

Microbial controls on contaminant metal transport in porous media

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Toxic heavy metals in aquifers, which may arise from either natural geologic processes or anthropogenic activities, pose risks to human health as well as to other life forms. Previous laboratory experiments have demonstrated that bacteria commonly found in geologic settings are likely to adsorb metal contaminants, a fact suggesting that their presence can attenuate metal migration. However, as bacteria are also likely to migrate through the groundwater system a better understanding of the combined effect of these two processes is required.

The aim of our laboratory study is to explore a) the affinity bacteria exhibit towards metals b) the effect that bacterial shape and surface chemistry have on the bacterial filtration and c) use the above data to develop predictive models of the impact of microbes on metal mobility in porous media.

We make use of *Micrococcus Luteus* (spherical shape) and *Pantoea Agglomerans* (rod shape) species, grown in the same medium to mimic the nutrient uniformity of the subsurface environment and a range of metals. Potentiometric titrations and spectroscopic measurements are conducted in order to identify the type and concentration of sites present on the bacterial wall. The stability constants for the adsorption of metals onto these sites are determined through batch adsorption experiments

Titration and Zn adsorption experiments confirm that by using the same growth medium, the two microbes acquire the same surface chemistry in terms of site pKa, site concentrations and Zn stability constants. We envisage that the use of a set of thermodynamic metal stability constants will improve the accuracy of the reactive transport model used to simulate our data.

Immobilisation of Arsenic in paddy soil by Iron(II)-oxidizing bacteria

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Arsenic-contaminated groundwater is an environmental problem with about 1-2% of the world's population affected. As arsenic-contaminated water is also used for irrigating rice fields, the uptake of arsenic via rice is in some cases even higher than via drinking water. Arsenic is oftentimes of geogenic origin, in many cases bound to iron(III) minerals. Microbial iron(III) reduction leads to dissolution of Fe(III) minerals and thus the arsenic bound to these minerals is released to the environment. In turn, iron(II)-oxidizing bacteria have the potential to co-precipitate or sorb arsenic during iron(II) oxidation followed by iron(III) mineral formation.

We are currently investigating arsenic co-precipitation and immobilization by anaerobic and aerobic iron(II)-oxidizing bacteria. Co-precipitation batch experiments with pure cultures of nitrate-dependent, phototrophic, and microaerophilic Fe(II)-oxidizing bacteria are used to quantify the amount of arsenic that can be immobilized during microbial iron mineral precipitation. Iron and arsenic speciation and redox state are determined by synchrotron-based methods (EXAFS, XANES). Microcosm experiments are set-up either with liquid media or with rice paddy soil amended with arsenic. Rice paddy soil from Vercelli (Italy) including a natural population of Fe(II)-oxidizing microorganisms is used as inoculum. Dissolved and solid-phase arsenic and iron are quantified, As speciation is determined and the iron minerals are identified. Additionally, As uptake into the rice plant is quantified and a gene expression pattern in rice (*Oryza sativa cv Gladia*) is determined by microarrays as response to the presence and stimulation of aerobic and anaerobic Fe(II) oxidizing bacteria.