Restoring Water Resources Through Soil Remediation: A Case Study on Smouldering Remediation

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Smouldering Experiments


Proof of the STAR Concept
Laboratory Experiments: Chemical Analysis

Coarse Sand Sand + Fresh Coal Tar

Up to 1000mg/kg <0.1mg/kg 70,000mg/kg
Scaling the STAR Process

- Proof of concept: 2006
- Laboratory testing: 2006 - present
- Intermediate testing: 2007 - present
- Ex situ demonstrations: 2008
- In situ demonstrations: Oct 2009 to present
Smouldering Remediation
Ex Situ Demonstration

Conc (TPH) = 31,000 mg/kg ± 14,000 mg/kg  Conc (TPH) = 10 mg/kg ± 4 mg/kg

### Treatment Grains Analysis

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Grains</th>
<th>Analysis points</th>
<th>Quartz</th>
<th>Tridymite</th>
<th>Cristobalite</th>
<th>Dumortierite</th>
<th>Geothite</th>
<th>Hematite</th>
</tr>
</thead>
<tbody>
<tr>
<td>untreated</td>
<td>5</td>
<td>9</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>500°C</td>
<td>3</td>
<td>5</td>
<td>0.60</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.40</td>
</tr>
<tr>
<td>1000°C</td>
<td>3</td>
<td>9</td>
<td>0.56</td>
<td>0.22</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.22</td>
</tr>
<tr>
<td>smouldering remediation</td>
<td>12</td>
<td>37</td>
<td>0.32</td>
<td>0.16</td>
<td>0.08</td>
<td>0.22</td>
<td>0.14</td>
<td>0.05</td>
</tr>
</tbody>
</table>

The table shows the analysis of various grains after different treatments. The treatments include untreated, 500°C, 1000°C, and smouldering remediation. The analysis points indicate the relative abundance of Quartz, Tridymite, Cristobalite, Dumortierite, Geothite, and Hematite.
Fate of Organic Contaminants: GCxGC-TOFMS

Masses: TIC

Coal tar

- N
- C1N
- DBF
- ACE
- PHE/A
- NT
- FLU
- Naphtho-thiophene
- CBZ
- FLT
- PYR

Fate of Organic Contaminants: GCxGC-TOFMS Coal tar
After remediation: front section zoomed

- Toluene (solvent)
- DCM (syringe wash solvent)
- Propanoic acid esters
- Benzyl alcohol
- Benzaldehyde
- Alkyl benzenes

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Potentially Toxic Element Availability

- USEPA M1313: pH dependent leaching
- USEPA M1314: column leaching (L/S ratio $\uparrow$)
- 2 soils: field-obtained loam and made ground
M1313 Results: Arsenic

![Graph showing arsenic concentration vs pH]

As concentration (mg/L)

As (untreated)
As (+coal tar +smouldered)
M1313 Results: Lead

The graph shows the relationship between pH and As concentration (mg/L) for different treatments:
- Pb (untreated)
- Pb (+coal tar +smouldered)
- As (spiked)
- As (+CT+sm)

The data points are plotted on a logarithmic scale for both axes, indicating the spread of results across various pH values and As concentrations.
M1314 Results: Lead

The graph shows the relationship between the liquid to solid ratio (L/S) and the leachate Pb concentration (mg/L). The different shapes and colors represent different conditions:

- Blue diamonds: Pb (soil)
- Red squares: Pb (soil + coal tar + remediation)
- Green triangles: Pb (soil spiked with PTEs)
- Purple crosses: Pb (spiked soil + coal tar + remediation)
M1314 Results: Arsenic

![Graph showing arsenic levels with different conditions.](image-url)
Conclusions and Future Work

• Contaminant source removal makes significant progress toward aquifer restoration

• Trace contaminants require further attention:
  – pH effects
  – Reductive conditions
  – Soil mineralogy changes

• Groundwater re-infiltration modelling