In-situ Flushing of Petroleum Contaminated Soil

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Scope of the presentation

✓ Principle of in-situ flushing
✓ Lignin derivatives as prospective flushing agents
✓ Work objectives
✓ Experimental setup
✓ Results and discussions
  ▪ Petroleum hydrocarbons
  ▪ Heavy metals
✓ Conclusions and recommendations
Principle of the process

In Situ Soil Flushing Technique

Main features of in-situ flushing

✅ Lower costs associated with in-situ treatment (no soil excavation/ building demolition required)
✅ Minimal interruption of commercial/industrial activities at the site
✅ Treatment rates are generally slower than for ex-situ treatment
✅ “Open” treatment system
Lignosulfonates as prospective flushing agents

- By-product of pulp and paper industry (~3,000,000 t/year worldwide).
- Uses: vanillin, industrial surfactants, polymer fillers, etc.
- Chemical properties: phenolic, carboxylic, aldehyde groups.
- Act as mild surfactants
- Bind metal ions.
Work objectives

- Bench-scale study
  - To evaluate commercially available lignosulfonates as flushing agents in in-situ treatment of petroleum contaminated soils
- In case of a successful treatment
  - Provide recommendations for a pilot-scale study
Experimental setup

- Phase I – aqueous solubility tests
- Oil added to 100 ml of water or LS solution
- Parameters under evaluation: type and concentration of LS, pH, and contact time
Experimental setup

✓ Phase II – slurry leaching
✓ 100-200 g samples of contaminated soil (spiked and actual)
✓ Parameters under evaluation: type and concentration of LS, pH, and contact time
Experimental setup

✓ Phase III – column leaching
✓ 1,000-1,500 g samples of contaminated soil
✓ Parameters under evaluation: volume and concentration of flushing solution, pressure, and contact time
Experimental setup

✓ Phase IV – leachate treatment
✓ Membrane filtration used to concentrate contaminants and reduce the leachate volume
Test results: The effect of lignosulfonate concentration on the solubility of petroleum hydrocarbons
Results of slurry leaching: Diesel fuel
Results of slurry leaching: Heavy oils

Heavy oils (area counts) in the leachate

- Lignin
- Water

Spiked soil samples
Results of column leaching: Total petroleum hydrocarbons

- Initial soil
- Soil Cell 1
- Soil Cell 2
Test results: Leachate treatment

✓ Permeates generated using semi-permeable membranes Desal-5, G50 and G20 (all of GE Osmonics)
✓ Concentrate is biodegradable
## Removal of heavy metals

<table>
<thead>
<tr>
<th>Contaminants*</th>
<th>Percentage removal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>“conventional” process</td>
</tr>
<tr>
<td></td>
<td>with lignin derivatives</td>
</tr>
<tr>
<td>Hg</td>
<td>0%</td>
</tr>
<tr>
<td>U</td>
<td>0%</td>
</tr>
<tr>
<td>Cd</td>
<td>26%</td>
</tr>
<tr>
<td>Cr (III)</td>
<td>0%</td>
</tr>
<tr>
<td>Pb</td>
<td>29%</td>
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</tbody>
</table>

* Initial concentrations: 500 mg/L
Stabilization of hexavalent chromium

Total chromium in the leachate (ppm)

Lignosulfonate/chromium mass ratio

- pH 4
- pH 7
- pH 10

Graph showing the stabilization of hexavalent chromium at different pH levels and lignosulfonate/chromium mass ratios.
Conclusions and recommendations

- Lignosulfonates enhance the removal of petroleum hydrocarbons from soil in situ flushing
- Ammonium lignosulfonate is the most effective agent
- Leachate can be concentrated using membrane filtration
- Heavy metal removal observed. Possibility for the treatment of mixed contaminated soil
- Stabilization of hexavalent chromium in the soil observed
- Pilot-scale trial is recommended
Flow chart of the proposed pilot test system
Cross section of the treatment zone