



## **Removal of Heavy Metals from Aqueous Solutions with Selected Materials**

A. Mentler (1), S. Klepsch (1,2), F. Ottner (1), C. Lesueur (1), N. Lotfi Moustafa (1), R. Neunteufel (1) and M. Fuerhacker (1)

(1) BOKU - University of Natural Resources and Applied Life Sciences, Vienna, Austria, (2) Austrian Research Centers GmbH - ARC, Seibersdorf, Austria

### **INTRODUCTION**

Urban and Industrial waste water effluents as well as street run-off and highway run-off contain heavy metals, which could pose a threat to the environment and have different management opportunities. Heavy metal contamination in run-offs could affect receiving waters and the aquatic life. Groundwater contamination by storm water can also be serious. Infiltration practices should therefore be used with extreme caution in areas where important groundwater is susceptible to contamination and when the pollutant is highly mobile, soluble and has high concentrations and high detection frequencies (Pitt, 2001). Dissolved metal ions are removed from aqueous solutions during infiltration mostly by adsorption onto the near-surface particles, while the particulate metals are filtered out at the soil surface. Metals may be a problem when infiltrating water using a rapid infiltration system, such as a dry well (Crites, 1985). Most metals have very low solubilities at the pH levels found in most natural waters and they are readily removed by either sedimentation or sorption removal processes. Problems encountered were that precipitated heavy metals could be easily redissolved after change in pH and already adsorbed heavy metals could be displaced by exchange processes induced by other salts.

Displacement of adsorbed heavy metals by salty solutions in waste water (for example coming from highway runoff) stated that this gives negatively effects in two ways: on the one hand cations of the salt exchange sorbed heavy metal ions, which go into solution again and on the other hand the chloride of the salt forms chlorine-complexes with cadmium and prevent adsorption anyway. Influence of the pH value on the sol-

ubility of metals can be evaluated only with consideration of the physical/chemical conditions of the system (soil, groundwater) pH and ORP (oxidation reduction potential) conditions. Mobility of heavy metals in soils generally increases with decreasing pH. Mobility of cadmium already starts rising at pH values around 6.5. At neutral to high pH values heavy metals are precipitated but could be easily redissolved after a change in pH (BRÜMMER et al., 1991; BLUME, 1987). Therefore it is important to find materials which bind or adsorb heavy metals in a way to prevent the release and wash out by change in pH or exchange by other salts. In our study the removal of heavy metals from water was investigated to find an optimised material that minimises the negative effects of the named problems. We applied the programs STANMOD and HYDRUS-1D to determine solute transport parameters by inverse modelling.

## **MATERIALS AND METHODS**

Mixed aqueous solutions of Cd, Cu, and Zn were prepared at concentrations of 50 mg L<sup>-1</sup>, 23.2 mg L<sup>-1</sup>, and 96 mg L<sup>-1</sup>, respectively. The pH values of this initial stock solution was 3.0. All chemicals used in these experiments were analytical reagent grade. A mixture of soil and seasand (10 g each) and vermiculite (10g) were used for the column experiments under acid conditions. All metal sorption studies were performed using flow through experiments. Tests were run using a steel column with an inner diameter of 2.1 cm. Flow was kept constant with a HPLC pump at 2 ml/min. Samples were collected in a fraction collector. For kinetic studies, sorption experiments were performed up to approximately 50 h. Samples were analysed using flame atomic absorption spectrophotometers (PerkinElmer 2100). The program CXTFIT implemented in the software STANMOD V.2.2 (STudio of ANalytical MODEls) (Simunek et al., 1999) was used to fit the data of the column experiments to analytical solutions of the convection dispersion equation. With this program, water flow and solute transport parameters for steady-state, one-dimensional flow conditions, accounting for linear sorption processes, can be obtained. Moreover, the finite-element model HYDRUS-1D V.2 (Simunek et al., 1998) was applied to use the more options available for this numerical software.

## **RESULTS**

The soil showed high adsorptivity for copper and were partly in line with batch experiments conducted earlier. The high adsorption capacity for copper exceeded that for cadmium and zinc. In the soil a pH value of 6.1 could be observed with corresponding K<sub>d</sub> values 62, 250 and 40 (l/kg), respectively. For the vermiculite, pH was 5.6 and K<sub>d</sub> values for Cd, Cu and Zn were 40, 87 and 114 (l/kg), respectively. For Cd and Zn saturation in the soil was reached during the experiment. The vermiculite material showed a very high adsorptivity for Zn. Cu and Cd adsorptivity were lower as compared to the

soil. Regarding simulation, adsorption of heavy metals could be calculated with an equilibrium approach for the soil applying linear and Freundlich isotherms, whereas inverse modelling of the column experiments point to occurrence of sorption kinetics for the vermiculite.

## CONCLUSION

Due to the high pH of the soil, it might be possible that several retention processes such as precipitation, coprecipitation, and surface sorption contribute simultaneously towards metal removal from aqueous solutions. For the metals studied, the adsorbed amount decreased with decreasing pH. This is also due to the adsorption of the vermiculite, which was performed at a pH of 5.7 in comparison to the soil with a pH of 6.5. The results of the adsorption experiments were in line with the batch experiments performed.

## REFERENCES

- Blume, H-P.; Brümmer, G. (1987). Prognose des Verhaltens von Schwermetallen in Böden mit einfachen Feldmethoden. Mitt. Dt. Bodenkdl. Ges., 53: 11-117; Göttingen.
- Brümmer, G.; Hornburg, V.; Hiller, D.A. (1991). Schwermetallbelastung von Böden. Mitt. Dt. Bodenkdl. Ges., 63: 31-42; Göttingen.
- Crites, Ronald W. (1985). "Micropollutant Removal in Rapid Infiltration." In: *Artificial Recharge of Groundwater*. Edited by Takashi Asano. Butterworth Publishers, Boston, pp. 579-608.
- Pitt, R. (2001). Stormwater Management for Highway Projects, Symposium an the Pollution of Water Sources from Road Run-Off, March 19, 2001, Tel Aviv University, Israel.
- Simunek, J., M. Sejna, & M.Th. van Genuchten (1998). The HYDRUS-1D software package for simulating the one-dimensional movement of water, heat, and multiple solutes in variably-saturated media. Version 2.0, IGWMC - TPS - 70, International Ground Water Modeling Center, Colorado School of Mines, Golden, Colorado, 202pp.
- Simunek, J., M.Th. van Genuchten, M. Sejna, N. Toride, & F. J. Leij. (1999). The STANMOD Computer Software for Evaluating Solute Transport in Porous Media Using Analytical Solutions of the Convection-Dispersion Equation, U.S. Salinity Laboratory, USDA/ARS, Riverside, California. Toride, N., Leij, F.J. & van Genuchten, M.Th. 1995. The CXTFIT Code for Estimating Transport Parameters from Laboratory or Field Tracer Experiments, Version 2.0. Research Report No. 137, U. S. Department of Agriculture Riverside, California.