# Effect of vegetation on Mixing and Dispersion Processes at the apex section of a meander bend

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ABSTRACT

Aquatic vegetation exerts a strong influence on the fluvial ecosystem. Understanding flow characteristics and turbulent structure in the presence of vegetation is especially important with respect to environmental processes as sediment transport and mixing of transported quantities. In the present paper attention is focused on the kinematic and mixing processes in the presence of flexible submerged vegetation on the bed of a curved channel. In particular, the effect of vegetation on the flux of mass distribution and on the transport process at the apex section of a meandering bend is investigated by comparing the distributions of the dispersion coefficient estimated in vegetated areas and in no-vegetated ones.

## 1. Introduction

On one hand vegetation modifies flow and sediment transport, influencing the evolution of bed morphology; on the other hand these processes affect the distribution of nutrients and oxygen and, thus, water quality conditions. It should be also considered that the alteration of hydrological conditions in fluvial systems determines changes both in river morphology and in riparian or riverbed vegetation. As consequence, the spatial distribution of vegetation can also change in time and in space depending on the combination of many factors, which might affect the settling and growth of the vegetated elements. The major part of studies conducted in this field consider straight flumes with different types of vegetation on the bed. Poggi et al. (2004) investigated flow turbulence structure in the presence of dense, rigid and submerged vegetation and suggested a phenomenological formulation of the mixing length. Tanino and Nepf (2008) analyzed the lateral dispersion processes in the presence of a random array of a rigid and emergent vegetation for different values of vegetation density. Other researchers focused on submerged flexible vegetation (among others Termini, 2015) and verified that the region around the top of the vegetation is the region of highest shear stress and maximum turbulence production. In the present paper attention is focused on the kinematic and mixing processes in the presence of flexible submerged vegetation on the bed of a curved channel. In particular, the effect of vegetation on the flux of mass distribution and on the transport process at the apex section of a meandering bend is investigated.

## 2. Methods

The analysis is performed with the aid of detailed experimental data collected in a laboratory channel. The collected data are processed in order to analyze the distributions of flow velocity components in vegetated and in no-vegetated areas highlighting how vegetation influences the kinematic characteristics of flow and the mixing and dispersion processes also in the no-vegetated areas. Thus, the velocity profiles of the time-averaged flow velocity components in the stream-wise, transversal and vertical directions estimated both inside the vegetated areas and in no-vegetated areas have been analysed and compared. As an example, Figure 1 reports the profiles of the time-averaged flow velocity components in the stream-wise ($\overline{v_l}$), transversal ($\overline{v_t}$) and vertical ($\overline{v_v}$) directions inside the vegetated area (i.e. at a distance of 15 cm from the outer bank of the examined section) and those obtained at the center of the cross-section (i.e. inside the no-vegetated area). To investigate the turbulence flow structure both the temporal and the spatial averaging of the flow quantities have been operated in order to limit the heterogeneity effect. Thus, the normalized dispersion coefficient in the transversal direction, $K_t$, has been determined as $\frac{K_t}{Ud} \approx \left\langle \frac{\sqrt{k'}d}{Ud} \right\rangle = \left\langle \frac{\sqrt{k'}}{U} \right\rangle$, where $U = Q/Bh_o$ ($h_o$=overall-averaged water depth) indicates the mean velocity, $k'$ is the turbulent kinetic energy per unit mass, $d$ is the vegetation stem dimension, the brackets represent the spatial average. Thus, the vertical profiles of the ratio $\frac{\sqrt{k'}}{U}$ and of its longitudinal spatial average $\left\langle \frac{\sqrt{k'}}{U} \right\rangle$ at the selected locations inside the vegetated areas and in the no-vegetated areas have been determined and compared. Figure 2, as an example, reports the comparison between the vertical profiles of $\frac{\sqrt{k'}}{U}$ and of the spatial average $\left\langle \frac{\sqrt{k'}}{U} \right\rangle$ obtained at a distance of 15 cm from the outer bank of the considered section (i.e. inside the vegetated area) and those obtained at the center of the cross-section (i.e. inside the no-vegetated area).

## 3. Results and Concluding Remarks

Results essentially confirm that mass exchanges in the presence of vegetation are strongly influenced by the presence of the vegetated stems and by the turbulent structures which form between the vegetated and the no-vegetated areas. The presence of the flexible and dense vegetation determines a reduction of the size of the turbulent structures and limits the transport process not only in the vegetated areas but also in the transition towards the no-vegetated ones.

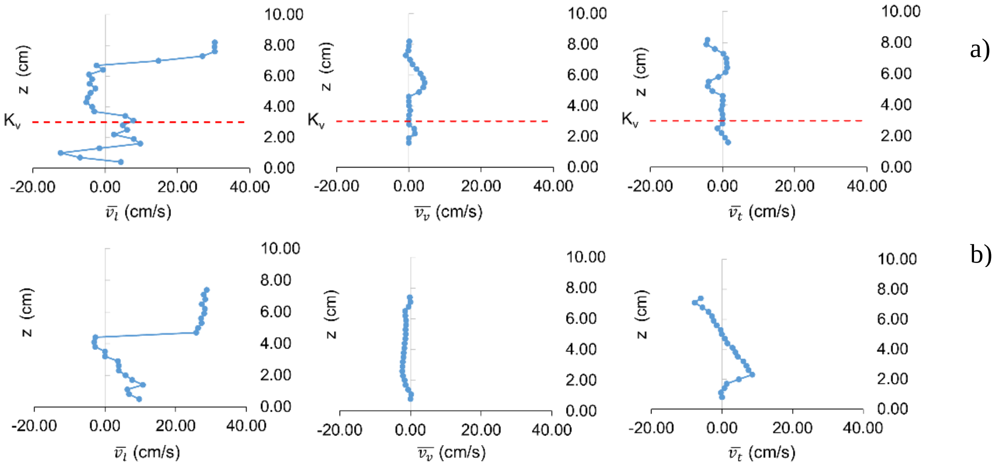


**Fig.1.** Time-averaged flow velocity components with vegetation (a) and without vegetation (b)

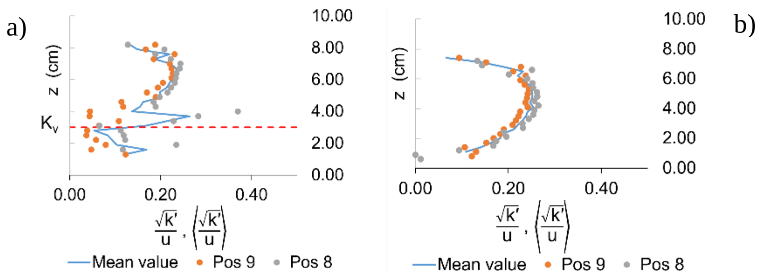


**Fig.2.** $\frac{\sqrt{k'}}{U}$ and $\left\langle \frac{\sqrt{k'}}{U} \right\rangle$ with vegetation (a) and without vegetation (b)

**Acknowledgements**

Part of this work has been supported by PRIN 2017, with the project “(ENTERPRISING)”

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