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Spatial and temporal variability of the biological activity of tidal Elbe sediments in the Port of Hamburg

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Introduction: The microbial turnover of organic matter in surface waters is suspected to affect the processes of flocculation, sedimentation and consolidation, leading to the formation of layers of different rheological properties in the transition zone between the water phase and the genuine river bed. Under anaerobic conditions, degradation of organic matter leads to gas formation, obstructing sonic depth finding, impeding sedimentation and delaying consolidation. Gas generation reduces sediment density, viscosity and shear strength, thereby impacting detection and maintenance of the navigable depth. In a vertical cut, four layers can be distinguished between the upper (water) and the lower (riverbed) boundary: suspended particulate matter (SPM), fluid mud (FM), pre-consolidated sediment (PS) and consolidated sediment (CS). The project BIOMUD investigates the role of the physicochemical properties of the organic and mineral phases in these layers for organic matter degradability and its influence on the rheological properties. Hereby, fundamental questions are directly linked to applied dredging practice as carried out in all major ports worldwide.

First results on the spatial and temporal variability of biogeochemical properties of sediments from nine locations in the area of the Port of Hamburg, sampled in five campaigns in 2018, are presented.

Methods: SPM, FM, PS and CS layers were analyzed for biological, physical and chemical properties, including aerobic (respiration) and anaerobic (flow analysis, pressure gradient) organic matter turnover rates.

Results: Anaerobic organic matter degradation (gas generation), normalized to the organic carbon content, varies with depth (Fig. 1) as well as within the greater harbor area (Fig. 2). Gas generation decreases with depth, with the exception of SPM material (Fig. 1). In a depth profile, usually only SPM material was well oxidized, while FM, PS and CS layers showed negative redox potentials. On the greater spatial scale, TOC-normalized gas generation decreased from the east (river-km 615) to the west of the harbor (river-km 645) (Fig. 2).

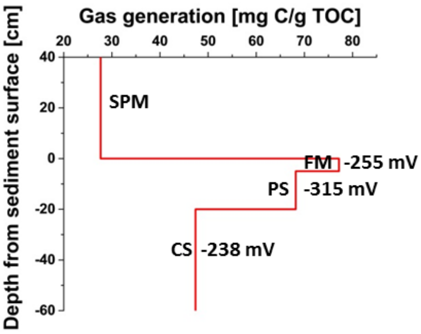

Fig. 1: Depth-related cumulative gas generation after 21 days at one sampling site.

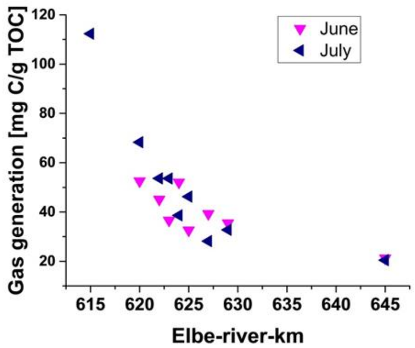

Fig. 2: Cumulative gas generation for pre-consolidated sediments, measured over 21 days.

Discussion and outlook: Higher gas production per unit TOC reflects the presence of more easily degradable organic matter, which at individual locations appears to decrease with increasing depth (Fig. 1) and to follow a gradient with higher rates upstream and lower rates downstream (Fig. 2). Gas production in the SPM layer is assumed to be lower due to its initial oxidized state.

Ongoing investigations address respiratory activity, density fractionation (see Gebert et al., this issue) and isotopic analyses of organic material, microbial slime (EPS) and DNA analyses of microorganisms.

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