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Design and Performance of a Large Modular Zero-Tension Lysimeter for in-situ Water Collection from Preferential Flow Paths

A. Peters (1,2) and W. Durner (1)

(1) Technische Universität Braunschweig, Institut für Geoökologie , Braunschweig, Germany (w.durner@tu-bs.de, +49-(0)531-3915605), (2) Now at: Institute of Ecology, Department of Soil Protection, Technische Universität Berlin

We present a modular system that allows large zero-tension lysimeter plates to be installed under undisturbed soils. Such large sampling devices are necessary if preferential flow paths are present in soils. We conducted a numerical 2-D simulation study using homogeneous and heterogeneous soils to investigate the influence of the lysimeter on the water flow field in the soil, and thus the representativity of the measurements. The results show that the collection efficiency is highly dependent on the soil hydraulic functions, infiltration rate, and lysimeter size. If the soil is homogeneous, zero tension plate lysimeters can collect soil water only in soils with relatively small saturated hydraulic conductivity. The collection efficiency increases with increasing infiltration intensities and lysimeter sizes. In homogeneous soils with high saturated conductivities, even very large lysimeters (width 250 cm) are bypassed completely. Heterogeneity of soil hydraulic properties results in a network of flow channels that may either hit or bypass small sampling devices. For large lysimeters, it generally increases the collection efficiency. Tracer transport simulations with an inert solute in a heterogeneous medium show that the solute breakthrough into the lysimeter occurs slightly retarded as compared to the free soil.

To test the performance of the plate lysimeter under real conditions, we conducted a field study with lysimeters of size 1.25 x 1.25 m. A tracer experiment with surface irrigation showed a collection efficiency of 45% and an almost immediate arrival of the tracers. This indicates that almost all collected water originated from preferential flow paths.