Evolution of Trace Metal Removal Products in Field-scale Vertical Flow Bioreactors

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Abstract: A passive treatment system, including two parallel vertical flow bioreactors (VFBR), was constructed in 2008 to treat net-alkaline ferruginous mine drainage in the Tar Creek Superfund Site in northeastern Oklahoma. The VFBR were installed to remove trace metals through a variety of mechanisms, including adsorption, carbonate precipitation, organic complexation, and sulfide precipitation. Substrate samples from the VFBR were collected in 2010 and 2014 and subjected to sequential extraction procedures to determine the final products of trace metal removal. Trace metals that were examined included Cd, Co, Fe, Mn, Ni, Pb, and Zn. Average total concentrations of Cd, Co, Fe, Mn, Ni, Pb, and Zn were 1.4, 6.9, 2.3, 2.3, 5.8, 2.3, and 4.1 times greater in 2014 than in 2010, respectively. Comparison of results from the two sampling episodes demonstrated an evolution in the final products, from less stable constituents in 2010 to more stable constituents in 2014. Higher percentages of all seven trace metals were found in the exchangeable fraction in 2010 than in 2014, while higher percentages were found in the organic/sulfide fraction in 2014 than in 2010. Adsorption played an important role in trace metal removal in the first two years of operation of the VFBR, but by the end of six years of operation, sulfide precipitation became the primary method of Cd, Co, Fe, Ni, Pb, and Zn removal. Removal of Mn was dominated by adsorption and carbonate precipitation in the first two years, but by the end of six years organic complexation accounted for nearly a third of Mn removal. With the exception of Mn, the majority of trace metals are being retained as insoluble sulfides in the mature VFBR.

Additional Key Words: Bacterial sulfate reduction, sulfide precipitation, sequential extractions

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