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Bioaugmentation for Complete Dechlorination of Chlorinated Ethenes

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Micro-organisms can reductively dechlorinate solvents such as tetrachloroethene (PCE) and trichloroethene (TCE) to less-chlorinated degradation intermediates and, environmental conditions permitting, environmentally acceptable end products such as ethene and ethane. However, years of field investigations, laboratory microcosm studies, and field pilot testing have revealed that PCE and TCE dechlorination stalls at cis-1,2-dichloroethene (cis-1,2-DCE) at a significant number of sites. The incomplete dechlorination often does not relate to electron donor type, concentration or availability; rather it relates to the intrinsic capabilities of the indigenous microbial populations, and to the presence and activity of specific micro-organisms termed halorespirers. A recent field demonstration by the Remediation Technologies Development Forum (RTDF) at Dover AFB in Delaware demonstrated that while TCE was dechlorinated to cis-1,2-DCE with electron donor addition (biostimulation), further dechlorination of the cis-1,2-DCE via vinyl chloride to ethene only occurred after the introduction of non-native dechlorinating bacteria into the subsurface (bioaugmentation).

We have enriched a stable culture, called KB-1, that dechlorinates PCE to ethene. Separate enrichment cultures targeting each individual chlorinated ethene were developed from KB-1 about 3 years ago. These enrichment cultures differ from each other in the range of ethenes that they can dechlorinate. The cultures enriched on vinyl chloride as electron acceptor are no longer able to effectively dechlorinate PCE. We have conducted laboratory and field evaluations of bioaugmentation at 5 different sites. At two California sites, TCE dechlorination invariably stalled at cis-1,2-DCE. Bioaugmentation with KB-1 promoted rapid and complete dechlorination of the cis-1,2-DCE to ethene in microcosms, with half-lives from 1 to 5 days. Bioaugmentation also successfully promoted TCE dechlorination past cis-1,2-DCE to ethene in microcosms from a fractured bedrock site in New Jersey, indicating that this approach may be feasible for fractured bedrock environments. We have also conducting laboratory trials for a site in Texas to evaluate bioaugmentation in high concentration areas. KB-1 can dechlorinate TCE to ethene at TCE concentrations up to at least 100mg/L. Therefore, bioaugmentation may be a suitable technology for treatment near to source areas.