BAUXITE RESIDUE VALORISATION AND BEST PRACTICES CONFERENCE
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Risks, Remediation and Recovery: Lessons for Bauxite Residue Management from Ajka

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• Risks
  – Fugitive dusts
  – Leachates
  – Soils & sediments
• Biological Impacts
• Remediation
• Recovery
Risks: fugitive dusts

Risks no greater than urban dusts; some evidence of mild respiratory irritation

Longer term studies valuable / toxicological information – valuable for rehab, particularly in arid areas

Risks: leachates

- pH 13.1, high alkalinity, Na, K, Ca, Si, Al, P, SO$_4$, range of other oxyanionic metal(loid)s: As, Cr, Mo, V

- Sequential filtration
  - Particulate
  - Colloidal
  - Truly dissolved
Leachate characterisation

- Cd, Cu, Pb, Zn < LOD

Limitation data available of leachate composition: essential for post-closure remedial planning.

Analytical suites crucial

Risks: soils & sediments

- Comparisons with Threshold and Probable Effects Levels (TEL / PEL)
- PEL exceeded for ~<20km (some reference sites exceed!)
- Hotspots of deposition
- Typically >60% in hard-to-leach fractions

<table>
<thead>
<tr>
<th>Selected Elements</th>
<th>Solid concentration (mg.kg(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>As</td>
<td>78 ±38 (5.9 / 17)</td>
</tr>
<tr>
<td>Cd</td>
<td>4 ±2 (0.6 / 3.5)</td>
</tr>
<tr>
<td>Ce</td>
<td>405 ±67</td>
</tr>
<tr>
<td>Co</td>
<td>97 ±13</td>
</tr>
<tr>
<td>Cr</td>
<td>811 ±108 (37 / 90)</td>
</tr>
<tr>
<td>Cu</td>
<td>56 ±8 (36 / 197)</td>
</tr>
<tr>
<td>Ga</td>
<td>79 ±3</td>
</tr>
<tr>
<td>La</td>
<td>150 ±13</td>
</tr>
<tr>
<td>Mo</td>
<td>14 ±3</td>
</tr>
<tr>
<td>Na</td>
<td>39918 ±1300</td>
</tr>
<tr>
<td>Ni</td>
<td>321 ±58 (18 / 36)</td>
</tr>
<tr>
<td>Pb</td>
<td>157 ±20 (35 / 91)</td>
</tr>
<tr>
<td>U</td>
<td>339 ±28</td>
</tr>
<tr>
<td>V</td>
<td>907 ±52</td>
</tr>
<tr>
<td>Zn</td>
<td>173 ±40 (123 / 315)</td>
</tr>
</tbody>
</table>

XANES – oxidation state

**Chromium** present as Cr(III) substituted into hematite

Vanadium is present in V(V) oxidation state; most likely as vanadate

Arsenic present as As(V); sorbed to red mud particles as arsenate

Composition – REE / CRM

- Enrichment of a range of critical raw materials
- Availability limited – >95% in particulate phases with exception of Ga and V

Based on flux of material released: in the region of US $0.8 million

+ Opportunities for 'passive recovery' from leachates?
+ Particularly relevant for elements that both have value and are environmental pollutants

Biological impacts

- Most trophic levels assessed by various workers
- Difficulty in discerning causal effects
- Na enrichment appears crucial (above metals)
- Representative of affected areas?

Ecotox data lacking for many red mud contaminants and in appropriate matrices
Remediation – acid dosing of leachate

- Effective buffering, limiting mobility of most elements
- Some retain mobility in aqueous phase (e.g. V)
Remediation – gypsum dosing of leachate

- $2OH^-_{(aq)} + CaSO_4.2H_2O_{(s)} + 2CO_2 \leftrightarrow CaCO_3_{(s)} + SO_4^{2-}_{(aq)} + 2H_2O_{(l)} + H_2CO_3_{(aq)}$
- $\sim 35\%$ CO$_2$ in secondary deposits from atmosphere
- Some metals associated with secondary deposits

Remediation – ploughing residual red mud

- <5cm layer, ploughed into topsoil, biofuel crops
- Salinity issues, and organic complexation at alkaline pH → increases mobility of Ni and As

Downstream trends: rapid dilution with some hotspots of deposition.

Recovery

Summary

• Initial risks well-managed; nuisance dusts
• Biological impacts: salinity → pH → metals?
• Majority of metal inventory in forms posing minimal risk
• Recovery far quicker than documented elsewhere
• Valuable environmental information support post-closure remediation plans incorporating carbon accounting and possible value recovery

Thank you!