The impact of tides on mixing and spreading in heterogeneous coastal aquifers.

M. Pool[1], V. Post[1] and C. Simmons[1]

[1] National Centre for Groundwater Research and Training, Faculty of Science and Engineering, Flinders University, Adelaide, Australia.

ABSTRACT

Understanding the effects of heterogeneity in the hydraulic conductivity field and tidal oscillations on the 3D dynamics of seawater intrusion in coastal aquifers is fundamental for the design of water-resources management schemes in coastal aquifers. Proper accounting of mixing is relevant not only in determining sustainable management policies but also in analyzing reactions that result from mixing. However, in most applications, the medium and thus the flow field are highly heterogeneous and mixing is strongly influenced by spatial heterogeneity and temporal flow fluctuations. Therefore, evaluating and dealing with seawater intrusion problems remains a challenge due to the complexity, spatial and temporal variability, and uncertainty inherent to natural flow and transport systems. The objective of this study is to identify the controls of tidally driven dynamics in heterogeneous coastal aquifers, with emphasis on the quantification of tidal impacts on solute mixing and spreading. Several sets of heterogeneous hydraulic conductivity realizations were generated, and for each realization, three-dimensional numerical simulations of density dependent flow and solute transport were conducted. The simulations show that heterogeneity produces an inland movement of the toe location along with a widening of the mixing zone. Tidal fluctuations have a similar effect on the seawater intrusion dynamics but the increase of the width of the mixing zone can be much larger than due to heterogeneity alone. The parametric analysis revealed that the key dimensionless parameter controlling the tidally mixing behavior is the wave number (n_w) which depends on the tidal amplitude and the aquifer's tidal propagation parameter. We find that tidal impacts become significant for $n_w \leq 600$. These insights critically underpin quantitative guidance on the inclusion and exclusion of tidal effects in the analysis of seawater intrusion for achieving ground-water sustainability in coastal aquifers.

Contact Information: Maria Pool, National Centre for Groundwater Research and Training, Flinders University, GPO Box 2100, Adelaide, SA, 5001, Phone: +61 8 8201 2193, Fax: +61 8 8201 7906, Email: mpoolr@gmail.com