A Field Study
on the Limitations of
ISCO Applications

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RPIC Federal Contaminated Sites National Workshop
April 14-16, 2014
Presentation Outline

• Why the Study
• Study Methodology
• Study Results
  • Distribution Summary
  • Effect of Pressure
  • Effect of Pulsing
  • Persistence
• Wrap Up
Why This Talk?

• Growing trend towards in situ approaches
  • New kid on the block
  • “Traditional” technologies kind of work but not really, especially for source zones, are we desperate?
  • Is in situ being “over applied”?
  • Is application ahead of academic research?
  • Does the chemistry work?
  • Do we know where the injectant is going?
Study Methodology

- **Site**
  - Unconsolidated
    - Fill & silty sand
    - Sand lens
  - Heterogeneous
    - $K \text{ } 10^{-5}$ to $10^{-1}$ m/sec

- **Data Collection**
  - 5 m by 5 m plots
  - Cores - 1 m horizontal grid
  - Cores - 0.2 to 0.25 m vertical grid
  - ~250-300 pore water samples per cell
  - Pore water analyzed for indicator parameters
Study Methodology

• Comparison field study
  • Oxidants
    • Percarbonate (RegenOx)
    • Persulfate (Klozur)
    • Hydrogen Peroxide
    • Stabilized Hydrogen Peroxide
    • All injected at 7.5 wt. %

• Injection Methods
  • Direct Push – Side Injection (SIT)
  • Direct Push – Drop Point (DP)
  • Vertical 1.5 m Well

• Treatment
  • Not evaluated
Study Methodology

Theory

Reality?

Groundwater Flow

- Injection Well/Point
- Monitoring Well
- Soil Core
Study Methodology

• Comparison field study
  • Pressure
    • 20 psi
    • 50 psi
    • 80 psi
    • Method of Delivery
  • Pulsing
    • 5 minutes cycles
    • 3 delivery methods
• Persistence
  • 24 hours
  • 168 hours (1 week)
Distribution

- McGregor & Rose (in press)
  - Evaluated lateral and vertical distribution
    - Injection wells vs Direct Push (DP vs SIT)
    - Various Oxidants

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<table>
<thead>
<tr>
<th>Injection Point</th>
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<tbody>
<tr>
<td>Direct Push - DP</td>
<td>Well</td>
<td>Direct Push - SIT</td>
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Persulfate
Distribution

- McGregor & Rose (in press)
  - Evaluated lateral and vertical distribution
    - Injection wells vs Direct Push (DP vs SIT)
    - Various Oxidants

Midpoint Using SIT Method

- Percarbonate
- Hydrogen Peroxide
- Persulfate
Distribution Summary

• McGregor & Rose findings:
  • Percarbonate > Persulfate > Hydrogen Peroxide
  • Lateral distribution
    Side Injection Tool (SIT) > Drop Point (DP) > Wells
  • Vertical distribution
    Side Injection Tool (SIT) > Drop Point (DP) > Wells
• Heterogeneity effects
  Wells > Drop Point (DP) > Side Injection Tool (SIT)
Results

Effect of Pressure
Effects of Pressure

Parallel to Flow: Persulfate

Perpendicular to Flow: Persulfate
Effects of Pressure

Persulfate - Direct Push: SIT

Persulfate - Wells

$\frac{C}{C_0}$

Distance from Injection Point (m)

Distance from Well (m)

Flow Direction

Transverse to Flow

Monitoring Wells

Injection Port/Well

Flow
Effects of Pressure

Radius of Detection

• Higher pressures did not correlate to larger RODs

• $\text{ROD}_{\text{Percarbonate}} > \text{ROD}_{\text{S2O8}} > \text{ROD}_{\text{H2O2}}$

• ROD Direct Push > ROD Wells

• ROD for Direct Push & Wells ~ similar parallel and perpendicular to flow
Results

Effect of Pulsing
Effects of Pulsing

Parallel To Flow: Persulfate

Perpendicular To Flow: Persulfate
Effects of Pulsing

• Similar RODs as with no pulsing at 20 psi, 50 psi and 80 psi.

• $\text{ROD}_{\text{Percarbonate}} > \text{ROD}_{\text{S2O8}} > \text{ROD}_{\text{H2O2}}$

• ROD Direct Push > ROD Wells

• ROD for DP & Wells ~ uniform
Results

Persistence
Persistence - Hydrogen Peroxide

![Graph showing persistence of hydrogen peroxide in different sand types: Fine Sand, Medium Sand, Silty Sand, with data points indicating concentration ratio (C/Co) over time (24 hours).]
Persistence - Hydrogen Peroxide

C/C^0

Target Zone

Fine Sand

Medium Sand

Silty Sand
Persistence - Percarbonate

- Fine Sand
- Medium Sand
- Silty Sand

Graph showing C/Co values for 24 hours and 168 hours.
Persistence Summary

Oxidant

- Percarbonate > Persulfate > Hydrogen Peroxide
- Hydrogen peroxide degraded too fast to measure

Geologic Material

- Oxidants persisted longer in coarser-grained materials relative to finer grained materials
Summary

• In situ approaches increasing with time
• Limitations with all approaches
• Lower pressures provide greater distribution
• Wells appear to be more susceptible to heterogeneity than direct push methods (DP & SIT)
• Pulsing had little to no effect on distribution or radius of detection
• Percarbonate had greater persistence than persulfate which was significantly greater than hydrogen peroxide
Questions?