SHORT ABSTRACT

Riparian vegetation plays a crucial role in determining the flow behavior in the channel. The effect of flow on the slope and main channel varies based on the size, type, and density of floodplain vegetation in a compound channel. Though vegetation distribution in different water bodies is non-uniform, most studies mainly concentrate on uniformly distributed vegetation with fixed vegetation height. Laboratory studies were conducted to address this issue as it was not explored properly. Experiments were performed by taking partially vegetated rectangular channels and compound channels. Rectangular channels were considered to compare flow between homogeneous height/single-layered partially vegetated channels and heterogeneous height/multi-layered partially vegetated channels. Compound channels of three bank angles, namely 31^0, $45^0$and 90^0 were considered with vegetated floodplains.

In the partially vegetated channels, although the average frontal area of both submerged cases is equal, flow characteristics differ in the main channel. It is because of the variation in height of vegetation in the fully submerged multi-layered case compared to the single-layered case. As the vegetation emergence and density increase, the flow characteristics near the interaction zone between the floodplain and the main channel undergo significant enhancements. In fully emergent cases, a dip phenomenon is noticeable near the water surface within the main channel. This dip phenomenon is characterized by the presence of positive velocity gradients near the wall and negative velocity gradients near the surface. Furthermore, the dip phenomenon induces negative streamwise Reynolds shear stress near the surface, indicating the prevalence of outward and inward interactions in fully emergent cases. The quadrant analysis for different vegetation distribution cases showed the dominance of sweep and ejection events near the channel bed of the main channel.

While investigating 31^0 bank angle compound channels, the flow properties are more pronounced for uniformly distributed vegetation than non-uniform distribution. The multi-layered vegetation showed higher velocity, turbulent intensity, and turbulent kinetic energy than single-layered vegetation on slopes and main channel sections. Turbulent anisotropy was studied in detail to get further insight into flow behavior in different vegetation setups with a combination of submerged and emergent vegetation in compound channels. The anisotropic invariant map (AIM) and invariant function F reveal that the main channel section of 67 percent emergent vegetation case has a greater tendency to approach two-dimensional turbulence than other non-uniform vegetation setups.

The role of bank angles in compound channels was also compared by considering two sets of $45^0$and 90^0 bank angle. The flow characteristics like velocity, Reynolds shear stress (RSS), and turbulent kinetic energy (TKE) do not vary much in the cross-section in the absence of vegetation. However, with vegetation, the slopes and nearby region are affected the most as it acts as an intermediary region between the main channel and floodplain. The analysis of the Anisotropic Invariant Map (AIM) shows the dominance of the transverse component in the slopes compared to the main channel and floodplain. The velocity in and around slopes is higher for steep slopes (90^0) compared to a gradual slope (45^0) compound channel. The streamwise RSS and bursting events also show higher magnitude near the channel bed in and around the sloping region. It indicates the instability of the steep banks compared to gradual bank slopes. The increase in floodplain vegetation emergence also affects the slopes. The magnitude of RSS and TKE in the slopes is higher with greater vegetation emergence in the floodplain. It shows the higher vulnerability of the slopes in the presence of higher vegetation emergence. From the hydraulic engineering perspective, this study will be helpful in the field of understanding the failure of banks and ways to maintain their stability.