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Influence of pre-existing bed on diluted turbidity current propagation

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Introduction: Turbidity currents are a subclass of gravity currents where a particle-laden fluid flows through a relatively lighter fluid under the effect of gravity. The particles in this case are mostly suspended by the turbulence created due to the forward motion of the current along the boundary of the domain [1]. Turbidity currents are an inevitable part of any dredging or deep-sea mining activity. They have a potential impact on the local ecosystem [2]. They have the tendency to propagate further from the area of operation before settling down.
This study examines the behavior of turbidity currents which are quite dilute in nature, as they flow over different bed types both pre-existing and freshly deposited ones. The pre-existing bed here refers to the ocean, river or channel bed while the freshly deposited bed consists of a layer of materials deposited from previous run, which has loose materials on its surface.

Methods: Experiments were carried out in a lock - exchange flume of 3m*0.4m*0.2m dimension (see Fig 1). A bed of 5mm was laid on the flume bottom using quartz flour. All the experiments were run on top of this bed which was renewed after every run. The experiments were conducted using illite clay and sediments from the Clarion Clipperton Zone (CCZ) in the Pacific ocean. Additionally, a synthetic organic matter (polyacrylamide flocculant Zetag 4120) was also used to form flocs with illite clay as it does not form flocs on its own.

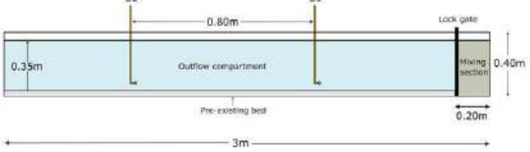

Fig. 1: Lock exchange flume with pre-existing bed.

An Ultrasonic Velocity Profiler (Met-Flow) and a Go Pro camera were used to measure particle velocity and record the front velocity of the turbidity currents, respectively. Two siphons were installed to collect samples from the body of the turbidity current to analyze flocs. The samples were analyzed using FlocCAM and Malvern Mastersizer 3000.

Results: The effect of a pre-existing bed on the turbidity current propagation was evident from the video analysis. The bed with a layer of illite clay on top of it reduced the front propagation velocity of turbidity current compared to both the no-bed condition and quartz bed (see Fig 2). Beds with traces of Zetag alone or a combination of illite and Zetag further reduced the front velocity of the propagating turbidity currents, thus highlighting the influence of organic matter. Additionally, floc analysis also proved that larger flocs were formed in presence of a bed.

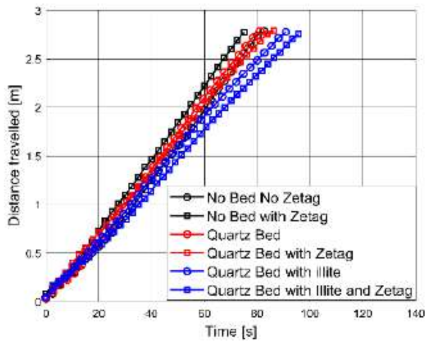

Fig. 2: Front position of Turbidity current under different bed conditions for 5g/L sediment concentration

Discussion: The results highlight the relationship between turbidity current velocity under varying bed conditions while taking flocculation into account. In case of CCZ sediment cases, the presence of a bed reduced the propagation speed significantly especially in cases of lower sediment concentrations. These findings emphasize the importance of bed roughness imparted by the freshly deposited sediments to the turbidity currents, thus reducing their velocities.

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