Treatment of 1,4-Dioxane and CVOCs by Bioaugmented Granular Activated Carbon and Bioaugmented Synthetic Zeolite

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Background/Objectives. Chlorinated volatile organic compound (CVOC) contaminated water resources are frequently contaminated with complex environmental problems that have been treated in a simplified manner for decades. Many CVOC remediation plans do not address 1,4-dioxane (1,4-DX), using methods that are ineffective in treating 1,4-dioxane, such as air-stripping or enhanced reductive dechlorination. While individual remediation technologies exist for each separate contaminant class, many are inappropriate for simultaneous treatment of 1,4-dioxane and CVOCs. There exists an immediate need for remediation techniques that can be used in complex biogeochemical and co-contaminant groundwater sites. Furthermore, recent studies suggest that the chlorinated ethenes such as trichloroethene (TCE), cis-1,2-dichloroethene (cDCE), and 1,1-dichloroethene can have negative impacts on biodegradation of 1,4-DX as well as potential competitive adsorption effects. This study explores the use of bioaugmented granular activated carbon (bioaugmented GAC) and bioaugmented synthetic zeolite ZSM-5 (bioaugmented zeolite) for the remediation mixed 1,4-DX and CVOC contaminated water.

Approach/Activities. In order to assess the feasibility of using bioaugmented GAC and zeolite as a treatment train system for 1,4-dioxane contaminated groundwater, a combination of batch reactors and flow-through columns were prepared using the bioaugmented and abiotic forms of the selected adsorbents. The bioaugmented adsorbents were inoculated with *Pseudonocardia dioxanivorans* CB1190 or *Mycobacterium austroafricanum* JOB5 prior to the start of the experiments. The reactions were monitored over time for both 1,4-DX and CVOCs and the results from bioaugmented reactors were compared with their abiotic counterparts. 1,4-DX and CVOC aqueous concentrations were plotted for abiotic and bioaugmented sorbents, for both batch and flow-through column modes, to determine both treatment kinetics as well as treatment extent. 1,4-Dioxane and CVOCs were measured using a Gas Chromatograph-Mass Spectrometer (GC-MS) or a GC eqipped with flame ionize detector (GC-FID). Bacterial growth was quantified by qPCR amplification of taxonomic and functional genes.

Results/Lessons Learned. Zeolite and GAC were demonstrated to adsorb 1,4-DX at a wide range of concentrations. Bioaugmented adsorbents combined adsorption, which rapidly removed the 1,4-DX and CVOCs from contaminated water, with biodegradation, which converted 1,4-DX to CO_2. Biodegradation by attached bacteria resulted in lower 1,4-DX concentrations available for desorption than the removal achieved by the abiotic adsorbents. Individual CVOCs had little effect, but CVOC mixtures slowed the removal of 1,4-DX by GAC. Both zeolite and GAC preferentially adsorbed TCE and cDCE over 1,4-DX. This approach lessened the inhibition of 1,4-DX biodegradation by CVOCs. These results suggest that bioaugmented adsorbents in ex-situ bioreactors or permeable reactive barriers might be an effective means of simultaneously treating both CVOCs and 1,4-DX in water resources. This research presents a novel approach for concurrent treatment of various pollutant mixtures in water.