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Comparison of Analytical and Modeling solutions of the hydrodynamic behavior of drainage channels covered by reed beds

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Abstract The purpose of this work is the validation of modeled turbulent features induced by hydrodynamic interaction between water flow motion and rigid emergent reed beds obtained by employing both analytical and Shallow-waters approaches. The experimental dataset employed for the validation was collected during three hydraulic experiments performed in a vegetated reclamation channel under three different scenarios of riparian vegetation management: one discharge for (1) vegetation in total abandonment, with infesting reed beds in natural conditions, and two discharges for (2) central riparian vegetation cleaning, with the presence of two side buffers of reed beds in undisturbed conditions. In particular, Reynolds shear stresses and Turbulent Kinetic Energy were computed based on the values of measured water flow velocity acquired by an acoustic Doppler velocimeter (ADV), located at the vegetated channel's upstream cross-section. The preliminary results of the present work embody a useful tool for the prediction of the effects of riparian vegetation in vegetated reclamation channels colonized by such riparian species at real scale.
Keywords: Ecohydraulics; Vegetated channels; Turbulence; Aquatic ecosystems; Shallow-waters.

1. Introduction

The main hydraulic traits of real vegetated channels strongly depend on the phenological and morphometric features of riparian vegetation stands interacting with water flow.

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

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

Observing and simulating the hydrodynamic behaviour of a real vegetated drainage channel covered by rigid reed beds are the purposes of this study, in order to predict the effects of real riparian stands on the hydraulic and hydrological main properties of real vegetated flows (e.g., Padulano et. al, 2020).

2. Methodology

As indicated in Figure 2, two riparian vegetation management scenarios were examined in the present work: a scenario of total riparian plants' abandonment and a scenario characterized by central riparian vegetation cleaning, with the presence of two side buffers of reed beds

in undisturbed conditions, hereinafter indicated as Scenario 1 and Scenario 2, respectively.

Figure 2. Experimental overview of Scenario 1 and Scenario 2.

Figure 3 shows an overview of the geometry model employed for simulating the hydrodynamic behaviour of the examined vegetated drainage channel.

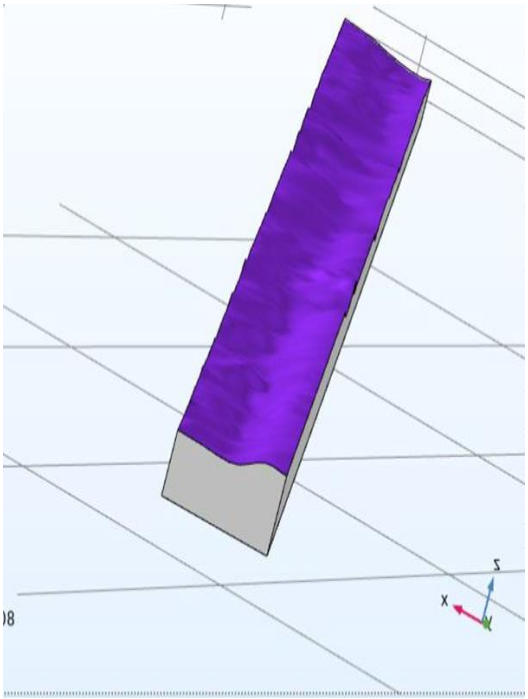

Figure 3. Geometry model of the examined vegetated drainage channel.

3. Results and discussion

Modeled Reynolds shear stresses and Turbulent Kinetic Energy associated with both Scenario 1 and Scenario 2 were obtained from the Shallow-water numerical simulation carried out for predicting the hydrodynamic behaviour of the examined drainage channel colonized by rigid reed beds (Errico et al., 2019; Lama and Chirico, 2020).

Figure 4 shows the simulated Reynolds shear stresses cross-sectional distribution at the channel's upstream cross-section.

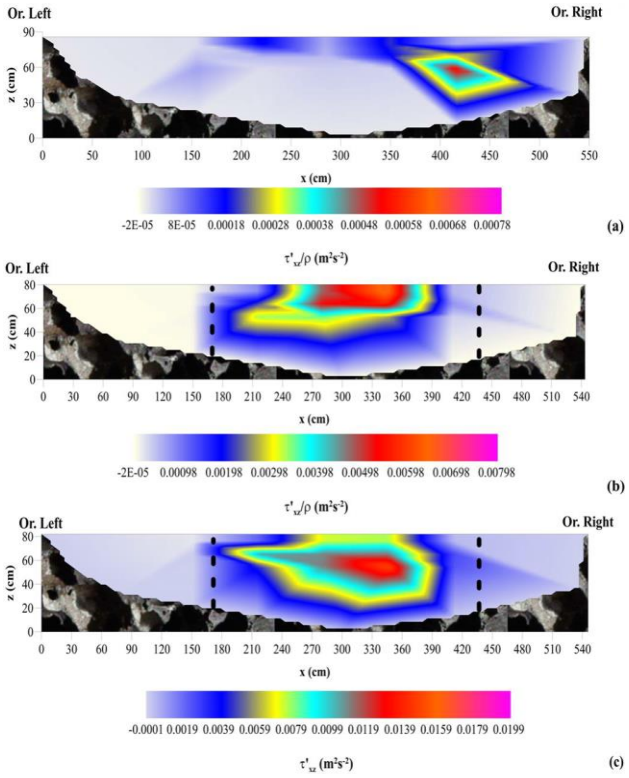

Figure 4. Reynolds shear stresses per unit mass.

Figure 5 shows the simulated TKE cross-sectional distribution at the channel's upstream cross-section.

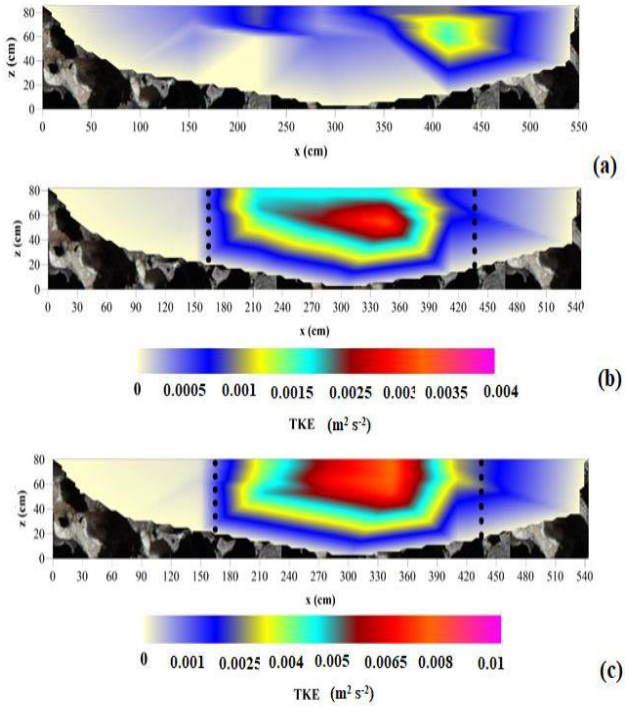

Figure 5. Turbulent Kinetic Energy (TKE).

As in the previous analysis, the black dashed vertical lines indicate the borders of the region of cross-section free from vegetation (Lama et al., 2020a; Lama et al., 2021a). Both Reynolds shears stresses and TKE cross-sectional fields for Scenario 2 are higher than for the case described by Scenario 1, indicating that riparian vegetation cut at the center of the examined vegetated drainage channel guarantees a high environmental value to the water resources within the channel.

4. Conclusion

The preliminary findings of this work demonstrate that the shallow water simulations can be used to model the examined vegetated channel covered by rigid *Phragmites australis*, representing a useful tool when dealing when the prediction of the main turbulence traits (Lama et al., 2020b; Lama et al., 2021ab.

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