Flow Characteristics around a freshwater mussel in a gravel bed flume

Donatella TERMINI[1,2]

[1] Department of Engineering, Italy
donatella.termini@unipa.it

[2] NBFC, National Biodiversity Future Center, Palermo, Italy

ABSTRACT

Mussels are a defined as “ecosystem engineers” capable of affecting the hydrodynamics, passively and actively (Navaratnam et al., 2018; Termini et al., 2023). The generation of larger-scale turbulence around the mussels living on the river bed may also affect the quality of the habitat. Thus, it is extremerly important to know the effects determined to the presence of mussels on flow characteristics. In the present study reports preliminary results on flow and turbulence characteristics around an isolated mussel over a gravel-bed. The presence of mussel enhances the effects determined by the rough-bed on the kinematic characteristics of flow. The analysis is performed on the basis of data collected in a straight laboratory gravel-bed flume both in absence and in presence of an isolated and partially buried mussel (*Unio elongatulus*), aligned with the incoming flow. In order to take into account spatial heterogeneities, the double-averaged velocities are considered for the analysis in the absence of mussel on the bed. Results show that, because of the presence of gravels, in the absence of the mussel, the streamwise velocity profiles show an inflection point with the formation of a mixing layer whose thickness varies passing from the banks to the channel axis. The presence of mussel modifies the shape of the velocity profile with the formation of turbulent flow structures around it. Different effects on the velocity and turbulence fields have been identified in relation with the mussel’s filtrating capacity.

1. Experimental apparatus and data

The experimental data were collected in a straight recirculating laboratory flume realized at Hydraulic Laboratory of Department of Engineering of University of Palermo (Italy). The channel is 11 m long, 0.4 m wide and with a rigid transparent banks 0.5 m high (Figure 1).

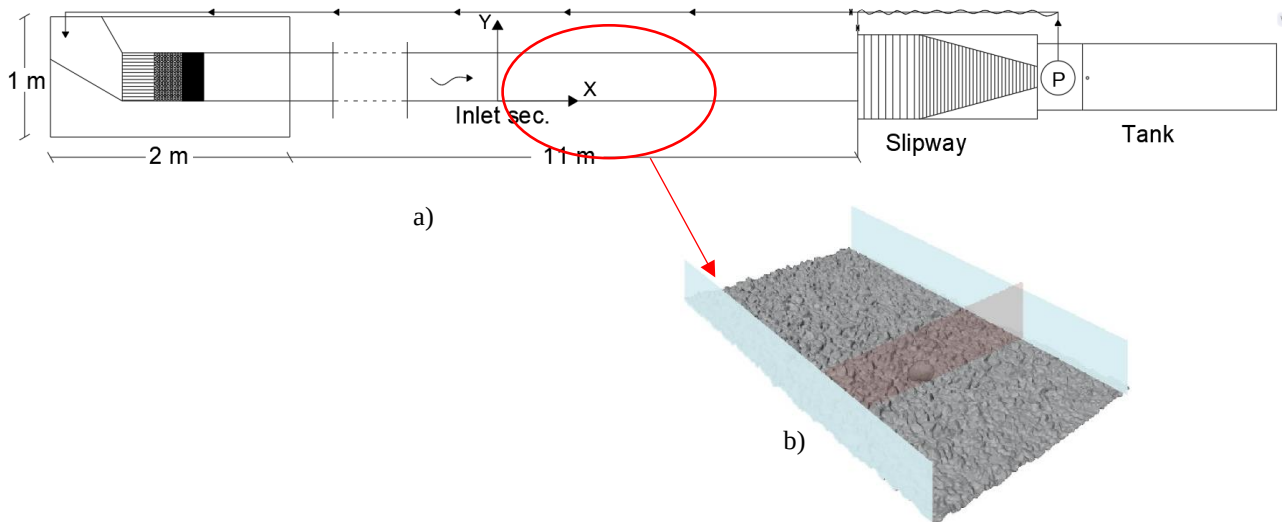

Fig. 1. a) Plane view of the channel; b) particular of the bed surface and of the section where the mussel was located

The bed surface was realized of fixed quartz sand in the first entering reach 3.0 m long and of non-uniform gravels (d_{84}=1.1 cm) in the remaining part. Three experimental runs were conducted with flow discharge of 0.00765 m^3/s. These runs were respectively: 1) in the absence of the mussels, 2) in the presence of a dead mussel, 3) in the presence of a live mussel. In the last two runs the mussel was located in the center of a cross-section located in the central area of the rough-bed channel reach (Figure 1). During each run the 3D instantaneous flow velocity components were measured in a fine grid of selected cross-sections along the channel by using an ultrasonic velocity profiler DOP2000 by Signal Processing s.a.

2. Results and conclusion

The instantaneous values have been used to estimate the corresponding time-averaged values. Figure 2 shows as an example the vertical profiles of the longitudinal, transversal and vertical time-averaged velocity components measured around the mussel. It is possible to note that, in the absence of the mussel, because of the presence of gravels the longitudinal velocity component presents low values close to the bed until to form an inflection point (with the formation of a mixing layer) and then gradually increasing as one moves toward the free surface. The presence of mussel, either dead or alive, modifies the shape of velocity profile close to mussel and in the mixing region, determining lower velocity values especially on the right side of the mussel itself. Here, the transversal velocity component changes the sign in the presence of the dead mussel but when the mussel is in live it becomes again positive because of the mussel's syphons filtration. A similar behaviour can be observed for the vertical velocity component. The observed effect determined by the presence of the mussel and by its filtration rate affects both the longitudinal and transversal water fluxes and the turbulent kinetic energy around the mussel itself.

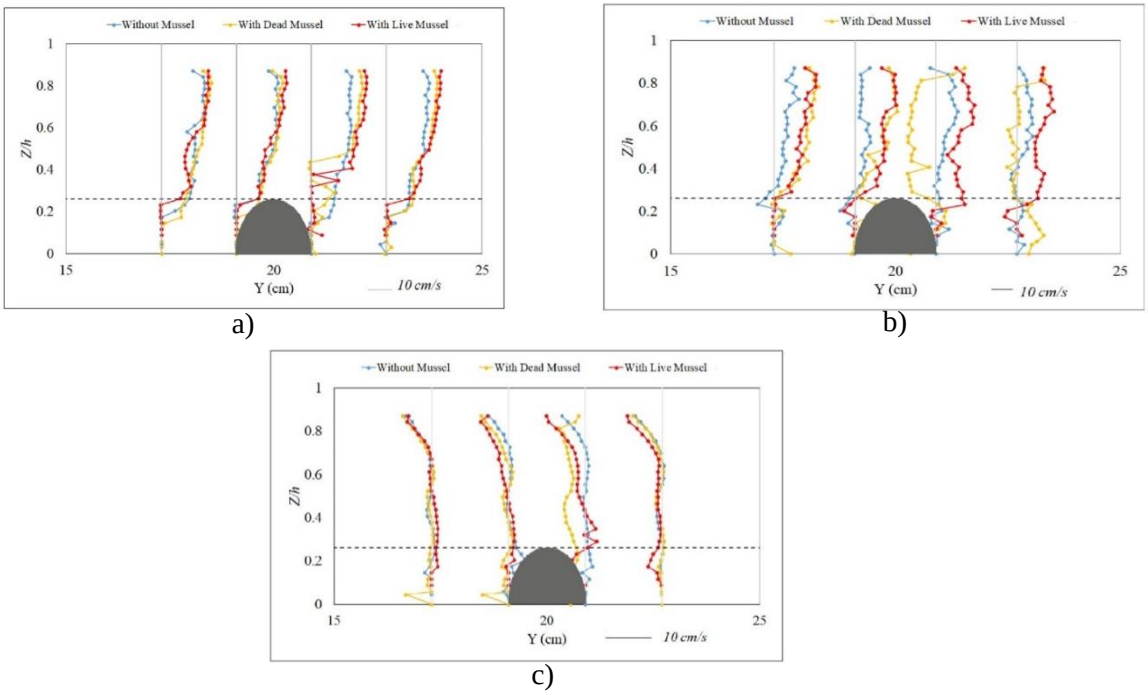

Fig. 2. a) vertical profiles of the longitudinal velocity component; b) vertical profiles of the transversal velocity component; c) vertical profiles of the vertical velocity component

It should be noted that the present study has been performed in a controlled environment and by considering a single mussel, not taking into account the complexity of natural ecosystems, both in terms of hydraulic and biotic interactions

Acknowledgements

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