Geophysical Research Abstracts
Vol. 19, EGU2017-17251, 2017
EGU General Assembly 2017

Propagation of a turbidity current in confined geometries

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Sedimentation in reservoirs due to turbidity currents originates problems of loss of storage capacity as well as clogging of outlets/intakes.

These currents are driven by the difference in specific weight between the current itself and the surrounding fluid, due to the presence of particles in suspension. As a gravity current, the main properties of these phenomena has been investigated by several authors since the 1970′s. Despite driven by a simple mechanism, the propagation of these currents can become more complex owing to the influence of factors such as geometry, bed roughness and other non-uniform elements. However, the majority of conducted studies has been focused in characterising only the influence of density imbalance.

The propagation of a density current in confined geometries and the influence of bed roughness is herein investigated, through laboratory experiments carried out at the Laboratory of Hydraulics and Environment of Instituto Superior Técnico, Lisbon. The density currents were generated with brine to allow for visualization and velocity measurement.

The laboratory experiments comprised point and continuous release of a dense NaCl mixture with a tracer (Rhodamine WT), with a density equal to 1028 g/L, into a tank with resting freshwater (1000 g/L). The transport and the mixing processes were recorded with high-speed video. The mass distribution was obtained through a photometric methodology and the Particle Image Velocimetry (PIV) technique was used to measure the instantaneous flow velocity fields and the depth of the density current. Both methodologies were used to measure different plan views of the phenomena, including profile and top views, for different regions, near-field and far-field. Different bed roughness were studied, including smooth and rough bed.

The facility was designed with the objective to generate a complex 2D flow with an advancing wave front but also shocks reflected from the walls.

As the image analysis technique provided high-resolution images, the front velocity in the far field was tracked with an algorithm that captured its geometry with great accuracy (including, for instance, the lobe and cleft formation). The temporal analysis of the velocity signal revealed great “oscillations” that are beyond the scale/influence of the irregularity of lobes and clefts. This sloshing effect is assessed and discussed.

The results obtained provide data with high spatial and temporal resolution that can lead to a better understanding of the mechanisms involved in such flows. Thus, these results can be used for a proper modelling and the development of mitigation measures against the adverse effects of density currents.

This research was partially supported by Portuguese and European funds, within programs COMPETE2020 and PORL-FEDER, through project PTDC/ECM-HID/6387/2014 granted by the National Foundation for Science and Technology (FCT).