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Impacts of Sterilization and Organic Matter Removal on the Rheology and Settling Behavior of Fluid Mud

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Introduction: Mud is a fine-grained cohesive material which contains mineral particles (predominantly clay and silt), organic (and inorganic) matter, and water. Understanding mud's rheological and settling behaviour is critical for sustainable sediment management in ports [1, 2]. A systematic analysis of the effect of clay minerology on the rheological and settling behaviour of mud has been conducted previously [3, 4]. In contrast, literature on the impact of organic matter on physical properties of sediment is scarce. Our previous work [5] demonstrated the impact of microbial inactivation via gamma radiation, revealing a significant increase in settling rates. Current research incorporates chemical sterilization (NaN_3) and organic matter removal (NaOCl), to systematically differentiate between effects of microbial activity and effects of organic matter on the physical properties of fluid mud (FM).

Methods: FM samples from the Port of Emden (Germany) were sterilized to inactivate microbial activity and chemical treated to remove organic matter. Each experiment was conducted in duplicate to ensure reproducibility. Microbial inactivation was achieved through several sterilization techniques:
1. A 500 ml FM sample was irradiated with 10 kGy Co-60 gamma for 24 hours. This dosage inactivates microbial life while preserving the physical structure of the sediment [6].
2. Sodium azide (NaN_3) was applied (1 mg per 1 g of dried sediment) to inhibit microbial activity (chemical Sterilization, [7]). A respiration test using gas chromatography was conducted at the beginning of the experiment and repeated after three weeks to confirm the sustained inactivation of microbial life.
Organic matter removal will be conducted using sodium hypochlorite (NaOCl), with TOC measurements confirming the effectiveness of carbon removal. For NaOCl treatment, samples will be exposed to a 1 M solution with a sediment-to-solution ratio of 1:50 (w/v), followed by centrifugation and washing to remove salts before restoring the original water content.
Reference samples were maintained without any treatment to allow comparison with treated samples. The physical properties of the FM e.g., density, yield stress, and settling behavior were measured after treatments.

Results: Microbial inactivation using NaN_3 treatment and gamma radiation did not alter the density or yield stress of FM significantly (Fig. 1). However, the settling behavior was significantly affected, with a 3.25 and 2.5 times increase in the initial settling rate (within the first 20 hours) observed in irradiated and NaN_3-treated samples compared to the reference sample (Fig. 2). While both treatments increased settling rates during the linear phase, NaN_3 treatment demonstrated a slightly slower initial (17%) settling behaviour compared to gamma radiation. After 20 hours, treated and reference samples settled similarly, although treated samples reached lower final height.

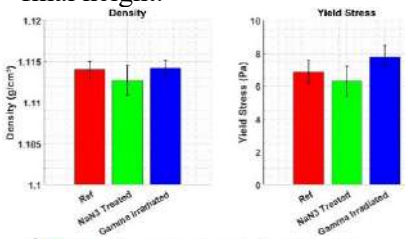

Fig. 1: *a) Density and yield stress for reference, NaN_3-treated, and gamma-treated samples (error bars: variation in duplicates)*

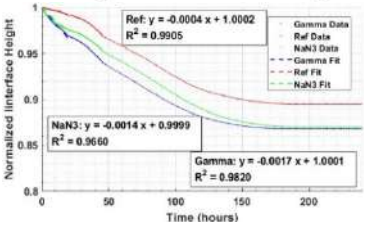

Fig. 2: *Settling rate for reference, NaN_3-treated, and gamma-treated samples*

Discussion: Inactivating microbial life in FM increased settling rates, presumably through the removal of buoyancy effects from microbial byproducts like CH_4 and CO_2 bubbles. These findings highlight the role of active microbiota for physical properties and hence the navigability of fluid mud in ports and waterways.

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