EXPERIMENTAL STUDY ON THE IMPACT OF VEGETETATION FLEXIBILITY ON SUSPENDED SEDIMENT CONCENTRATION UNDER OSCILLATORY FLOW

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INTRODUCTION

Nature-based solutions are being increasingly considered as a favorable option to mitigate the impacts of extreme weather events due to climate change (IPPC 2021, Narayan et al., 2016; Sutton-Grier et al., 2015). Coastal vegetation has been proven to attenuate waves (Moller et al., 2014), acting as a buffer zone for coastal communities. Whilst wave-vegetation hydrodynamic interactions are widely researched, the impact of coastal vegetation on sediment transport remains ambiguous. Previous studies have shown that combining different vegetation characteristics can significantly impact the suspended sediment transport rate (Tinoco & Coco, 2014, 2018). Studies predominately focus on rigid vegetation, and often, plant flexibility is discounted. Here, we take the initial steps to understand the differences and the impacts of rigid vs flexible vegetation under oscillatory flow. We implement a novel experimental approach, utilising simultaneous hydrodynamic and suspended sediment concentration (SSC) measurements to investigate the impact of both rigid and flexible vegetation on suspended sediment transport.

METHODOLOGY

The experiments were conducted in 30.7m long, 0.8m wide and 1.2m deep wave flume of the Coastal Engineering Laboratory of Swansea University, UK. A piston-like wave maker created regular waves. The complete experimental setup can be viewed in Figure 1. Only waves not contaminated with reflected waves were considered in the study. Rigid and flexible vegetation mimics were secured to the flume bottom and covered by a 5cm layer of sediment. The sediment properties were D50=0.310 μm, D90=0.398 μm, D10=160 μm and ρs=2.64 g/cm3. These values fall inside the ranges found in nature. The two plant mimics differed in flexural rigidity. Rigid mimics were wooden rods, and flexible mimics were silicone sealant rods. Both vegetation mimics were cylinders with a stem height (hv) of 0.3m and stem diameter (bv) of 5 mm. The vegetation patch was 4.1 m long, including a 10cm PIV window. The vegetation mimics can be viewed in Figure 2. Three patch densities were chosen, representing sparse, intermediate and dense vegetation scenarios (Nepf, 2012) where the number of stems per meter was 27,72, and 260 respectively. Both emergent and submerged conditions are considered by using water depths of 0.3m and 0.6m. Wave heights varied between 0.06m and 0.2m and wave period between1s and 2s. These values are consistent with values found in nature, and there is no direct scaling between nature and experiments. The hydrodynamics were measured using a PIV for wave orbital velocity, and four-wave gauges were employed to measure wave height across the vegetation patch. The suspended sediment transport was recorded using an ABS, which measures a complete SSC profile over the entire water depth. A bed-profiler-traverser was employed to measure the bed morphology within the first 45cm of the vegetation patch and compare the formation of rippled and scouring between rigid and flexible vegetation.

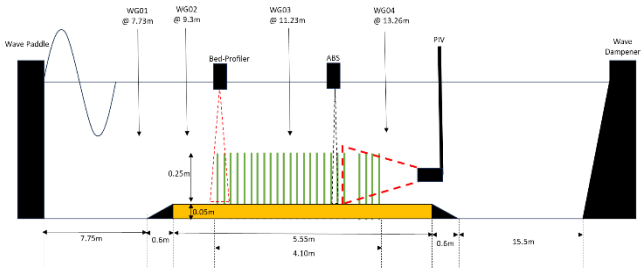

Figure 1 – Experimental Setup in the wave flume.

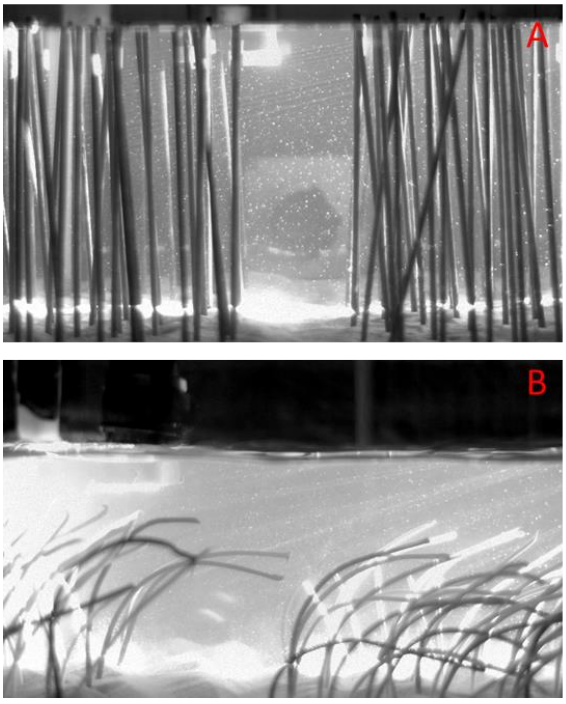

Figure 2 – Example of (A) rigid vegetation and (B) flexible vegetation under oscillatory flow.

RESULTS

We will present the impact of the vegetation flexibility on

suspended sediment concentration. We will explore the relationship between turbulent kinetic energy and sediment resuspension in rigid vegetation (Tinoco and Coco, 2018) and explore how stem movement in the case of flexible vegetation impact sediment resuspension. We will compare the impact of vegetation density on suspended sediment concentration, particularly dense cases to sparser cases representative. Finally, we will compare the impact of vegetation flexibility on scouring and bed morphology.

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