Treatment of 1,4-Dioxane with Permanganate

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Background/Objectives. 1,4-Dioxane was used as a stabilization agent for chlorinated solvent mixtures and as a result is frequently detected in groundwater as a co-contaminant at sites where chlorinated solvents have been released. Treatment of 1,4-dioxane can be challenging and many of the remediation technologies that are effective for chlorinated solvents have limited effectiveness for treatment of 1,4-dioxane. When 1,4-dioxane is identified as a primary contaminant of concern, remediation costs can increase and frequently in situ methods of treatment are removed from the technology selection process.

Traditionally, when oxidation is considered as a treatment technology for destruction of 1,4-dioxane, advanced oxidation processes that use a combination of ozone, hydrogen peroxide, or UV are selected. Because of the nature of advanced oxidation processes, application of oxidation for 1,4-dioxane is typically conducted ex situ. In situ remedies for 1,4-dioxane have been limited to ozone sparge and injection of activated persulfate. Permanganate, which is frequently used for in situ oxidation of chlorinated ethenes, has been generally considered ineffective on 1,4-dioxane. However, while permanganate requires a longer contact time for complete oxidation of 1,4-dioxane than other oxidants (weeks as opposed to minutes), the reaction kinetics are sufficient for oxidation. This paper will present the results of several bench test studies that demonstrate that 1,4-dioxane can be oxidized by permanganate

Approach/Activities. Two bench tests were conducted to identify the optimal oxidant design mixture for treating 1,4-dioxane released as a co-contaminant with chlorinated solvents (PCE and 1,1,1-TCA) at two sites. The 1,4-dioxane concentrations targeted for treatment during bench testing ranged from 100 ppb to 1,000 ppb. Both bench tests evaluated the use of permanganate, persulfate, and a combination of permanganate and persulfate for treatment of 1,4-dioxane. For both bench tests, the study was completed in two phases. In the first phase, the total concentration of oxidant was varied and the ratio of permanganate to persulfate was held constant. In the second phase, the ratio of permanganate to persulfate was varied and the total concentration of oxidant was held constant.

Results/Lessons Learned. For both bench tests, 1,4-dioxane was completely oxidized by permanganate within 14 days. For both bench tests, the treatment that consisted of 100% permanganate performed as well or better for oxidation of 1,4-dioxane than the treatments with varying ratios of persulfate to permanganate. For both bench tests, the treatment that consisted of 100% permanganate performed as well or better for oxidation of 1,4-dioxane than the treatments that consisted of 100% persulfate. For both bench test, minimal variation of 1,4-dioxane was observed in control samples. Pilot testing for field demonstration of the bench test results is planned for the fall of 2018. Based on the results of the bench test, additional data evaluation was performed at several sites where 1,4-dioxane was present as a co-contaminant with a chlorinated ethenes, and where injection of permanganate has been completed. Preliminary evaluation of field data indicates that decreases of up to 30,000 ppb of 1,4-dioxane have been observed in monitoring wells where permanganate has been injected. The presentation will discuss the results of the bench test, the results of the upcoming pilot test injection, and present field data from several sites where permanganate injection has been conducted for treatment of chlorinated ethenes and ethanes that are co-contaminated with 1,4-dioxane.