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Can TCE, 1,4-Dixoane, and Cr^{6+} in a Dilute Plume Be Treated Concurrently through In Situ Cometabolic Bioreactors?

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Background/Objectives. Large dilute industrial plumes often contain a variety of chemicals and thus, multiple treatment processes are often needed to removal all contaminants of concern (COCs). A treatment process that can degrade many of these COCs at the same time would be expected to provide significant cost saving for site cleanup. In some dilute plumes, chlorinated solvents, 1,4-dioxane, and hexavalent chromium (Cr^{6+}) are co-present in groundwater. A recent field study has shown that 1,4-dioxane and many chlorinated ethenes and ethanes in a dilute plume can be degraded concurrently to levels below site-specific cleanup goals by aerobic cometabolism. Reduction of Cr^{6+} has been known to occur under both aerobic and anaerobic biogeochemical conditions. An intriguing question naturally arises: Can aerobic cometabolism treat all these COCs concurrently?

Approach/Activities. A literature review was conducted to evaluate whether the biogeochemical reactions of chromium reduction and aerobic cometabolism can occur concurrently. The review focused on: (1) chromium reduction and biosorption under aerobic biogeochemical conditions and (2) the range of possible biogeochemical conditions in the field achievable by aerobic cometabolic biodegradation. The potential rates of relevant degradation or removal processes reported in the literature will be used to assess the feasibility of concurrently treating a hypothetical mixed plume of TCE (100 µg/L), 1,4-dioxane (50 µg/L), and Cr^{6+} (100 µg/L) to their respective assumed cleanup goals of 5 µg/L, 6 µg/L, and 10 µg/L through engineering calculations and/or modeling.

Results/Lessons Learned. The initial literature review indicates that the processes of chromium biological reduction and bio-sorption under aerobic conditions is compatible with aerobic cometabolic oxidation processes. Some aerobic Cr^{6+} reduction bacteria and algae have been efficiently used to treat Cr^{6+}-rich wastewater. Aerobic bacteria with nitrogen fixing capability appears to enhance both Cr^{6+} reduction and aerobic cometabolism. A field-scale study on in situ aerobic cometabolic biodegradation of 1,4-dixoane, TCE, and 1,2-DCA indicates that stable performance is achievable under both high and low dissolved oxygen conditions in groundwater. The literature review suggests concurrent removal of TCE, 1,4-dioxane, and Cr^{6+} is promising. The results of the reaction kinetics review and engineering calculations/modeling will be presented. These will be used to show a potential design of an in situ aerobic cometabolic bioreactor and the expected performance of the treatment of the hypothetical mixed dilute plume.