Evidence of Biogeochemical Transformation Processes in an EVO Biobarrier

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Biogeochemical transformation processes refer to the abiotic transformation of contaminants by minerals that occur naturally or were formed by biological activity. The minerals most frequently involved in the biogeochemical transformations are iron sulfides. Sulfate reducing bacteria reduce naturally occurring sulfate to sulfide which then reacts with soluble iron forming iron sulfide precipitates. This can occur on the surface of other minerals like quartz or occur in the water column.

At a TCE contaminated site in California experiencing DCE stall, an emulsified vegetable oil (EVO) biobarrier was installed and a commercially available dechlorinating culture was added to promote complete degradation of TCE to ethene. In the area of the biobarrier, baseline sulfate concentrations were between 365 to 895 mg/L and ferrous iron concentrations were between 0.169 to 6.65 mg/L. A series of fourteen injection wells were installed to form a biobarrier. In wells 8 through 14, 50% of the EVO was injected with followed two weeks later by the dechlorinating culture. After approximately one week, the remaining 50% of the EVO was injected into the wells. Black precipitates were noted in the groundwater samples from the wells within 2 months of the second (final) round of EVO injections. These precipitates were accompanied by a drop in pH from an average of 7.5 to 6.5. In addition to the black precipitates, a grey foamy material was also noted in the wells. The objective of this evaluation was to determine the chemical characteristic of the black precipitates formed in these wells.

Groundwater samples were taken for analysis of the black precipitates. Total and soluble sulfide concentrations in the groundwater were measured. The black precipitates were analyzed by X-ray diffraction (XRD) and scanning electron microscopy – electron dispersive backscatter (SEM EDS). Total sulfide concentrations in the wells range from 0.325 to 31.5 mg/L. Based on the XRD and SEM EDS analyses, the samples were composed of a mixture of minerals, crystalline material and organic material. SEM-EDS analysis was able to differentiate the organic material from the mineral material. Specifically in wells 9 and 11, the particles were mainly gray and foamy in nature and were shown to be either biofilm or surfactant. However, the black precipitates from well 11 had FeS_2 particles distributed throughout the precipitate. The groundwater from wells 12, 13 and 14 was dark with black particles suspended in the water. These particles were also very fine, but revealed the presence of an organic material (biofilm or surfactant) along with FeS and FeS_2 mineral particles. The black precipitate also turned red upon exposure to oxygen. Wells 12, 13 and 14 had higher initial sulfate concentrations than wells 9 and 11. Wells 12 and 14 were also the last wells to receive EVO injection. Soluble lactate could have transferred from the wells initially injected (11 and 13) into the area of wells 12 and 14. This soluble lactate would promote the faster growth of sulfate reducing bacteria and therefore sulfate reduction to sulfide.