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Analytical model for multispecies transport in a PRB-aquifer system subject to nonequilibrium sorption

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Transport behavior of contaminants through a permeable reactive barrier (PRB)- aquifer system is complicated because of the different physical and chemical properties of the PRB and the aquifer. Dual-domain contaminant transport models are efficient tools for predicting and describing the movement of contaminants in the PRB–aquifer system. Multispecies transport models should have the ability to account for mass accumulation from parent species while simultaneously considering the distinct transport and reactive properties of both the parent and daughter species during the transport of a degradable contaminant such as dissolved chlorinated solvent. For mathematical simplicity, the current multispecies dual-domain transport analytical models are derived assuming equilibrium sorption. However, experimental and theoretical studies have indicated that nonequilibrium sorption could have a profound effect upon solute transport in the subsurface environment. This study presents an analytical model for multispecies transport in a PRB-aquifer system subject to nonequilibrium sorption. The first-order reversible kinetic sorption reaction equation systems are incorporated into two sets of simultaneous advection-dispersion equations coupled by sequential first-order decay reaction that describe the multispecies nonequilibrium transport in both the PRB and the aquifer. The analytical solutions to the complicated governing equation systems are derived with the aid of the Laplace transform. The derived analytical solution is verified by comparing its computational results against those a numerical model where the same governing systems are solved using the advanced Laplace transform finite difference method. Ultimately, the derived analytical model is used to investigate how the sorption reaction rate influences the performance of a PRB-aquifer system.