Exploring the conservativeness of deuterated water as the artificial tracer for hydrogeological tests

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Abstract

Deuterated water has been applied in hydrogeological tracer tests in recent years. However, there is a contradiction about the conservativeness of artificial deuterium (D/2H). In this study, what circumstances HDO behaved truly conservatively were investigated through laboratory-scale experiments via comparing the widely used tracer chloride (Cl-). And reasons for the non-conservativeness of HDO were discussed comprehensively for the first time. In addition, the advection-dispersion equation (ADE) and dual-domain mass transfer (DDMT) equation were employed to describe the breakthrough curves (BTCs) of tracers. HDO behaved conservatively when it transported in the porous media with high permeability (approximately K > 1m/d), and ADE could describe BTCs successfully. While hysteresis effect of HDO expressed in the media with low permeability. And the lower the permeability of the porous media, the stronger the hysteresis effect. DDMT was more suitable for demonstrating BTCs in low permeability media. Hydrogen bonds between HDO and H2O, the isotopic exchange effect, and the dual-domain model of the media all could lead to the hysteresis effect. The retardation factor (R = 1.712) was used to describe transporting behaviors of HDO in clay firstly. And the threshold hydraulic conductivity (Kcr) and the proportion of immobile regions of HDO were greater than that of Cl-, while dispersion coefficients of HDO were smaller. These could provide further considerations for using deuterium in hydrogeological tracer tests.

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