(Re-) Evaluating the Role of Microbes for Fluid Mud Rheology and Settling

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Introduction: Organic matter interacts with charged mineral surfaces and thereby influences sediment properties relevant for port navigability, such as rheological characteristics [1], [2], and settling and consolidation behavior [3], [4]. Microbially produced extracellular polymeric substances (EPS) have been thought to enhance suspension and thereby the desired low yield stresses of fluid mud (FM) [5]. This study investigates the relationship between concentration and composition of EPS, particle size distribution, mineralogy, settling rates and yield stresses in fluid mud from the ports of Emden and Hamburg.

Methods: Concentration and composition of EPS, microbial biomass, rheological parameters, settling rates, microbial community composition and standard solids properties were measured over several years in Port of Hamburg and over one year in Seaport Emden. Single analyses of clay mineralogical composition were carried out on samples from both ports.

Results: The fine-grained fraction (< 63 µm) in FM exceeded 90% in both ports. The microbial community at both sites was highly diverse and total EPS concentration significantly lower in the saline inner harbor of Seaport Emden than in the freshwater Port of Hamburg (Fig. 1, left). Here, FM at downstream site KH with the lowest ratio of biomass to clay (Fig. 1, right) featured hindered settling behaviour. Yield stress increased exponentially with density (Fig. 2, left), with a similar relationship for the two Emden locations and a more scattered one for the Port of Hamburg, in relation varying organic matter content [6]. Settling rates were inversely related to density, as shown by Emden data (Fig. 2, right).

Discussion: The favourable properties of fluid mud in Seaport Emden appear to result from the low density achieved by recirculation dredging and not by particularly high concentrations of EPS, which are also subject to strong seasonal variation. Comparative results from different sites within the Port of Hamburg show that a low ratio of biomass to clay experience promotes hindered settling, likely due to a lesser extent of floc formation. These results support the relevance of fresh, biomass-derived organic matter for particle-particle interactions [7], flocculation and settling behavior, but shed doubt on the assumption that EPS contribute to keeping FM in suspension. The latter appears to be accomplished by the density window generated from recirculation dredging, with densities that are low enough to enable low yield d stresses but high enough to allow for low settling rates.

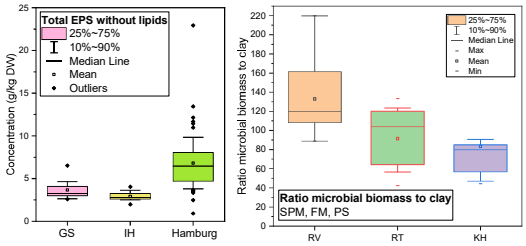

Fig. 1: Left: EPS in Seaport Emden (sites GS and IH) and in Port of Hamburg. Right: Ratio of microbial biomass to clay at three sites in Port of Hamburg.

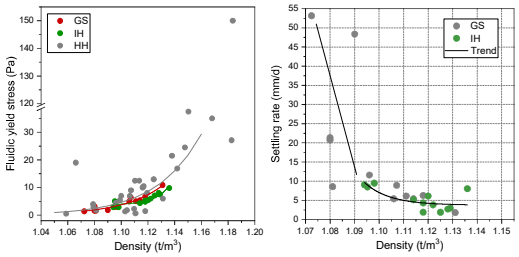

Fig. 2: Relationship between density and fluidic yield stress in fluid mud from Emden and Hamburg (left) and settling rate (Emden, right).

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