EGU21-16313
https://doi.org/10.5194/egusphere-egu21-16313
EGU General Assembly 2021

Gravity induced vertical motion of dense fluids into saturated granular beds

Rui M L Ferreira[1], Gabriel Solis[1,2], Claudia Adduce[2], and Ana Margarida Ricardo[3]
[1]CERIS – Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal (ruimferreira@tecnico.ulisboa.pt)
[2]Department of Engineering, Roma Tre University, Italy
[3]CERIS - Civil Engineering Research and Innovation for Sustainability, Lisbon, Portugal

Gravity currents propagating over and within porous layers occurs in natural environments and in industrial processes. The particular modes by which the dense fluid flows into the porous layer is a subject that is not sufficiently understood. To overcome this research gap, we conducted laboratory experiments aimed at describing experimentally the dynamics of the drainage flow.

The experiments were conducted in a horizontal channel with a rectangular cross-section. The channel is 3.0 m long, 0.05 m wide. The porous bottom was composed of 5 cm and 10 cm layers of 3 mm borosilicate spheres – unimodal bed – and of a mixture of 3 mm (50% in weight) and 5 mm spheres (50%) – bi-modal bed. The porosity of the unimodal bed ranged between 0.60 and 0.64 (compatible with loose packing). The porosity of the bi-modal bed ranged between 0.61 and 0.65. All gravity currents were generated by releasing suddenly denser fluid locked by a thin vertical barrier placed at 0.2 m from the channel end. The dense fluid consists in a mixture of freshwater and salt (coloured with Rhodamine) while the ambient fluid is a solution of freshwater and ethanol. The density difference between the ambient fluid and the current, and the need to maintain the same refractive index, determine the amount of salt and alcohol added in each mixture. Here we report the findings of currents with a reduced gravity of 0.06 ms^{-2}.

Each experiment was recorded by an high-speed camera with a frame-rate of 386 Hz and a resolution of 2320 x 1726 pxxpx. Measurements were based on light absorption techniques: a LED light panel 0.3 m high and 0.61 m long was used as back illumination. All images were calibrated to ascribe, pixel by pixel, a concentration value from a 8 bit gray level. Different calibrations were performed for the porous layer and for the surface current.

Results show that, in the slumping phase, the gravity current flows with velocities compatible with those over rough beds. As the current progresses further attenuation of momentum is noticed owing to mass loss to the porous bed.

The flow in the porous bed reveals plume instability akin to a Saffman-Taylor instability. The growth of the plumes seems independent from the initial fluid height in both types of porous beds. The wavelength and the growth rate of the plumes depends on the bed material. Plumes grow faster in the case of the bi-modal bed and the wavelength of the bi-modal bed is about 1.5 as

that of the unimodal bed. It is hypothesised that the gravity-induced porous flow is best parameterized by a Péclet number defined as a ratio of dispersive (mechanical diffusion) and advective modes of transport. Smaller wavelengths and slower growths are attained for stronger dispersion, characterisitic of the unimodal bed. For bimodal beds, permeability is larger, and thus also advection. This causes the flow to concentrate in faster growing but farther apart plumes.

This research was funded by national funds through Portuguese Foundation for Science and Technology (FCT) project PTDC/CTA-OHR/30561/2017 (WinTherface).