In Situ Thermal Hydrolysis of 1,2-Dichloroethane (EDC) in Fine-Grained Soil: Pilot Test

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Agenda

• Site Background
• Hydrolysis of EDC
• Pilot Study Approach
• Heating History and Issues
• Sampling Results
• Summary and Conclusions
Site Background
Why the need for the project

- Elevated EDC in soil and groundwater due to historical operations (former EDC product rail loading facilities)
- Limited Access – cannot disrupt operational rail lines
Site Geology
Hydrolysis of 1,2-dichloroethane
EDC Transformation

• Neutral Hydrolysis – reaction with water at neutral pH conditions

• EDC Hydrolysis
  • \( \text{C}_2\text{H}_4\text{Cl}_2 \text{ (EDC)} + 2\text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_6\text{O}_2 \text{ (ethylene glycol)} + 2\text{H}^+ + 2\text{Cl}^- \)
  • Abiotic production of ethylene glycol
  • Ethylene glycol is biodegradable
  • Temperature strongly accelerates hydrolysis rate

\[ \text{EDC} + \text{H}_2\text{O} \rightarrow \text{Ethylene Glycol} \]
Thermal Hydrolysis Lab Test

• 2008 Lab Study:
  • Site soil/groundwater
  • Closed batch reactors incubated at approx.:
    • 20°C
    • 80°C
    • 100°C
  • Monitored for EDC and abiotic degradation products (Cl⁻, glycol)
Field Scale Pilot Test
Field-scale Pilot Study

Pilot Objectives:

1. To reduce the concentration of EDC in soil at Block 270 Former Railcar Loading Area.
2. Develop a better understanding of the effectiveness and applicability of in situ thermal hydrolysis as a remedial technology for EDC.
3. Provide operational data to help optimize the design and operation of future in situ thermal hydrolysis at other sites.
4. Target Concentrations: 500 mg/kg in soil.
Electrical Resistance Heating

- Alternating current is applied to subsurface electrode arrays
- Electrical resistance of the soil generates heat
- ERH relies on water for electrical conductance
- SVE for contaminant recovery when needed
- Temperature limited to boiling point of water at local pressure

Typical energy applied – 200 to 300 kW-hrs/cy
Site Layout

- 24 vertical electrodes
- 15 Monitoring Locations (Temperature, Water Samples)
- Initial target temp.: 60°C
- Depth: 2-7 m interval
- Target area: ~16m x 27m
- Treatment Soil Volume: 2,160 m³
Heating History and Issues
Unexpected Observations:

- Rapid response to system changes
- Area near center of site difficult to heat
Soil Temperatures Varied in Pilot Test Area

• Differences in soil properties (EC)?

• Unknown source of water in area?
Sampling Results
Sample Locations
## Groundwater Results - Summary

<table>
<thead>
<tr>
<th>Location Name</th>
<th>Sample Date 1</th>
<th>Sample Date 2</th>
<th>EDC (mg/L) 1</th>
<th>Chloride (Cl) (mg/L) 1</th>
<th>% Reduction ([O-E]/E)</th>
<th>EDC (mg/L) 2</th>
<th>Chloride (Cl) (mg/L) 2</th>
<th>% Reduction ([O-E]/E)</th>
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<tbody>
<tr>
<td>12MW0005-270</td>
<td>11-Mar-13</td>
<td>31-May-14</td>
<td>2510</td>
<td>34.1</td>
<td>-99%</td>
<td>19.3</td>
<td>127</td>
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<tr>
<td>12MW0008-270</td>
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<td>31-May-14</td>
<td>71.9</td>
<td>96.2</td>
<td>-22%</td>
<td>56.3</td>
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<tr>
<td>12MW0009-270</td>
<td>28-Aug-13</td>
<td>31-May-14</td>
<td>1540</td>
<td>298</td>
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<td>10.5</td>
<td>62.5</td>
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<tr>
<td>12MW0011-270</td>
<td>11-Mar-13</td>
<td>31-May-14</td>
<td>2590</td>
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<td>0.0958</td>
<td>10.5</td>
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<tr>
<td>12MW0012-270</td>
<td>28-Aug-13</td>
<td>31-May-14</td>
<td>153</td>
<td>108</td>
<td>-85%</td>
<td>23</td>
<td>192</td>
<td>-</td>
</tr>
</tbody>
</table>
EDC vs. Chloride

MW05

MW08

MW11
EDC Vs. Temperature

MW05

MW08

MW011
Soil Results

EDC in Soil

- BH07
- BH08
- BH09
- BH10

EDC, mg/Kg

- Oct-13
- Dec-13

Ethylene Glycol in Soil

- BH07
- BH08
- BH09
- BH10

EG, mg/Kg

- Oct-13
- Dec-13
Summary and Conclusions
Summary and Conclusions

• EDC Reduced in soil and groundwater (pilot test objectives met)
• Indications that hydrolysis occurred
• Some reductions may be result of other factors (volatilization?)
• Uneven soil heating was a problem
• Final soil and groundwater sampling underway this week
• Wells are being slug tested to evaluated differences in hydraulic K across the site
Factors affecting choice of in situ hydrolysis

• Only appropriate for chemicals that hydrolyze at relatively low temperatures (for example, EDC, 1,1,1-TCA)
• Site hydrogeology (low groundwater flow velocities helpful in achieving target temperatures)
• Site factors, such as access restrictions or presence of structures, that might preclude other approaches, such as soil mixing
• Availability and cost of energy
• Local infrastructure, especially occupied buildings
EDC, Chloride, and Ethylene Glycol

MW009

- EDC
- Chloride
- Ethylene Glycol

Graph showing the levels of EDC, Chloride, and Ethylene Glycol over time.