Figure 9-1 In Situ Bioremediation of Carbon Tetrachloride

CCL₄ degrades by replacement of chlorine atoms with hydrogen atoms in anaerobic conditions.

Are conditions anaerobic? [Yes] No

Are CCL₄ degradation products present? CH₂Cl, CHCl₃, CHCl₂, CH₄

Are dehalorespiers present? [Yes] No

Deplete competing electron acceptors

A co-metabolite may have to be introduced to promote degradation of high concentrations of CF to DCM

Microcosm Test to:
- Establish appropriate redox conditions & modification, or bioaugmentation, or
closure of competing electron acceptors

Microcosm Test to:
- Confirm reactions and kinetics
  - Test reaction chemistry
  - Test various electron donors

Complete site conceptual model?

Have permitting and approval requirements been identified? [Yes] No

Pilot field test

Has underground injection control inventory been submitted? [Yes] No

Is field stoichiometry adequately documented? [Yes] No

Can amendments be adequately distributed & mixed? [Yes] No

Does monitoring indicate a decrease in electron donor & appropriate mass balance among e-donor and degradation compounds? [Yes] No

Does performance testing demonstrate adequate reliability & sustainability? [Yes] No

Have you identified and satisfied all additional permitting requirement for full scale deployment? [Yes] No

Scale-up, engineering design, amendment & operating costs, electrical costs, nutrient costs

Review regulatory requirements & resubmit treatability study application to authorized State or EPA

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Figure 9-2 In Situ Bioremediation of Carbon Tetrachloride

1. Are conditions reversible? (Yes/No)
   - Yes: Denitrification/Cometabolism.
   - No: Manipulate ORP conditions be manipulated into the denitrifying range.

2. Is there enough NOs and Carbon Source to mineralize all Carbon Tetrachloride? (Yes/No)
   - Yes: Can a simple carbon source be introduced? (Yes/No)
   - No: A simple electron donor will work best e.g. molasses or alcohol.

3. Is the reaction producing CF and other degradation products? (Yes/No)
   - Yes: Has nutrient been identified? (Yes/No)
   - No: Reductive Dehalogenation.

4. Can ORP conditions be maintained at denitrifying levels? (Yes/No)
   - Yes: Complete site conceptual model.
   - No: Did mono benzene tetrachloride (MCT) compound to MCL with daughter products? (Yes/No)

5. Have permitting and approval requirements been identified? (Yes/No)
   - Yes: Pilot field test.
   - No: Review regulatory requirements & resubmit treatability study application to authorized State or EPA.

6. Has underground injection control inventory been submitted? (Yes/No)
   - Yes: Can amendments be adequately distributed? (Yes/No)
   - No: Does monitoring indicate a decrease in ORP, NOs and electron donor? (Yes/No)

7. Does monitoring demonstrate and increase in alkalinity? (Yes/No)
   - Yes: Does performance testing demonstrate adequate reliability & sustainability? (Yes/No)
   - No: Have you identified and satisfied all additional permitting requirement for full scale deployment? (Yes/No)

8. Scale-up, engineering design, amendment & operating, costs, electrical costs, nutrient costs.

Class IV wells are to be used when re-injecting groundwater containing a regulated hazardous waste.
Class V wells should be used for all other amendment additives.

Is the problem biotailing, chemical interference, equipment malfunction or hydrologic controls?

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