A two-dimensional semi-analytical model for multispecies transport of the contaminant and its degradation-related products subject to rate-limited sorption

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Abstract

Several previous studies have demonstrated that analytical models incorporating rate-limited sorption can influence the accurate prediction of contaminant concentrations in the subsurface environment. A multidimensional, multispecies transport model would have more practical applications for predicting the transport of chemical mixture of some contaminants such as radionuclides, nitrogen and dissolved chlorinated solvents which generally involve a series of first-order decay/degradation chain reactions. This study introduces a semi-analytical model for the two-dimensional multispecies transport of contaminants and their degradation-related by products under the action of rate-limited sorption. Coupled advection-dispersion equations (ADEs) for multiple contaminants as described by a system of partial differential equations are reduced to obtain linear algebraic equations through sequential application of integral transforms. Comparison of the results of the derived analytical model with those obtained with the numerical model show, high similarity proving the accuracy and reliability of the new model. Investigation on how the sorption rate affects contaminant plume migration indicates the identical plumes for equilibrium-controlled and rate-limited sorption models and when the sorption rate constant reaches 50 year-1. A wider plume and the high concentration level rate-limited model as the sorption rate constant decreases, implying the newly derived solutions should be used when the equilibrium-controlled model is invalid.