Mine Water Treatment with Cement Kiln Dust (CKD)

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Acid Rock Drainage (ARD)

- Sulphide ores
  - Pyrite, FeS₂
  - Sphalerite, ZnS
- Low pH, high soluble metals
- Generated for decades to centuries

Active Lime Treatment Plant

- Lime (CaO)
- Previous studies
  - Effective for target metal removal
  - Dry material
  - Limited CKD samples
  - Synthetic wastewater
- Trace metal concentrations

Objective

- To evaluate the potential of substituting quicklime with CKD in active mine water treatment
  - Acid neutralization
  - Metals precipitation
  - Treated, settled water quality

CKD as a Lime Substitute

- Lime (CaO)
- Precipitation of metals:
  \[ M^{n+} + nOH^- \rightarrow M(OH)_{n+} \]

Cement Kiln Dust (CKD)

- Raw Materials:
  - CaO, Si, Al, Fe
- Clinker (65 % CaO)
- CKD (10 to 60% CaO)
### Materials

#### Cement Kiln Dust

<table>
<thead>
<tr>
<th>Sample</th>
<th>Specific Surface Area (m²/g)</th>
<th>Median Particle Size (µm)</th>
<th>Total Lime (wt %)</th>
<th>Free Lime (wt %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CKD-A</td>
<td>0.502</td>
<td>8.5</td>
<td>44</td>
<td>15</td>
</tr>
<tr>
<td>CKD-B</td>
<td>0.350</td>
<td>15.9</td>
<td>48</td>
<td>9</td>
</tr>
<tr>
<td>CKD-C</td>
<td>0.471</td>
<td>20.5</td>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td>CKD-F</td>
<td>0.393</td>
<td>21.2</td>
<td>57</td>
<td>37</td>
</tr>
<tr>
<td>Quicklime</td>
<td>0.164</td>
<td>32.0</td>
<td>90</td>
<td>87</td>
</tr>
</tbody>
</table>

#### Mine water

- lead/zinc mine
- 3 liquid waste streams

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Mine Effluent</th>
<th>Discharge Regulation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>2.4 ± 0.1 6.0 – 9.5</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td></td>
<td>70 ± 50 15</td>
</tr>
<tr>
<td>Zinc (mg/L)</td>
<td></td>
<td>122 ± 15 0.5</td>
</tr>
<tr>
<td>Iron (mg/L)</td>
<td></td>
<td>429 ± 78 ---</td>
</tr>
</tbody>
</table>

*Metal Mining Effluent Regulations

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### Methodology

#### Acid Neutralization Capacity

![Graph showing Acid Neutralization Capacity](chart.png)

#### Neutralization

![Graph showing Neutralization](chart.png)

#### Metals Precipitation

![Graph showing Metals Precipitation](chart.png)

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**Flocculation**

Mean Particle Size (µm) | Largest Particle Detected (µm)
--- | ---
CKD-B | 7.41 ± 11.10 | 364.25
CKD-F | 8.43 ± 25.55 | 739.50
Quicklime | 10.63 ± 37.41 | 864.25

**Settled Water Quality**

- **CKD-A**
- **CKD-B**
- **CKD-C**
- **CKD-F**
- **Quicklime**

**Effect of Settling Time**

- **CKD-B**
- **CKD-F**
- **Quicklime**

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Conclusions

CKD is as effective as quicklime in neutralization of acidity and precipitation of soluble metals.

Low free lime CKDs vs. Quicklime:
- Higher slurry volume required for neutralization
- Comparable metals precipitation and removal
- Higher TSS concentrations after settling
- Lower sludge volume after settling

CKD-F vs. Quicklime:
- Similar slurry volumes required
- Comparable metal precipitation and removal
- Comparable TSS concentrations after settling
- Lower sludge volume after settling
- Increased settling time
  - Significantly reduced TSS and final total metal concentrations in mine water treated with CKD-B slurry
  - No effect with CKD-F or quicklime

Recommendations

- Sludge characterization (i.e. CST, TCLP)
- Effect of sludge recycle (i.e. HDS)
- Pilot and full scale studies

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