BIOSTIMULATION AND BIOAUGMENTATION TO ENHANCE DEGRADATION OF CHLORINATED SOLVENTS IN WETLAND SEDIMENTS

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Chlorinated solvents, including 1,1,2,2-tetrachloroethane (TeCA) and trichloroethene, are reaching land surface in localized areas of focused ground-water discharge (seeps) in a wetland and tidal creek in the West Branch Canal Creek area, Aberdeen Proving Ground, Maryland. Although natural attenuation has been shown to be an effective ground-water remediation method in much of the wetland, biostimulation and bioaugmentation are being tested as possible methods to enhance anaerobic degradation in the seep areas. For bioaugmentation tests, a mixed anaerobic culture was developed by enrichment of wetland sediment collected from two sites in the study area where rapid and complete reductive dechlorination occurs.

To test the effect of biostimulation by nutrient (ammonia and phosphate mixture) addition, anaerobic batch microcosms to measure TeCA degradation were constructed with wetland sediment and ground water collected from three sites in early June and September 2002. Microcosms were constructed during these two periods to determine whether growth of wetland plants in the summer limited nutrient availability for microbes and caused the lower biodegradation rates observed in previous experiments during the summer and early fall (July through October). In the June 2002 microcosms, nutrient addition enhanced the degradation rate of TeCA by nearly 40 percent for two of the sediments compared to controls that did not receive added nutrients. Degradation of TeCA's anaerobic daughter compounds (1,1,2-trichloroethane, 1,2-dichloroethane, trichloroethene, 1,2-dichloroethene, and vinyl chloride) was not enhanced substantially by nutrient addition, and daughter compounds remained after 35 days of incubation. In the September 2002 microcosms, nutrient addition either had no effect or decreased TeCA degradation rates in the three sediments compared to microcosms without added nutrients. Although TeCA degradation rates were lower in the September 2002 microcosms than in the June 2002 microcosms, limited nutrient availability does not seem to be a factor.

To test the effect of bioaugmentation, microcosms constructed with wetland sediment from the three sites in September 2002 were amended with TeCA and the developed anaerobic mixed culture in media (suspended culture addition was 10 percent by volume of the microcosm solution). TeCA biodegradation rates were about 100 percent higher in the bioaugmented microcosms than in controls amended with culture media alone. In addition, bioaugmentation substantially enhanced degradation of the daughter compounds. Rapid biodegradation of TeCA and its chlorinated daughter compounds in the bioaugmented microcosms was associated with more rapid methanogenesis than in microcosms without the added mixed culture. The sum of chlorinated daughter products that accumulated in the bioaugmented microcosms reached a maximum of 25 percent (calculated as percent of the initial TeCA added), and complete degradation of TeCA and the daughter products occurred in less than 25 days in the methanogenic microcosms. In contrast, 100 percent daughter product accumulation was observed in the media controls, and substantial concentrations of chlorinated daughter products remained after 42 days. Bioaugmentation, therefore, was more effective than biostimulation.