One dimensional solute transport in low permeability homogeneous and saturated soil columns

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Solute transport in low-permeability media such as clay has not been studied carefully up to present, and we are often unclear what is the proper governing law for describing the transport process in such media? In this study, we composed and analyzed the breakthrough curve (BTC) data and the development of leaching in one-dimensional solute transport experiments in low-permeability homogeneous and saturated media, to identify the parameters controlling transport. Sodium chloride (NaCl) was chosen to be the tracer. A number of tracer tests were conducted to inspect the solute transport under the conditions of having the same column diameter but with different column lengths, or having the same column length but with different column diameters. Tracer tests with non-smooth inner walls of the soil columns were also conducted. The modeling approaches considered were the Continuous Time Random Walk (CTRW), Two-Region Model (TRM), Classical Convection-Dispersion Equation (CDE) and Fractional Advection-Dispersion Equation (FADE). Both the breakthrough process and the leaching process were analyzed and the results indicated that the breakthrough process was Fickian, whereas the leaching process was non-Fickian. Higher values of coefficient of determination (R^2) and lower values of root mean square error (RMSE) were observed with respect to the fits of CTRW, CDE, TRM and FADE. However CDE and TRM failed to characterize the transport behavior in leaching. The CTRW and FADE models were better in capturing the full evaluation of tracer-breakthrough curve and late-time tailing in leaching.

Keywords: Solute transport, Low permeability media, Breakthrough curve

