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Investigating water flow and solute transport heterogeneities in cultivated soils using water isotopes

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Water isotopes were used as tracers to study the effects of land cover and fertilizer applications on water flow and solute transport in the unsaturated zone. Five lysimeters containing undisturbed soil monoliths from the same agricultural field site were investigated over a period of five years. Liquid cattle slurry and solid animal manure were applied to the maize and winter rye lysimeters. The grass/clover lysimeter was treated with PK fertilizer. The quantitative influence of land use and spatial heterogeneities on water flow and solute transport was evaluated for all lysimeters using a modified version of HYDRUS-1D.

The highest drainage was observed in the maize lysimeter treated with cattle slurry, and the lowest in the grass lysimeter. Pronounced differences in water contents and estimated saturated hydraulic conductivities were restricted to the upper 25 to 30 cm of the soil. In particular, the lysimeters treated with animal manure had higher porosities, indicating a higher content of organic matter. Main differences in discharge were observed in spring and during the plant growth periods, indicating the importance of preferential flow during snow melt and root water uptake, respectively. Calculations indicate that numerical modeling can reproduce the general trend of water flow and isotope transport. However, more data would be required to improve its accuracy. In particular, spatial heterogeneities, which were independent of land use and land cover, seemed to have a significant influence on water flow and transport processes.