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Transient Freshwater-Saltwater Transition-Zone Dynamics in Heterogeneous Coastal Aquifers

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Abstract : The ever growing threat of saltwater intrusion has prompted the need to further advance the understanding of underlying processes related to SWI for effective water resource management. While research efforts have mainly been focused on steady state analysis, studies on the transience of saltwater intrusion mechanism remain very scarce and studies considering transient SWI in heterogeneous medium are, as per our knowledge, simply inexistent. This study provides for the first time a quantitative analysis of the effect of both inland and coastal water level changes on the transition zone under transient conditions in layered coastal aquifer. In all, two sets of four experiments were completed, including a homogeneous case, and four layered cases: case LH and case HL presented were two bi-layered scenarios where a low K layer was set at the top and the bottom, respectively; case HLH and case LHL presented two stratified aquifers with High K–Low K–High K and Low K–High K– Low K pattern, respectively. Experimental automated image analysis technique was used here to quantify the main SWI parameters under high spatial and temporal resolution. The findings of this study provide an invaluable insight on the underlying processes responsible of transition zone dynamics in coastal aquifers. The results show that in all the investigated cases, the width of the transition zone remains almost unchanged throughout the saltwater intrusion process regardless of where the boundary change occurs. However, the results demonstrate that the width of the transition zone considerably increases during the retreat, with largest amplitude observed in cases LH and LHL, where a low K was set at the top of the system. In all the scenarios, the amplitude of widening was slightly smaller when the retreat was prompted by instantaneous drop of the saltwater level than when caused by inland freshwater rise, despite equivalent absolute head change magnitude. The magnitude of head change significantly caused larger widening during the saltwater wedge retreat, while having no impact during the intrusion phase.

Keywords : freshwater-saltwater transition-zone dynamics, heterogeneous coastal aquifers, laboratory experiments, transience seawater intrusion
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