Seawater Intrusion in Coastal Aquifers: Combined Effect of Salinity and Temperature

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ABSTRACT

Density-driven flow initiates and maintains the advance of marine saltwater in coastal aquifers, resulting in the seawater intrusion phenomenon. Despite the well-known dependence of fluid density and other important parameters (such as viscosity and hydraulic conductivity) on temperature, little is known about the overall impact of temperature (variations) on pore-water flow in the seawater intrusion process. The co-existence of salt and heat gradients has been found to cause the double diffusive convection phenomenon in porous media. Yet, attention has been given primarily to systems with dramatic temperature and salinity contrasts such as geothermal reservoirs and salt domes (salinity of brine and temperature up to hundreds of degree Celsius) at depth of kilometers rather than shallow seawater intrusion settings.

In this study, we conduct laboratory experiments and numerical simulations using SUTRA-MS to investigate the manifestation of temperature effect on various seawater intrusion characteristics (pore-water flow, salinity distribution, submarine groundwater discharge, and seawater circulation). The results reveal significant difference between the patterns of heat and salt distribution in which energy and solute spreading are decoupled. Such dissimilarity is unique for transport in porous media due to different modes of heat and solute transport. Convection contributes to the movement of both heat and salt in porous media. Meanwhile, diffusion of salt takes place via liquid phase only whereas conduction of heat occurs through both liquid and solid phases. Furthermore, the flow pattern varies considerably under varying thermal conditions in the saline water zone. The circulation of marine seawater as well as discharge of terrestrial freshwater are also affected.