INFLUENCES OF PREFERENTIAL FLOW ON MICROBIALLY MEDIATED REDUCTIVE DECHLORINATION OF CHLORINATED SOLVENTS

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Distinct and consistent areas of focused ground-water discharge (seeps) have been identified and characterized in two freshwater tidal wetlands at Aberdeen Proving Ground, Maryland, using thermal infrared imaging technology. These areas of more rapid ground-water discharge result in elevated mass flux of dissolved chlorinated ethane, ethene, and methane contaminants from contaminated aquifers, through overlying wetland sediments, to the surface water. Evidence supporting efficient natural attenuation of contaminants, primarily due to anaerobic biodegradation, has been collected in non-seep areas of the wetlands. A combination of field and laboratory studies are being conducted to characterize the influence of seeps on biodegradation of chlorinated solvents and evaluate the feasibility of conducting enhanced bioremediation in seep areas to reduce the overall mass flux of contaminants to surface water.

Results of field investigations indicate that the hydrology in seep areas in the two freshwater tidal wetlands impacts biodegradation by: (1) increasing contaminant loading to the wetland sediments, (2) decreasing residence time in the anaerobic wetland sediments, (3) changing oxidation-reduction (redox) conditions, and (4) changing the indigenous microbial community compared to non-seep areas. Lateral and vertical distribution of contaminants shows that shallow wetland porewater in most seep areas is dominated by parent compounds at equivalent concentrations observed in the aquifer, whereas non-seep areas are dominated by anaerobic daughter compounds at lesser concentrations. Seepage measurements indicate a one- to two-order of magnitude increase in interstitial velocity of porewater in the seep areas compared to non-seep areas of the wetland sediments. The increased flux is also evident in elevated levels of major ions in surface water typically associated with ground water in the near vicinity of the seeps. This increased velocity and resulting flux indicates that there is a lower residence time of porewater within the wetland sediments. The more rapid transfer of aerobic ground water from the aquifer to the wetland surface is evident in the detected levels of redox constituents. Concentrations of ferrous iron, methane, and sulfide indicate that wetland sediments in most seep areas are iron-reducing, or mixed iron- and sulfate-reducing, whereas wetland sediments in non-seep areas are methanogenic or mixed iron-reducing and methanogenic. Microbial community analysis of the seep sediments shows an overall decrease in abundance and diversity of the bacterial population compared to sediment in areas where efficient degradation has been previously observed. However, some microbial groups considered key to the different degradation reactions of the contaminants are present in the seep sediments.

In the laboratory, continuous, up-flow columns are being used to simulate field conditions and evaluate the effect of bioaugmentation on the ability of seep-area sediments to degrade chlorinated solvents. Degradation rates, before and after bioaugmentation, will be compared to seepage rates to determine the feasibility of enhanced bioremediation in seep areas.

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