Feasibility of integration of an electrodialytic process into soil remediation procedure for removal of copper, chromium and arsenic

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Presentation outline

• Site characteristic and history
• A new approach to soil remediation - Combination of soil washing and electrodialytic remediation (ED)
• ED principles and results
• Conclusions
COLLSTROP CONTAMINATED SITE – FORMER CCA - WOOD IMPREGNATION PLANT

Colour map source: „Transformation of natural ferrihydrite aged in situ in As, Cr and Cu contaminated soil studied by reduction kinetics” S.S. Nielsen et al. / Applied Geochemistry 51 (2014) 293–302
Soil characteristics and criteria to fulfil

<table>
<thead>
<tr>
<th>mg/kg DM</th>
<th>Location A – for lab scale investigations</th>
<th>Location B – excavated and washed in Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu</td>
<td>1130 ±90</td>
<td>183 ± 80</td>
</tr>
<tr>
<td>Cr</td>
<td>300 ±20</td>
<td>10 ± 5</td>
</tr>
<tr>
<td>As</td>
<td>214 ±5</td>
<td>220 ± 80</td>
</tr>
</tbody>
</table>

Contribution of contaminants load in each fraction to overall content in hot spot soil sample

Danish clean soil criteria

<table>
<thead>
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<th>Metals</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu</td>
<td>500</td>
</tr>
<tr>
<td>Cr</td>
<td>500</td>
</tr>
<tr>
<td>As</td>
<td>20</td>
</tr>
</tbody>
</table>
COMBINATION OF SOIL WASHING AND ELECTRODIALYTIC REMEDIATION

- Soil in Situ
- Excavation
- Backfilling
- Soil Regeneration
- Coarse fraction >63 µm
  - About 80% of soil
- Separation
- Clay fraction ≤63 µm
  - About 20% of soil
- Electrodialytical remediation
- Clay fraction ≤63 µm
- Arsenic
- Cu
- Cr

Adjust pH, Ad nutrients + compost

About 80% of soil
Soil washing

- decrease mass of treated material
- increase initial contaminant concentration

Soil separation to fractions

Electrodialytic remediation

Arsenic faith after soil washing
Electrodialytic (ED) remediation

Arsenic (AsO$_4^{3-}$, AsO$_3^{3-}$)

Copper (Cu$^{2+}$)

Anode (+)

K$_{2}$-1
Lab scale results

Removal of metals and arsenic
- Cations were removed at low pH, in a first phase lasting for 2 days,
- Anions at high pH, in a second phase lasting for 15 days

Removal of arsenic only
- Material: fine-B, fine fraction from soil washing facility, and fine-M, fine fraction from laboratory sieving;
- The experiments were performed in 2C cell setup, where slurry were kept at high pH 10-11 for 12 days
ED – up-scaling
Pilot plant
Performance of ED in pilot scale

Variations of main parameters during ED pilot remediation applied for soil-A suspension (45kg of soil in 515 L of water): applied voltage (a) and current (b) to electric field; pH and conductivity of suspension (c); concentration of Cu and As in electrolytes (d) and Cu, As and Fe mobilized to water phase (e)
Comparison of energy use per removed contaminant

<table>
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<th>Location A – for lab scale investigations</th>
<th>Location B – excavated and washed in Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soil-A</td>
<td>Fine-A</td>
</tr>
<tr>
<td>Cu</td>
<td>1130 ±90</td>
<td>8500 ±1600</td>
</tr>
<tr>
<td>Cr</td>
<td>300 ±20</td>
<td>1900 ±200</td>
</tr>
<tr>
<td>As</td>
<td>214 ±5</td>
<td>2080 ± 400</td>
</tr>
</tbody>
</table>
Conclusions and perspectives

- It is possible to apply electrodialytic remediation for separation of arsenic and copper from soil materials, but chromium remains a challenging compound;
- The amount of treated material can be reduced with the help of soil washing that enables to separate the most contaminated soil fractions, which were found to be the finest and light/organic fractions;
- To remove cations it is necessary to mobilize them at low pH, but for anions removal, especially arsenic, high pH of the suspension has to be used to have sufficient arsenic mobilization and anions forms;
- The ED remediation was found to be feasible for up-scaling;
- The main factors influencing the ED process in the pilot scale are:
  - pH of treated suspension,
  - stirring routine to maintain material suspension.
Any questions?

Thank You