The influence of rate-limited sorption on the transport of a multi-species contaminant and its degradation products with arbitrary time-dependent inlet boundary conditions

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Abstract

Most analytical models currently used to simulate multispecies transport assume the sorption process, which describes mass transfer between the dissolved and sorbed phases, is equilibrium-controlled sorption. However, some previous studies have demonstrated that a rate-limited sorption process can significantly impact solute transport in the subsurface environment. In addition, the determination of inlet boundary conditions greatly affects the prediction of contaminant transport in groundwater. This study introduces a novel analytical model for the two-dimensional multispecies transport of contaminants and their degradation-related by-products with arbitrary time-dependent input boundary conditions under the action of rate-limited sorption. According to the findings of an investigation on the relationship between the sorption rate and the migration of contaminant plumes, a lower sorption rate constant results in a plume that is more widespread. The concentration level distribution, on the other hand, is reliant on the different inlet boundary conditions that have been applied. While the predicted concentrations of all species in the decay chain decreased as the sorption rate increased for some input conditions such as constant flux and exponentially decaying input functions, the concentrations tended to increase tendency in some species of the degradation chain under pulse loading boundary conditions. The new model has the potential to develop into an efficient instrument for predicting levels of pollution and determining the extent of the health risk connected with degradable contaminants.

Keywords: analytical model, multispecies transport, rate-limited sorption, arbitrary time-dependent inlet boundary conditions.