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Colloid-facilitated Transport of Contaminants over Redox Cycles in Temporary Flooded Riparian Wetland Soils

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Riparian wetland soils develop in dynamic interaction with the adjacent river channel and underlying groundwater. Temporary flooding of otherwise well-aerated soils may cause periods of microbially-driven soil reduction, followed by abiotic oxidation when O2 supply is restored. Over such redox cycles, the mobility of metal contaminants may be affected both directly by altering contaminant speciation as well as indirectly by altering sorbent phases.

The role of potentially mobile sorbent phases, such as colloidal particles and dissolved organic matter (DOM), has been demonstrated in oxic systems, but is unclear under variable redox conditions. It has been hypothesized that clay particles are mobilized as colloids in the reduction period that were previously cemented to the soil matrix but detach when cementing Fe(III) oxide phases reductively dissolve. In the aeration period, Fe(III) (hydr)oxides colloids are produced by homogeneous Fe(II) oxidation. Especially when stabilized by sorption of DOM, both clay and Fe(III) oxide colloids could be mobile in soils and facilitate the translocation of strongly sorbing contaminants.

In our research we investigate the mechanisms controlling formation and stability of colloidal particles and the dynamics of DOM under variable redox conditions. In a microcosm setup we incubate soil samples over flooding and aeration cycles and examine the effect of colloid-facilitated transport on the mobility of selected redox-sensitive (As(V)/As(III)) and rather redox-insensitive (Pb(II), Cu(II)) contaminants. The microcosm is equipped with a profile of open-pore (15μm) mini suction cups for extraction of pore water including colloidal particles over depth- and redox-gradients. Ultrafiltra-

tion (0.025μm) allows for comparing concentration and redox speciation of dissolved with colloid-bound elements using ICP-OES, TOC-analyzer, phenanthroline, and a selective hydride generation ICP-OES coupling for As(III/V) measurements, respectively. Colloid size and zeta potential are monitored using dynamic and electrophoretic light scattering.

Preliminary results from incubating mining-contaminated soil sampled at the river Mulde near Bitterfeld, Saxony-Anhalt, Germany show a tenfold increase of As, Cu, and Pb concentrations in the pore water within 3 weeks of flooding. As expected, the mobilization of As from 0.3 to 5.1 mg/L was accompanied by a shift in redox speciation from As(V) to As(III). Work in progress evaluates Al, Si, Fe(II/III) and TOC concentrations in filtered versus unfiltered pore water samples to derive indications for the presence of DOM-stabilized clay or Fe(III) oxide colloids and relates those findings to colloid size and zeta potential measurements.

At the interface between groundwater and the river channel water, riparian wetlands have an important function within the hydrological cycle. Within the EU-AQUATERRA project, our research is intended to determine the conditions, under which riparian wetlands act either as a sink or a source for contaminants, and thus to contribute to an improved understanding of contaminant mobility on the river basin scale.