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Real-scale Analysis of Riparian Vegetation Deformations and Flow Resistance of Vegetated Streams

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Abstract The objective of this study is the comparative analysis of the main hydrodynamic traits of vegetated streams and riparian vegetation 3D bending through the processing of real-scale measurements retrieved during field hydraulic experiments in a vegetated water body colonized by young flexible riparian weeds. The structural measurements of riparian vegetation bending were carried out by employing a built-in system of micro load cell sensors, implemented during three years of Research program and calibrated in specific Laboratory Flume tests, and then installed directly on the weed flexible stems in the field in real vegetated water streams. The measurements were carried out continuously, aiming at correlating the riparian weed deformation to the complete 3D water flow field. The promising outcomes of this study represent a useful tool for the prediction of the effects of riparian vegetation in vegetated channels colonized by such a widespread riparian species like reed beds.

Keywords: Riparian vegetation bending; vegetated flows; real-scale measurements; field experiments.

1. Introduction

The purpose of both experimental and numerical analyses in Ecohydraulics is to predict the effect of the main hydrodynamic features of real vegetated flows strongly affected by real-scale dimensional and bio-mechanical traits of riparian vegetation stands interacting with water flow (Errico et al., 2019; Padulano et al., 2020).

As shown in Figure 1, one of the most widespread riparian vegetation species colonizing covering both manmade and natural vegetated water bodies is represented by rigid and emergent *Phragmites australis* plants, most known as reed beds.

Figure 1. *Phragmites australis* plants, most commonly known as reed beds.

The bio-mechanical behaviour of riparian reed beds was analyzed here in terms or stems' bending, as a response to the flow dynamic action developing in a real vegetated drainage channel colonized by rigid reed beds in terms of bulk drag coefficients (Lama and Chirico, 2020).

2. Methodology

The bio-mechanical analysis was carried out at the channel upstream cross-section, by correlating riparian vegetation

bulk drag coefficients obtained in the field and streamwise velocity components at 15 measuring points, as shown in Figure 2a.

In Figure 2b is shown the experimental set-up arranged to measure the streamwise velocity components at the channel's downstream cross-section. It was also employed to check the flow rate according to the continuity of water volumes inside the channel (Lama et al., 2019).

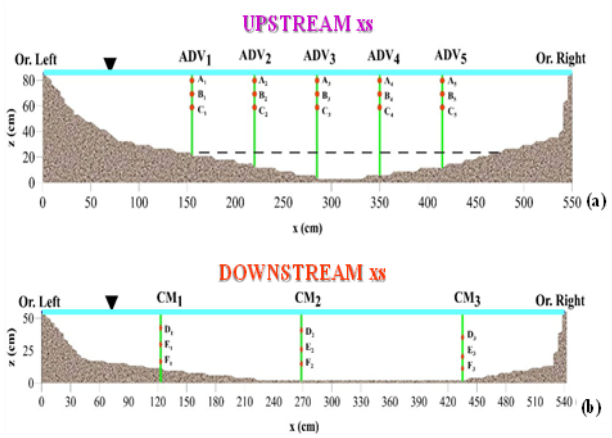

Figure 2. Upstream and downstream channel's cross-sections. Adapted from Errico et al. (2019).

3. Results and discussion

As displayed in Figure 3, bulk drag coefficients trends were here estimated from the calibration of flow resistance model based on riparian rigid stands, based on the assessments of flow average velocities associated with the experimental measurements of streamwise velocity components performed at the upstream channel's cross-section.

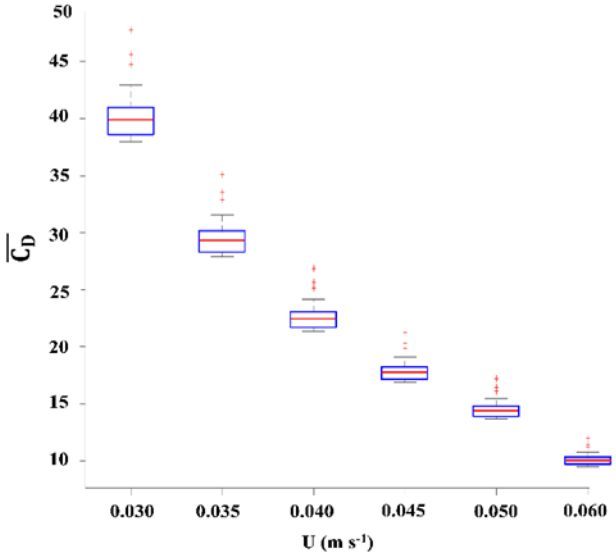

Figure 3. Bulk drag coefficient trends as a function of the flow average velocity estimations considered in the present study.

It emerges from the analysis of Figure 12 that the variability in the values of bulk drag coefficients estimated at to the examined channel's cross-sections decreased moving from U = 0.030 m s^{-1} to U = 0.060 m s^{-1}, testified by two corresponding standard deviations equal to 2.23 and 0.58, respectively (Lama et al., 2020a).

4. Conclusion

The preliminary outcomes of this study demonstrate that the proposed methodology can be used to predict the bio-mechanical behaviour of the examined rigid *Phragmites australis* plants covering the vegetated channel, representing a useful tool when dealing when the prediction of its main hydrodynamic features (Lama et al., 2020b).

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