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Microbial and mineralogical characterization of zero-valent iron barriers

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The use of zero-valent iron in permeable reactive barriers (PRB's) has been shown to be very effective for passive, long-term applications of groundwater remediation. A remaining issue, however, relates to the longevity of the iron barriers. Corrosion of the iron grains and the subsequent precipitation of minerals can lead to loss of iron reactivity, reduced hydraulic conductivity, and the development of preferential flow. Little is known about the microbial activity and dynamics within and in the vicinity of the Fe^0-barrier matrix. Major uncertainties need to be resolved with respect to the adaptation of indigenous micro-organisms to the strongly reducing Fe^0 environment, changes in the microbial community composition, and their beneficial or detrimental effects on the longevity and long-term efficiency of the Fe^0 barriers.

We used PCR-DGGE with general and group specific primersets on samples of both lab-scale and pilot-scale multifunctional permeable reactive barriers (MULTIBARRIERS) to study the evolution of the microbial population and to get a clearer view on the different groups of micro-organisms that are present. Multibarriers can be used for the treatment of mixed contaminant plumes by a combination of abiotic and biotic removal processes and samples were taken from different column configurations which were running under different electron acceptor conditions. Regardless which electron acceptor conditions were used, less biomass was detected in the iron columns compared with the aquifer columns and biomass was particularly located in the bottom of the iron columns. Different groups of bacteria (including denitrifying, iron-reducing and sulfate-reducing bacteria) were detected, in the aquifer columns as well as in the iron columns and the mixed columns. Methanogens were only detected in the columns with iron-reducing conditions and the columns without extra electron acceptor.

Besides the microbial screening of the different barrier systems, the geochemical interactions were studied by the observation of aqueous geochemical data as well as the identification of iron corrosion products and other mineral precipitates by scanning electron microscopy (SEM), combined with energy dispersive x-ray analysis (EDX) and X-ray diffraction (XRD). The main secondary phases include vivianite ($Fe_3(PO_4)_2.8H_2O$), siderite ($FeCO_3$), ferrous hydroxy-carbonate ($Fe_2(OH)_2CO_3$) and carbonate green rust ($Fe_4^{II}Fe_2^{III}(OH)_{12}CO_3.2H_2O$). Iron sulfides were detected in samples of the columns under sulfate-reducing conditions, which is corresponding with the detection of sulfate-reducing bacteria. Oxides (magnetite, hematite, maghemite) were not detected amongst secondary phases.

Microbial and mineralogical characterization of full-scale PRB samples is ongoing.