Remediating 1,4-Dioxane Contaminated Groundwater
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Introduction
Water quality is one of the most important environmental issues in the United States. One of the biggest threats to groundwater quality is contamination from industrial solvents. Chlorinated solvents such as trichloroethene (TCE), tetrachloroethene (PCE), and 1,1,1-trichloroethane (1,1,1-TCA) represent some of the most prevalent groundwater contaminants observed worldwide [1].

Another contaminant often associated with industrial solvent use is 1,4-dioxane (dioxane). Dioxane is a colorless, flammable liquid that is used as a stabilizer and corrosion inhibitor with chlorinated solvents. Recognized as a possible human carcinogen (Class B2), improved analytical testing has now verified the presence of dioxane in ground and surface waters.

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Figure 1: 1,4-Dioxane structure.

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Research Objective
My objective was to use ISCO to treat 1,4-dioxane-contaminated water. This was accomplished by comparing three different methods of delivering persulfate: 1. one dose; 2. multiple doses; and 3. slow-release oxidant candles.

Methods
For my experiment, I treated 500 mg L⁻¹ dioxane with three different persulfate treatments.

1. One Dose – 0.75 g of persulfate was added to 50 mL of dioxane (persulfate conc = 15,000 mg L⁻¹)
   • Samples taken every 10 min for 1 h.

2. Multiple Doses – 0.75 g split into 4 doses of 0.1875 g and added every 30 min
   • Samples taken every 10 min for 2 h.

3. Persulfate candles (3:1 ratio oxidant to wax)
   • Samples taken once a day for five days

Persulfate Chemistry
Sodium persulfate is one oxidant commonly used with ISCO. While persulfate is an oxidant, a stronger oxidizing persulfate radical can be formed with activation by iron.

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\text{S}_2\text{O}_8^{2-} + \text{Fe}^{2+} \rightarrow \text{SO}_4^{2-} + \text{SO}_4^{2-} + \text{Fe}^{3+}
\]

Results
Results show that both one and multiple dose treatments lead to an initial decrease in dioxane concentration but both treatments eventually reached a plateau (Fig. 4,5). The candle treatment produced a gradual and consistent degradation rate (Fig. 6). Given that our control wax treatment showed that dioxane was not adsorbed by wax, we hypothesize that products of the dioxane-persulfate reaction may be interfering with the persulfate radical; these products may be adsorbed by the wax matrix of the candles.

Figure 4: Reaction Kinetics: One Dose

Figure 5: Reaction Kinetics: Multiple Doses

Conclusion
Slow-release oxidant candles provided a more consistent means of degrading 1,4-dioxane. Products of the dioxane-persulfate reaction are being investigated.

References

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