Abstract

This manuscript presents the results of a thorough experimental and numerical investigation on dense gravity currents jet flows into a calm lighter ambient fluid over a horizontal smooth rigid bottom as a case of discharge the denser fluid in coastal environment. The main aim of this investigation is to contribute to a better understanding of the propagation dynamics and the miscibility of gravity currents jet underneath of ambient environment. Laboratory experiments were conducted with fixed initial gravity current jet concentration in one experimental set-up: rectangular basin consist a calm fresh water, and a rectangular injection channel for unsteady state volume saline gravity currents injection.

The mathematical and numerical model based on the Reyonlds-Averged Navier Stokes equations (RANS), K-epsilon (k-ε) and the Diffusion-Convective equation (DCE) of the saline water volume fraction are used to model the mixing and the propagation of the saline gravity current jet. The evolution of the boundary interface of jet obtained experimentally are used to validate the numerical model. On the other hand, comparison of the obtained mean flow ($z/z_{0.5} = U/U_{max}$) with previous two dimensional numerical simulations and experimental measurements have shown similarities. The numerical simulations of the hydrodynamic fields show that the velocity maximum is located at 0.18 $z_{0.5}$, where $z_{0.5}$ is the height at which the mean velocity u is equal to the half of the maximum velocity u_{max}. The excess-density shows a radial symmetry close to the inlet and asymmetry far from the inlet.

As well, calculation of the gradient of the Richardson number Ri_g as a function of the height for different longitudinal positions can give the zone of turbulent mixing. The comparison of the numerical with the experimental front positions presents a good agreement for Reynolds and Richardson numbers lying respectively in the ranges $2222<R<3889$ and $0.003<Ri<0.01$. The local gradient Richardson number Ri_g shows that the maximum of the turbulent mixing occurs at $z \approx z_{0.5}$ in the first stage of the gravity current, i.e. close to the inlet and it collapses far from the inlet. Consequently, calculation with the relative volume of the gravity jet and entrainment as threshold in the space or in the time permit to evaluate the degree of the mixing. By analyzing the turbulent mixing in a 3D configuration, the volume of the turbulent mixing increases with the x-coordinate close to the inlet jet and decreases far from the inlet. The entrainment depends both on the front position and on the values of the iso-density threshold. The entrainment is found independent on Reynolds numbers between 2222 and 3889.

Keywords: Bottom gravity current, Buoyant jet, Entrainment, Experiments, Mixing, and RANS model.