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Comparison of transport in lysimeters with undisturbed loamy sand and silty soil using non invasive imaging with electrical resistivity tomography

S. Garre (1), J. Köstel (1), J. Vanderborght (1), and M. Javaux (2)

(1) Agrosphere (ICG-4), Forschungszentrum Jülich, Germany (s.garre@fz-juelich.de), (2) Dep. of Environmental Sciences, UCL, Louvain-la-Neuve, Belgium (mathieu.javaux@uclouvain.be)

The transport of chemicals through soil is subject to the 3-D structure of the soil hydraulic properties (e.g. unsaturated hydraulic conductivity function) and state variables (e.g. water content). Although this is known for decades, it is still difficult to quantitatively predict solute transport especially when preferential flow or fingering occurs. One reason for this is the shortcoming of 3-D data on both the solute transport process itself and its determining parameters. Lysimeters provide excellent means to control the boundary conditions and are accessible from all sides. Filled with undisturbed soil and equipped with geophysical imaging devices they provide a valuable tool to visualize and better understand solute transport in natural soils.

In our study we conducted solute tracer step experiments on two distinct undisturbed unsaturated field soils (gleyic Cambisol and orthic Luvisol). The boundary conditions were set to constant irrigation (1.5 cm/day) at the top and a constant suction at the bottom. Tracer breakthrough was monitored using 3-D Electrical Resistivity Tomography (ERT) and Time-Domain Reflectometry (TDR). We used the effluent tracer breakthrough and TDR measured breakthrough as a ground truth for the ERT data. From these data, apparent convection-dispersion transport parameters were derived. We found considerably different transport velocities and dispersivities for the two soils. In the orthic Luvisol, distinct preferential transport paths were visualized and followed in time. In the gleyic Cambisol we observed minor heterogeneities in the transport front which were aligned to the plowing direction.

The study demonstrates the usefulness of ERT to characterize and compare the 3-D spatio-temporal evolution of solute fronts. The results are beneficial to investigate relationships between soil structure and the transport process and to explain the scale dependency of the transport processes from the spatial structure of the process at a smaller scale.