Stochastic Study on Impact of Heterogeneity of Coastal Aquifers on Movement of Transition Zone (TZ) between Freshwater and Saltwater Induced by Pumping

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ABSTRACT

Extensive extraction of fresh groundwater in coastal areas is not uncommon and the resultant effect is serious seawater intrusion. Recovery of head and Total Dissolved Solids (TDS) starts as soon as the pumping wells are shut off. In the paper, TZ is treated as a mixing zone, and the first spatial moment is borrowed to express the centroid of the zone. The characteristics of movement of centroids with time in a synthetic heterogeneous aquifer are studied. The heterogeneity of the aquifer is presented by 12 random realizations, which are controlled by the stochastic parameters such as spatial structure, variance, and correlation length of the hydraulic conductivity field of the aquifer in the SGSIM model. 12 cases corresponding to these realizations are designed and a 2D density-dependent flow and solute transport model is setup to derive the distributions of head and TDS for each case. A base-case considering homogeneous aquifer is designed as the benchmark case. The displacements of the centroids between the base-case and the other 12 cases are computed. The accumulated distances of centroids at different percentage of recovery of head for each case are computed as well. Results suggest the movement of TZ is largely delayed compared with the recovery of head. The sensitivity of TZ to variance and correlation length is mainly dependent on the spatial structure of the hydraulic conductivity field of the aquifer. If the hydraulic conductivity field owns an isotropic spatial structure, TZ is more sensitive to correlation length than variance. However, when the hydraulic conductivity field has an anisotropic spatial structure, TZ is more sensitive to variance than correlation length throughout the recovery process. When both the variance and correlation length are large, TZ can move landward further. The landward intrusion of TZ compared with that in homogeneous base-case implies a simplified homogeneous model may underestimate the location and movement of TZ.

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