Geophysical Research Abstracts, Vol. 7, 01676, 2005
SRef-ID: 1607-7962/gra/EGU05-A-01676

Quantifying Pore Size Spectrum of Macropore-Type Preferential Pathways

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To predict chemical transport through preferential flow pathways, classical deterministic models depend on soil hydraulic conductivity, which effectively lumps flow contributions from all individual pathways. We contend, however, that quantifying the pore spectrum of preferential pathways, i.e., without lumping the contributions of individual pores, is the appropriate method for simulating convective chemical transport through macropore-type preferential pathways. We conducted field-scale experiments to measure the mass flux breakthrough patterns of conservative tracers through preferential flow pathways under four different steady-state infiltration rates. The tails of these patterns suggested that the impact of preferential pathways on contaminant transport can be conceptualized as that occurring through cylindrical capillary tubes. We then proposed a distribution function bracketed by sharp "cut-off" points to represent the pore spectrum of these tubes. Finally, we used the measured tracer breakthrough curves as data sources to derive pore spectrum of preferential pathways. Our results showed that preferential pathways with a wide range of pore radii could become active simultaneously when infiltration rate increases. Because the derived pore spectra simultaneously satisfy both water movement and solute transport, pore spectra can be used to: (1) calculate soil hydraulic conductivity of preferential pathways in deterministic approaches; and (2) construct multiple probability density functions for the Transfer Function approach, to accommodate different precipitation patterns.