First-Flush Effects in the Leaching of Arsenic and Chromium from an Unsaturated Soil Column

L. Hopp 1, U. Buczko 1, S. Peiffer 2, W. Durner 3

1 Department of Hydrology, University of Bayreuth 2 Department of Hydrogeology, RWTH Aachen 3 Institute of Geocology, TU Braunschweig

Motivation

Groundwater risk assessment can normally be subdivided into two parts: an estimation of contaminant release and a transport prognosis. Recently there have been efforts to establish column experiments as a representative basis for quantifying the emission rate of contaminants in the vadose zone.

Column Experiment

Soil column tests were carried out with samples collected from an experimental site contaminated with CCA-based wood preservatives. The predominant contaminants were polyaromatic hydrocarbons, arsenic, chromium and copper.

The experimental procedure is depicted in Fig. 1. It is characterised by transient, unsaturated flow conditions with flow interruption. This allows the identification of sorption non-equilibrium by fitting the data with a process model that describes the time-dependent release and the transport of contaminants in the vadose zone.

Results I

All 26 columns studied so far showed a similar trend: high initial concentrations, followed by an immediate decline to a stable level. After the flow interruption concentrations start again at a higher level, followed by a decrease again. The trend was more prominent in the chromium data compared to the arsenic data. Very often a parallel run of the DOC curve was discernible. Fig. 2 exemplifies a typical leaching curve of chromium and DOC for one soil column.

Interestingly this rapid decline in concentrations was not observed with an inert tracer under identical flow conditions and is therefore not in accordance with model calculations based on purely dissolved contaminant transport. Simulations of the leaching curves with the numerical model Hydrus-1D showed that this leaching pattern could be reproduced with a standard convection-dispersion process (two region model with first-order kinetically controlled desorption).

Hypothesis

Apparently not all significant processes for the discharge of arsenic and chromium have been considered. In order to investigate whether colloid-facilitated transport may be responsible for the rapid decline of metal concentrations observed, the percolates of one soil column were subjected to multiple step ultrafiltration (UF). Additionally, samples of soil solution obtained in-situ at an experimental site were also treated with UF. Concentrations of arsenic, chromium, and DOC (only in selected samples) were analysed in the filtrates.

Fig. 2: Leaching curves of Cr and DOC (specified as non-purgeable org. carbon NPOC).

Results II

Fig. 3: Concentrations of As, Cr, and DOC (specified as non-purgeable org. carbon NPOC) in the UF fractions.

Conclusions

The results of the ultrafiltration study clearly demonstrate that there is a fractionation of contaminant concentrations (Fig. 3). The chromium data show distinct curves of Cr and DOC for one soil column. The chromium data show distinct trends was more prominent in the chromium data compared to the arsenic data. Very often a parallel run of the DOC curve was discernible. Fig. 2 exemplifies a typical leaching curve of chromium and DOC for one soil column.

In-situ samples

Fig. 4: Concentrations of As, Cr, and DOC (specified as non-purgeable org. carbon NPOC) in the UF fractions.

More details: Luisa.Hopp@uni-bayreuth.de www.geo.uni-bayreuth.de/hydrologie/