Geophysical Research Abstracts, Vol. 9, 03609, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-03609

Quantification of preferential flow in cropped lysimeters using environmental isotopes

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Knowledge about soil water transport and groundwater renewal rates is crucial for groundwater research and risk assessment. Particularly the impact of preferential flow paths on pollutant transport is an important topic, as it affects the vulnerability of the adjacent aquifer. However, in literature the determination of preferential flow is only partly solved and especially quantification attempts have been rare. Therefore, a new method combining mathematical modeling with hydrological and environmental isotope data was developed to estimate the heterogeneity of the unsaturated water transport by separation of preferential and matrix flow. Both flow components are quantified and their transit time distribution functions are determined to construct vulnerability diagrams. The transport of Oxygen-18 through the matrix is calculated using the software package Hydrus 1D. The preferential flow component is assumed by piston flow occurring within one week and having no interaction with the soil matrix. For quantification a two component mixing was applied to the isotope and hydrological data. The mean transit time distribution functions were determined using a lumped parameter approach and visualized in vulnerability diagrams, showing when infiltrating water reaches the groundwater. This method was already applied successfully to sandy soils of lysimeter experiments without vegetation (Stumpp et al., submitted). Here, the impact of vegetation, soil hydraulic properties, and soil depth on the amount of preferential flow is considered. One lysimeter of 2 m depth containing sandy material showed in general 8.3 % preferential flow with every vegetation and fallow period (over four years). During the maize vegetation period 10.6 % of the seepage water was transported preferentially. In a loamy sand lysimeter (1.5 m) the general amount of preferential flow was 11.5 % (over six years). During six different maize vegetation periods it ranged from 13.5 % to 27.3 %. Here, the maximum amount of preferen-

tial flow was higher (33 mm/week) than in the sandy lysimeter (14 mm/week), but it occurred less frequently. Although the material is coarser, less preferential flow was found in the sandy lysimeter. This is explainable by the increased length of the lysimeter and the lower saturated hydraulic conductivity. In both lysimeters preferential flow occurred only when an increase of mean water content was observed. During the crop vegetation periods, preferential flow was only determined after heavy precipitation events and the amounts were higher than during fallow periods.

It was shown that the presented method enables the quantification of the amounts of preferential flow under natural atmospheric conditions in cropped lysimeters using environmental isotope data.

Stumpp, C., Maloszewski, P., Stichler, W. and Maciejewski, S. (2007). Quantification of heterogeneity of the unsaturated zone based on environmental deuterium observed in lysimeter experiments. Hydrological Sciences Journal, submitted.