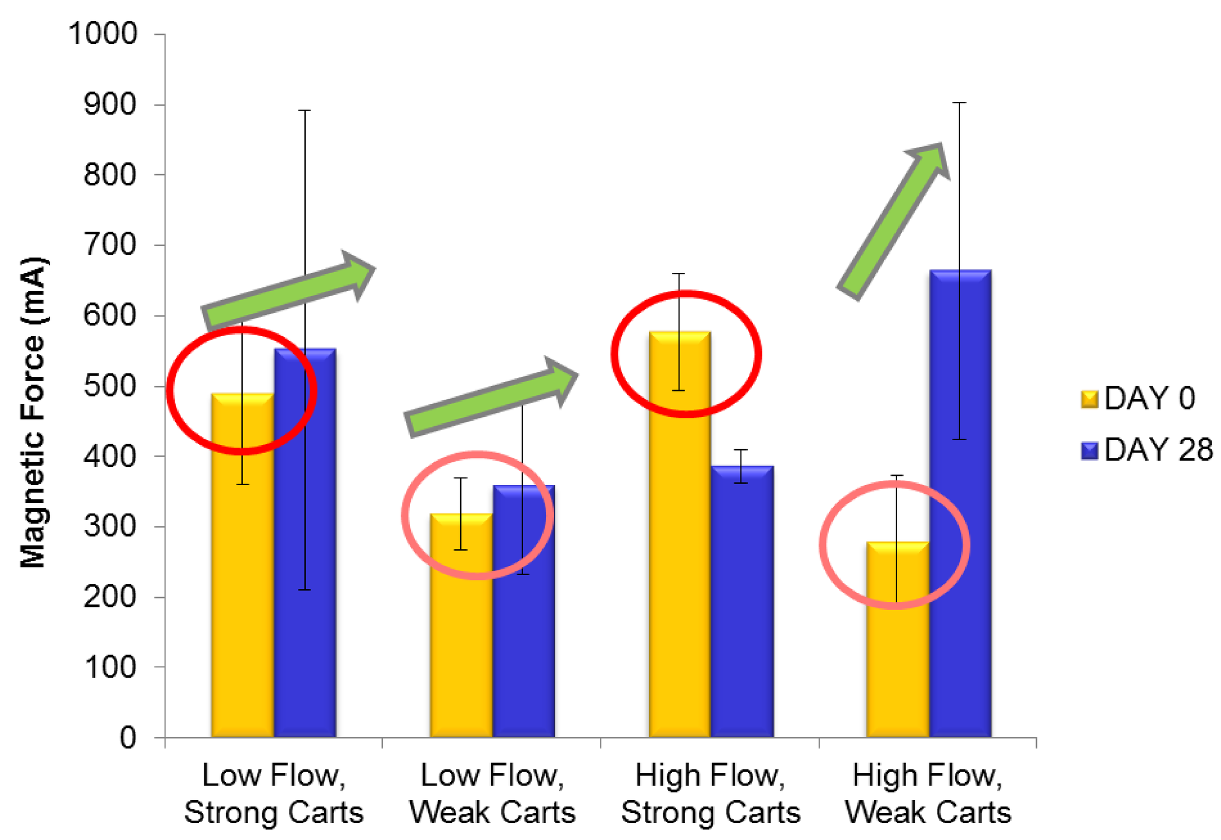


Fig. 3: The magnetic force is a direct measure of biofilm adhesiveness and thus, biostabilisation capacity (left axis). Shown is the development of biostabilisation for weak and strong cartridges under ongoing low flow and higher flow conditions.

II. EPSs dynamics and microalgae

The EPS analysis confirmed the sloughing-off event in the strong cartridges under high discharge – with a significant decrease and later increase in sugar and protein moieties (Fig. 4). In the other cartridges, the EPS quantities increased along with biofilm adhesiveness to explain very well biofilm stability.

The microalgae were largely dominated by typical pioneer diatoms: the mobile *Eolimna minima* which can quickly recolonize new habitats after physical disturbence and the sessile *Achnanthidium minutissimum* that contributes to stabilisation by forming EPS stalks attached to the sediment grains (Fig. 5).

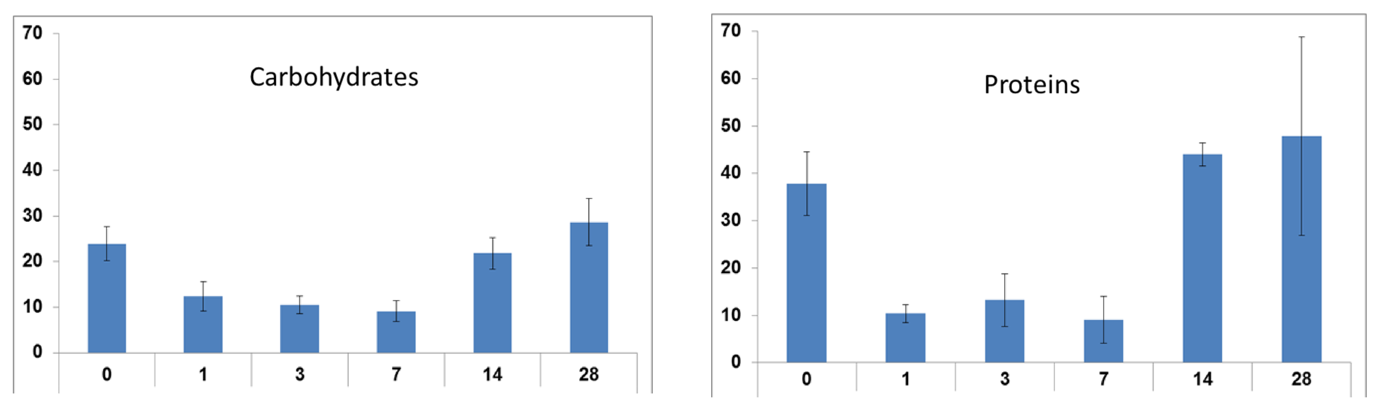


Fig. 4: Development of EPS quantities over the period of 28 days in the strong cartridges exposed to high flow conditions.

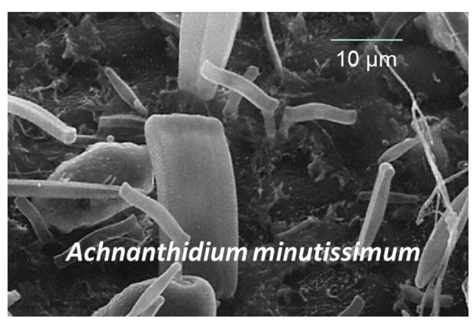
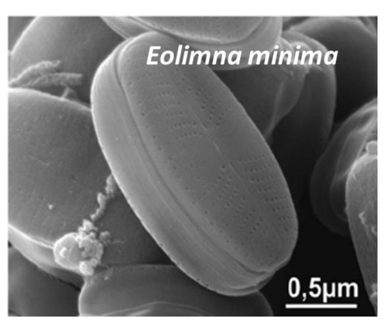


Fig. 5: Dominating diatoms in the biofilm



References:

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Conclusions

The stabilizing effect of biofilms upon lotic fine sediment is currently unaddressed in reservoirs despite its broad range of economic and ecological implications. Reservoir managing (ranging from daily basis up to extreme events such as flushing) should take the biostabilisation potential into account to maximize their efforts in decreasing siltation or optimizing the removal of sediments.

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