IN-SITU CHEMICAL OXIDATION
ACTIVE INDUSTRIAL FACILITY NEAR SÃO PAULO, BRAZIL

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Facility Overview

- Active chemical manufacturing facility
- Historical release of xylene at truck loading area
- Treatment area adjacent to river
- Affected zone
  - 3-7 m: silty sand
ISCO Technical Challenges

- Pressure and temperature control
- Application adjacent to river
- Vertical contaminant migration
- Chemical storage and safety
International Challenges
United States / Brazil

- Language, hand signals (translation of key technical/field terms)
- Units of measure (English to metric)
- Logistics for equipment and chemicals (transportation and delivery)
ISCO Process

- Oxidant and reagent screening
- Continuous dosage refinement
  1. Oxidant demand empirical modeling (initial dosage determination)
  2. Design Parameter Evaluation (dosage refinement)
  3. First/pilot field application (dosage refinement)
  4. Subsequent polishing field application if necessary
# 1. Oxidant Screening/Selection

<table>
<thead>
<tr>
<th>Oxidant</th>
<th>Volts&lt;sup&gt;(1)&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluorine (F)</td>
<td>3.0</td>
</tr>
<tr>
<td>Hydroxyl Radical (OH• )</td>
<td>2.7</td>
</tr>
<tr>
<td>Sulfate Radical (SO4• )</td>
<td>2.6</td>
</tr>
<tr>
<td>Ozone (O₃)</td>
<td>2.4</td>
</tr>
<tr>
<td>Sulfate (S₂O₈²⁻)</td>
<td>2.1</td>
</tr>
<tr>
<td>Hydrogen Peroxide (H₂O₂)</td>
<td>1.8</td>
</tr>
<tr>
<td>Permanganate (MnO₄⁻)</td>
<td>1.7</td>
</tr>
<tr>
<td>Chlorine (Cl₂)</td>
<td>1.4</td>
</tr>
</tbody>
</table>

<sup>(1)</sup> = Provided by FMC Corporation
Activating Sodium Persulfate

Activation methods for sodium persulfate:

- Presence of transition metal
- Heat (> 40°C)
- Hydrogen peroxide (H₂O₂)
- Alkaline conditions (high pH)
- Ultraviolet

Catalyzed hydrogen peroxide (CHP) uses synergistic activation via 3 of the 5 activation methods:

1. presence of transition metal
2. heat
3. hydrogen peroxide
2. Laboratory Treatability Test

- ISCO with radicals is **not** solely stoichiometric
- Total oxidant demand (TOD) is determined via predictive empirical modeling and laboratory testing
- Oxidant demand and viability confirmed via parallel oxidant formulation treatability tests

**Treatability test objectives include:**

1. determine reactivity of the site media
2. select the optimum reagent formulation
3. observe adverse reactions, if any
Chemical Safety

Oxidant properties

- reactive with most metals
- highly acidic (pH < 2)
- requires careful handling/use

Chemical Storage:

- stored in cool/dry area
- ISCO solutions homogenized in vented, chemically compatible vessels
Application Metrics

- Target treatment Area: 500 m²
- 28 application wells total
- Over 700 m of chemical hose
- Over 25 tons of chemicals applied
- Two weeks of reagent application
Application Well Coverage
Solution Vessels
Reagent Distribution Manifolds
Pressure Monitoring and Flow Control
Results

- 2 weeks of safe ISCO reagent application
- Treatment Area reduced with one application from:
  - 500 m² to approximately 100 m²
  - Initial 28-well ISCO application reduced to a “Hot Spot” covering 6 ISCO wells
Challenges Going Forward

- Portion of plume was not included in initial ISCO application (identified during post-ISCO investigation activities).
- Additional source material identified in isolated deeper zone beneath original treatment area.
- Major flood in 2011 submerged treatment area and mobilized deeper source material into original shallow treatment area.
- Additional ISCO treatment planned for near future.
Questions

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