

Constructed Wetland Bioremediation of Chlorinated Organic Compounds in a Groundwater Capture and ReInjection System

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Background/Objectives. Control and treatment of a mixed inorganic and chlorinated VOC groundwater plume emanating from a historical unlined waste storage lagoon was required as part of an overall Site strategy to remediate a complex mixture of dissolved chemicals in an alluvial aquifer with sands and silts. Constituents requiring treatment included nitrate (>1,000 mg/L), sulfate (>350 mg/L), tetrachloroethylene (PCE) (~21,000 µg/L), carbon tetrachloride (CT) (~4,700 µg/L), cyanide (CN) (~1,400 µg/L), and molybdenum (Mo) (~10 µg/L). Previous operations to treat the groundwater through conventional ex situ, while successful, were found to be costly. Therefore, one of the primary objectives was to develop a system to treat this complex array of constituents in a cost-effective manner and to manage long-term operation and maintenance (O&M) costs. Factors such as groundwater conservation and sustainability also factored into the decision-making process.

Approach/Activities. Based on the results of a technology screening it was decided to utilize hydraulic control with upgradient reinjection as the primary means to control plume migration. An evaluation of treatment methods for the extracted water identified biological treatment utilizing constructed wetlands as a viable treatment alternative to conventional methods. The design included an anaerobic horizontal subsurface flow (HSSF) wetland to function as a bioreactor to remove nitrate, sulfate, Mo, PCE and CT followed by an aerobic vertical flow (VF) wetland to remove ammonia, cyanide, and reduce biological oxygen demand prior to filtration and reinjection to the aquifer. The HSSF wetland was filled with a layer of approximately 2 m of locally-sourced wood chips to provide a carbon source and create reducing conditions. Water level is maintained just below the top of the wood chips as it moves laterally through the HSSF wetland. The VF wetland includes an approximately 1.5 m thick sand layer with an underlying gravel drainage layer. Water is introduced at the top of the sand and moves downward via unsaturated flow. Both the HSSF and VF wetlands are topped with 0.5 m of peat and indigenous wetland plants. Parameters including mass loading, temperature variation, degradation rates, evapotranspiration and the rate of carbon release from the wood chips were used to determine the HSSF wetland bioreactor volumes.

Results/Lessons Learned. Reducing conditions were quickly created in the HSSF wetland after being filled with extracted groundwater and have been consistently maintained throughout the HSSF wetland with only minor addition of biologically available carbon in the colder months. Nitrate and sulfate reduction greater than 99% and 75%, respectively, is observed, and effluent concentrations for all parameters continue to be less than discharge limits. After approximately 6 months of operation and data collection, it has been observed that reductive dechlorination of PCE and CT commenced without the addition of cultured dehalococoides and initial PCE concentrations of greater than 12 mg/L are consistently reduced by more than 99% in the effluent of the HSSF wetland. Monitoring points within the HSSF wetland indicate that nitrate and sulfate are reduced within the first 25 percent of the wetland. This supports the reductive dehalogenation of PCE to vinyl chloride, degradation of CT and CN, and removal of Mo through the remainder of the wetland. The VF wetland has been successful in reducing BOD (75%) and vinyl chloride (88%), but residual BOD and vinyl chloride in the effluent are a concern and are being evaluated to determine if adjustments to the VF wetland are needed. Data collection is ongoing, and approximately 1 year of data will be compiled for presentation at the conference.