Effects of vegetation on sediment transport, experience from laboratory measurements

A. Vargas-Luna[1], W.S.J. Uijttewaal[1], A. Crosato[1,2], I.C. Tánczos[3], M. de Vries[4]

[1] Environmental Fluid Mechanics Section, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, the Netherlands. A.vargasluna@tudelft.nl, W.S.J.Uijttewaal@tudelft.nl
[2] Dep. of Water Engineering, UNESCO-IHE, Delft, the Netherlands. a.crosato@unesco-ihe.org
[3] Rijkswaterstraat, The Netherlands. ilka.tanczos@rws.nl
[4] Deltares, Delft, The Netherlands. Mindert.deVries@deltares.nl

1. Introduction

Riparian vegetation is a strong control for fluvial geomorphology that significantly affect flow and sediment transport. Vegetation causes an increase of local hydraulic roughness altering flow patterns, decreasing flow velocities and shear stresses, promoting flow deceleration and sediment retention within plants, modifying the sediment balance in channels. Much research has been dedicated to describe the relationship between flow resistance and the presence and spatial distribution of vegetation and several flow resistance estimators have been proposed. However, there is no agreement on the uncertainty of their estimations and the implications on sediment transport.

2. Previous work

After the work of Petryk and Bosmaijan (1975), several theoretical formulations for estimating the flow resistance due to vegetation have been proposed. Based on the agreement with experimental data collected from literature, Galema (2009) and Augustijn et al. (2011) have identified some of the formulas that show the best performance. Nevertheless, there is a lack of measurements of the resistance in the field and monitoring high water level conditions to extrapolate their estimations for real rivers. The effects of vegetation on suspended load and bed-load sediment transport have been studied less than hydraulic roughness. Based on experimental data, the effects of vegetation on bed-load transport sediment have been studied by Baptist (2005) and Wu and He (2009), among others. Baptist evaluated sediment entrapment and retention potential using a 1-DH morphodynamic model and Wu & He tested the agreement between bed-load transport rates modelled and measured in an experimental flume.

3. Methodology

Considering the findings of Galema (2009) and Augustijn et al. (2011), we selected the following formulas to analyse their implications for sediment transport in vegetated areas: Klopstra et al. (1997), Baptist (2005) and, Yang and Choi (2010). Based on the velocities obtained from each formula, the sediment transport rate was estimated and the results compared with the measured values in a laboratory channel (130m x 1m). The experiments were conducted in the Tidal Flume of Deltares (formerly WL | Delft Hydraulics) with artificial plants attached to a sandy bottom. Experiments were carried out separately with waves or a current. Three types of vegetation were used: two natural and one artificial (Figure 1). Current velocities ranged from 0.05 to 0.20 m s^{-1} at a water depth of 0.8 m. Regular waves were generated with a height of 0.05 m and a period of 1 s in water depth of 0.4 m. Plant length ranged between 0.10 to 0.50 m.

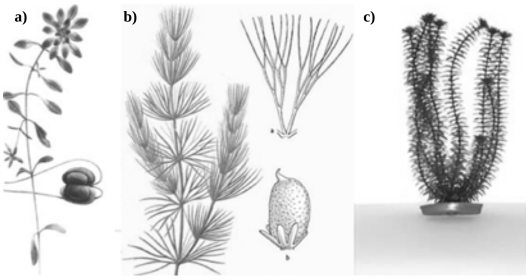

Figure 1: Vegetation types. a) Calitriche hamulata, b) Ceratophillum demersum and c) Egeria densa.

4. Results and Conclusions

A comparison between the results of the best performing models and an experimental data set is shown in Fig. 2.

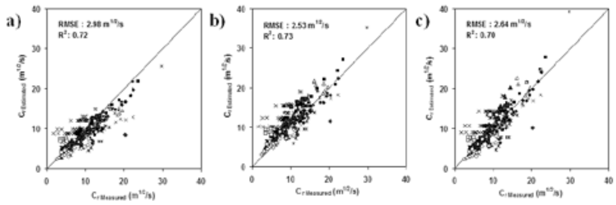

Figure 2: Comparison of modelled with measured values for representative roughness. a) Klopstra et al. (1997), b) Baptist (2005) and c) Yang and Choi (2010).

Based on the evaluation made, it can be concluded that the tested resistance formulas work similarly for small water depths, but for high water depths the sediment transport predictions have marked differences. This point is a key aspect in river management practices and flooding studies, where the high water levels prevail and floodplain vegetation play a significant role.

References

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