



## **Relevance of colloidal carriers in contaminant transport in the vadoze zone: insights from experiment and modeling**

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The transport of persistent contaminants in the vadoze zone takes place in a 4-phase system. Mobile particles which may contribute significantly to contaminant transport typically exhibit particle sizes in the colloidal domain (1 – 1000 nm) like natural inorganic colloids as e.g. clays or natural complexing agents as e.g. humic substance. For the unsaturated soil environment only little is known about the role of natural colloids for the relocation of contaminants in general and hence it is difficult to assess a-priori the relevance of this process for a specific site and situation.

Among others two main task are:

- 1) To assess the transport of colloids itself. The transport of colloids is the net result from removal & dissolution and release & generation. The process of colloid removal consists of two steps: collision with the collector (soil matrix, aquifer material) and the attachment to the collector. Colloid release is partly depending on composition of the water phase but mechanical shear forces are commonly not known and difficult to assess.
- 2) To assess the interaction of the contaminant with the immobile soil matrix and the mobile and fixated colloidal phases. Here the partition between solute, matrix and colloid is of importance and may be influenced by the large specific surface area of colloidal phases.

Column experiments were carried out with natural sediment in saturated and unsaturated columns in order to describe and predict colloid transport in natural environments. Transport experiments were carried out with natural and polystyrene particles. In addition, re-mobilization at different flow velocities and hydrochemical boundary conditions was investigated. Colloid filtration was tested at different ionic strength and colloid surface charge.

Colloid filtration experiments with different ionic strengths showed that the filtration theory can be extended by a modified sticking probability in order to provide a first estimate of colloid retention in the soil. This sticking probability was not directly derived from electrostatic interaction forces but taking into account heterogeneous charge distributions. Thus, even under unfavourable conditions for colloid deposition, it was possible to describe colloid filtration.

Analysis was undertaken on natural colloidal dispersions (humic acid isolated from forest soil) to investigate the desorption behaviour of selected elements using a Chelex resin. Only a small fraction of iron, copper and lead was removed from the suspension by Chelex resin while e.g. calcium and zinc were nearly completely depleted.

Size fractionation together with ICP-MS analysis was carried out on original and Chelex resin treated humic acid extract to elucidate size-specific binding behaviour. Two different size domains were found which behave different according to the type of metal analysed.

Using a numerical forward modelling approach it was possible to identify cases, where colloid bound transport is the major pathway for the relocation of hydrophobic contaminants and cases, where colloid transport can be neglected.