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The Effect of Subsurface Dam on Saltwater Intrusion in Heterogeneous Coastal Aquifers

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Abstract : Saltwater intrusion (SWI) in coastal aquifers has become a growing threat for many countries around the world. While various control measures have been suggested to mitigate SWI, the construction of subsurface physical barriers remains one of the most effective solutions for this problem. In this work, we used laboratory experiments and numerical simulations to investigate the effectiveness of subsurface dams in heterogeneous layered coastal aquifer with different layering patterns. Four different cases were investigated, including a homogeneous (case H), and three heterogeneous cases in which a low permeability (K) layer was set in the top part of the system (case LH), in the middle part of the system (case HLH) and the bottom part of the system (case HL). Automated image analysis technique was implemented to quantify the main SWI parameters under high spatial and temporal resolution. The method also provides transient salt concentration maps, allowing for the first time clear visualization of the spillage of saline water over the dam (advancing wedge condition) as well as the flushing of residual saline water from the freshwater area (receding wedge condition). The SEAWAT code was adopted for the numerical simulations. The results show that the presence of an overlying layer of low permeability enhanced the ability of the dam to retain the saline water. In such conditions, the rate of saline water spillage and inland extension may considerably be reduced. Conversely, the presence of an underlying low K layer led to a faster increase of saltwater volume on the seaward side of the wall, therefore considerably facilitating the spillage. The results showed that a complete removal of the residual saline water eventually occurred in all the investigated scenarios, with a rate of removal strongly affected by the hydraulic conductivity of the lower part of the aquifer. The data showed that the addition of the underlying low K layer in case HL caused the complete flushing to be almost twice longer than in the homogeneous scenario.

Keywords : heterogeneous coastal aquifers, laboratory experiments, physical barriers, seawater intrusion control
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