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Research on the effects of vegetation on suspended sediment transport

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Keywords — suspended solids, vegetation, filtering capacity

Introduction

Suspended load is responsible for sedimentation in the lower parts of river channels, in river floodplains, as well as in river harbours and side channels. Reduction of suspended solids is often desirable, to reduce sedimentation, but also to reduce pollution, due to the tendency of heavy metals and other contaminants to bind to fine sediment particles. Ideally, filtering of suspended solids can be obtained by planting vegetation at strategic locations due to the ability of plants to enhance local sediment deposition. When water flow passes through vegetation patches, velocities and turbulence reduce because of the additional drag forces exerted by the presence of plant stems and leaves, promoting fine sediment deposition. Compared to other filtering facilities, planting vegetation is more eco-friendly, so the potential of using vegetation to filter suspended solids in river systems should be studied.



Figure 1. Natural aquatic vegetation grown at Plitvice Lakes, Croatia

The effects of plant submergence, density, spatial geometry arrangement, reconfiguration and foliation on water flow have been extensively studied experimentally and numerically (e.g. Nikora, 2010; Nepf 2012; Siniscalchi et al. 2012; Västilä, 2015). Often, rigid cylinders have been used to represent

vegetation (Vargas-Luna 2016), whereas other work has focused on the effects of plant flexibility (e.g. Caroppi et al. 2019). In natural conditions, different types of vegetation are present at the same time, with different flexibility and submerging conditions (Figure 1).

Often died leaves and stems surround the living part of vegetation (Figure 2), indicating that foliage changes with the season. This means that the plant growth cycle plays also an effect on flow resistance and turbulent transport.

Due to the complexity of the processes involved, the interaction between vegetation, sediment and water flow is far from been fully understood. Most studies analysed the effects of vegetation on bed load (e.g. Box and Västilä, 2019; Vargas-Luna, 2016), whereas suspended solids processes in vegetated flows needs further attention. Research on the filtering effect of vegetation on suspended solids is lacking.



Figure 2. Vegetation on the floodplain in Plitvice Lakes National Park, Croatia

Objectives

The main goal of this project is to quantify the filtering effects of vegetation, considering different flow conditions, plant and sediment characteristics for applications on rivers and estuaries. The study focuses on the use of reed and other types of vegetation to create natural filters.

Methods

The work will be carried out in the framework of PhD research at IHE Delft and TU Delft, the Netherlands.

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Series of flume experiments will be carried out to study the deposition of fine sediment in presence of vegetation. Different plant characteristics, sediment and flow conditions will be considered. The work will be complemented with field data, so that real conditions such as changes of season, tidal level, and water salinity can be taken into account. If needed, a mathematical model will be developed to describe suspended solid processes in presence of aquatic vegetation and numerical modelling will be carried out to test the mathematical model. Finally, more convenient ways for designing schemes applying vegetation to filter suspended solids will be explored.

Expected results

This PhD research seeks to quantify the filtering capacity of vegetation in terms of reduction of suspended solids concentration as a function of: plant characteristics and density, extension of vegetated area, flow characteristics and water characteristics such as salinity and their application to some real projects.

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