EFFECT OF ROOT WATER AND SOLUTE UPTAKE ON SOLUTE TRANSPORT IN SOILS: A 3D SIMULATION STUDY

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Plant transpiration is an important component of the hydrological cycle. Through root water uptake, plants do not only affect the three-dimensional soil water flow distribution, but also solute movement. This numerical study aims at investigating how solute fate is impacted by root uptake using the three-dimensional model R-SWMS (Javaux et al., 2008). This model combines the three-dimensional Richards equation describing water flow in soil with an equation describing flow in root xylem vessels. The coupling was implemented by defining the water flow along water potential gradients in the root-soil continuum.
For solute transport simulations, the three-dimensional random walk particle tracking algorithm PARTRACE (Bechtold et al., 2011) was used. Here, the water flow velocity from the Richards equation and a random displacement for dispersion are used to move large numbers of solute particles through the soil.
In a numerical study, we investigated how root and solute uptake by plants affects solute movement in soil. Therefore, we simulated three-dimensional virtual steady-state breakthrough curves (BTC) experiments in soils with transpiring plants. Simulated BTCs of averaged concentrations in a horizontal cross section of the simulation domain were then fitted with a 1D numerical flow and transport model under steady-state conditions to obtain apparent transport parameters of the 1-D model: apparent velocity and dispersivity. In these virtual experiments, the impact of root architecture, solute uptake mechanism and transpiration rate on t he apparent disperisivity and velocity could be evaluated.
Our simulation results show, that both, apparent velocity and dispersivity length are affected by water and solute root uptake. Under high exclusion processes, solute accumulates around roots and generates a long tailing to the breakthrough curves, which cannot be reproduced by 1D models that simulate root water uptake with solute exclusion. This observation may have an important impact on how to model pollutant mass transfer to groundwater at larger scales.