Geophysical Research Abstracts, Vol. 9, 10641, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-10641

Modeling transport of contaminants in a transient preferential flow field

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Enhanced transport of contaminants due to preferential flow effects plays an important role when various problems related to the pollution of environment are dealt with. Preferential pathways may substantially contribute to the migration of contaminants from the soil surface to deeper soil horizons. These pathways are often temporarily activated during rainstorm events, when rainfall intensity is greater than the infiltration capacity of the soil matrix. If such conditions last for a sufficiently long period of time, this may result in a relatively deep breakthrough of contaminants through the vadose zone, and possibly in a pollution of groundwater. In shallow soils, the pollution can move to considerable distances by saturated lateral flow formed at the soil-bedrock interface. A dual-continuum model of variably saturated water flow and solute transport is used to study the soil water dynamics and the interplay of the soil matrix and preferential flow domains, which control the movement of contaminants (together with biological and geochemical transformations). The analysis reveals well defined periods of deep percolation interspersed with longer lasting periods when soil water movement is confined to a shallow stratum below the soil surface. The deep percolation episodes represent periods of increased susceptibility to the contamination from possible sources of surface pollution.