Sediment transport within submerged model canopies under oscillatory flow

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Introduction: Sediment dynamics within saltmarshes are a complex result of many factors including day/night convection, wind mixing, tides, waves, and vegetation, and their interaction induces spatial and temporal variability at both canopy and plant stem scales. A key aspect of vegetated flow on saltmarshes is the extent to which the presence of vegetation alters sediment deposition patterns, since it is via this process that saltmarshes initiate and evolve. The present study had two objectives: (1) determining the impact of canopy density on the degree of sediment resuspension driven by progressive waves; as well as on wave attenuation and the vertical distribution of turbulent kinetic energy, along with (2) determining the levels of sediment resuspension reached in diverse submerged aquatic vegetation models.

Methods: The study was conducted in a 6 m x 0.5 m x 0.5 m wave flume, with a mean depth of 0.3 m. The flume was equipped with a paddle-type wavemaker that was placed at the beginning of the flume and a plywood beach of slope 1:3 situated at the end. In order to obtain features in the laboratory similar to those in the field, 54 different situations were studied featuring three canopy models (submerged rigid, submerged flexible and real vegetation -*Ruppia maritima*-, Fig.1) with canopy height of 14 cm, low and high densities, and six oscillating frequencies of the wavemaker (f= 0.6, 0.8, 1, 1.2, 1.4 and 1.6 Hz).

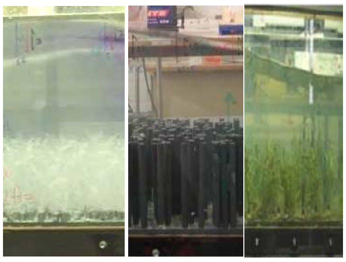

Fig. 1: Photographs of the canopy models used: flexible, rigid and real (from left to right).

Vertical velocity profiles were measured with an Acoustic Doppler Velocimeter (Sontek/YSI16-MHzMicroADV) at one longitudinal location in order to obtain the TKE values. We define ΔTKE as the difference, in percentage, between samples with and without plants. The bottom of the flume was a sediment homogeneous bed of minimum 3 mm. The suspended sediment concentration was measured by three turbidity sensors (Seapoint Turbidity Meter) and a Laser in Situ Scattering and Transmissometry probe (LISST), at the same longitudinal position where velocity was measured and at 3 points in the vertical, at 5 cm (well inside the canopy) and at 15 cm and 21 cm (above the canopy).

Results and discussion: Resuspension of sediment within the canopies relative to the unimpeded experiment were significantly correlated to the vertical wave attenuation by canopies, highlighting the importance of waves for sediment resuspension transport. The degree of vertical resuspension of sediment strongly depended on the model vegetation in such a way that within the rigid model canopy, high densities (SPF= 5, 7.5 and 10%) and high wave frequencies (f= 1.4 and 1.6 Hz) promoted sheltering within the canopy and a large decrease in sediment resuspension compared to the non-vegetated case. For frequencies • 1.2 Hz or low canopy densities of SPF = 1% turbulent kinetic was larger than the free vegetated case and sediment resuspension was larger compared to those obtained in the free vegetated case. Above the rigid canopy model, turbulence was larger compared to the unimpeded case, and increased at increasing wave frequencies. The flexible canopy model produced a reduction of turbulent kinetic energy at all densities and wave frequencies, associated with the movement of the blades that dissipated the wave energy, with the largest ΔTKE attained at the highest canopy densities. Above the flexible canopy model, ΔTKE was positive for the lowest density (SPF= 1%) and negative for the largest ones (SPF= 7.5 and 10%). The characteristics of the *Ruppia maritima* produced differential resuspension levels at varying wave frequencies.

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