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Effect of water table fluctuations on solute transport: column experiments and modelling

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In headwater catchments underlain by crystalline bedrock, shallow groundwater accumulates in weathered material. Groundwater exhibit large water table fluctuations at the year scale, reaching 8m of amplitude in the upslope domain. These large water table fluctuations may have considerable effect on solute transport through the vadose zone groundwater continuum. The objective of this work is to investigate experimentally and numerically the effect of water table fluctuations (WTF) on the conservative and inert tracer transport in a column repacked with weathered granite. The column was 1m-long and 0.3m-diameter. Displacement experiments with bromide were performed at two flow regimes and at two inflow rates (12 and 19 mm h^{-1}). For each of the two flow regimes, the inflow rates at the upper boundary remained steady. The two distinct flow regimes were obtained with different lower boundary conditions. The first flow regime was an unsaturated steady-state flow obtained with a seepage face lower boundary and the second one was an unsaturated flow with a fluctuating water table in the down half part of the column. Water table fluctuations were obtained by controlling the outflow rates. Successive fluctuations consisted in triangular wave functions with a time period corresponding to about 130 mm of cumulative inflow. For all the experiments the mass recovery exceeded 90%.

Breakthrough curves under both steady-state flows are typical of a physical non-equilibrium transport in a double porosity medium with flowing and non-flowing regions. The mobile-immobile model (MIM) fits observed concentrations very well for the 12 $mm.h^{-1}$ experiment ($r^2 > 0.99$) and with a little greater discrepancy ($r^2 \approx 0.97$) for 19 $mm.h^{-1}$. Two major results are drawn from the experiments under WTF flow regimes. **i)** At both inflow rates the WTF induce much higher solute dispersion as com-

pared to the unsaturated steady-state flow. **ii)** The evolution of the cumulative bromide flux according to the cumulative outflow is remarkably similar whatever the inflow rates. Thus, within the range of inflow rates studied in this work and in a weathered granite aquifer with a WTF zone, solute transport down to the groundwater could be more controlled by the WTF regime in the WTF zone than by the flow regime in the unsaturated zone.

Numerical investigations coupling flow and transport models were performed to test the effect of WTF amplitude and frequency on the solute transport in a weathered granite medium. The flow was represented by the classical Richards equation using the hydraulic properties of the weathered granite. The transport was simulated with the convection-dispersion and the MIM models.