

Treating 1,4-Dioxane with Activated Persulfate

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Background

1,4-Dioxane is a known carcinogen that has emerged as a contaminant of concern in the United States and multiple other countries. It continues to emerge in other regions. It is commonly used in commercial products and as a stabilizer. 1,4-Dioxane is only degraded under specific circumstances such as cometabolic aerobic bioremediation but is readily degraded by powerful oxidative radicals such as the sulfate or hydroxyl radical. Due to its use, it is found in wastewater effluent and in contaminated groundwater. Within the subsurface, it is most commonly found at sites co-mingled with the chlorinated solvents it was used to stabilize and their daughter products. The co-mingling of 1,4-dioxane with chlorinated solvents can make treatment of the entire contaminated suite more complex as 1,4-dioxane is typically treated using an oxidative radical pathway and several of the chlorinated solvents are best treated with a reductive pathway. In several instances this has led to sites where the chlorinated solvents were treated only to expose the untreated 1,4-dioxane. As such, understanding if 1,4-dioxane is present at a site may dictate remedy selection.

1,4-Dioxane is also atypical compared to the contaminants it is often comingled with as it is miscible in water and has a very low organic carbon partitioning coefficient (K_{oc}) resulting in unique transport characteristics compared to the contaminants with which it is usually comingled.

Approach

In Situ chemical oxidation using activated potassium persulfate was evaluated at two separate sites contaminated with a mixture of 1,4-dioxane, chlorinated ethenes, and chlorinated ethanes. The sites were first evaluated in a series of column reactors where site groundwater was run through the columns until the potassium persulfate had been consumed. Two different activation chemistries were evaluated at the bench: (1) iron activation using zero-valent and (2) alkaline activation using hydrated lime. Although both activation chemistries demonstrated complete treatment of 1,4-dioxane to below the detection limit, hydrated lime was selected for the subsequent pilot and full-scale field implementation due to its ability to treat the full suite of contaminants present, including dichloroethanes (1,1-DCA and 1,2-DCA).

Results

Field data not only evaluated treatment effectiveness but also the persistence of potassium persulfate under flow-through conditions in a Permeable Reactive Barrier (PRB) configuration. Field data indicates the potassium persulfate was persisting as expected based on the observed groundwater velocities and temperature. Performance monitoring showed a reduction of 1,4-dioxane, chlorinated ethenes, and the chlorinated ethanes concentrations to below the detection limit within the PRB. Significant reductions in groundwater concentrations were also observed downgradient from the PRB over time.

Author brief biography:

Josephine Molin, M.Sc. - Josephine Molin is the Technology Applications Manager for ISCO technologies at Evonik. She has over 20 years of experience in the application of Evonik's portfolio of in situ remediation technologies and in her current role she helps guide new product development, R&D and lab studies, and assist clients with remedial design, data interpretation and application strategies for implementation of ISCO. She received a Master's degree in Environmental Engineering from Uppsala University in Sweden in 2003, during which she published and presented her work on using surfactant modified zeolites for adsorption of viruses and bacteria in groundwater.

Presentation format: Platform preferred

Sustainability angle: The case study highlights a passive, in situ treatment approach using a permeable reactive barrier (PRB) as a viable, less energy consuming alternative to a more classic pump and treat approach. The persulfate product used (Klozur® KP) was manufactured using renewable hydroelectric power.