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Laboratory experiments of salt water intrusion

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The problem of saltwater intrusion in coastal aquifers is dealt with by the proper setup of a sand-box device to develop laboratory experiments in a controlled environment. Saline intrusion is a problem of fundamental importance and affects the quality of both surface water and groundwater in coastal areas. In both cases the phenomenon may be linked to anthropogenic (construction of reservoirs, withdrawals, etc.) and/or natural (sea-level excursions, variability of river flows, etc.) changes. In recent years, the escalation of this problem has led to the development of specific projects and studies to identify possible countermeasures, typically consisting of underground barriers. Physical models are fundamental to study the saltwater intrusion problem, since they provide benchmarks for numerical model calibrations and for the evaluation of the effectiveness of solutions to contain the salt wedge.

In order to study and describe the evolution of the salt wedge, the effectiveness of underground barriers, and the distance from the coast of a withdrawal that guarantees a continuous supply of fresh water, a physical model has been realized at the University of Padova to represent the terminal part of a coastal aquifer. It consists of a laboratory flume 500 cm long, 30 cm wide and 60 cm high, filled for an height of 45 cm with glass beads with a d_{50} of 0.6 mm and a uniformity coefficient $d_{60}/d_{10} \cong 1.5$. The material is homogeneous and characterized by a porosity of about 0.37 and by an hydraulic conductivity of about 1.8×10^{-3} m/s. Upstream from the sand-box, a tank, continuously supplied by a pump, provides fresh water to recharge the aquifer, while the downstream tank, filled with salt water, simulates the sea. The volume of the downstream tank ($\cong$ 2 m^3) is about five times the upstream one, so that density variations due to the incoming fresh water flow are negligible. The water level in the two tanks is continuously monitored by means of two level probes and is controlled by a couple of spillways placed in both the upstream and downstream tanks, ensuring a constant gradient during the tests. The flow rate spilled from the downstream tank is continuously measured so that it is possible to control the fulfillment of the stationary condition in the system.

While we use food dye to mark saltwater to give an easy visual evidence of the salt wedge, the spatio-temporal evolution of the concentration is monitored during the experiment by using electrical resistivity tomography (ERT). An electrode system specifically realized to be effective in the flume is used during the experiments to achieve electrical resistance measurements, later converted in concentrations through the calibration of a petrophysical law. The presentation describes the laboratory setup and the data achieved from the developed experiments compared with numerical simulations obtained by the SUTRA software.