A result of batch test to select effective co-precipitator of zinc containing mine drainage treatment

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Annual amount of mine drainage and contained heavy metals

<table>
<thead>
<tr>
<th>Mine Discharge</th>
<th>Volume of mine drainage treated in m³</th>
<th>Volume of treat. in (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mine drainage</td>
<td>80</td>
<td>61,700,000</td>
</tr>
<tr>
<td>Number of heavy metals</td>
<td>Soluble Iron (t/year)</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Zinc (t/year)</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Soluble Manganese (t/year)</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Copper (t/year)</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Lead and Lead compounds (t/year)</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Arsenic and Arsenic compounds (t/year)</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Cadmium and Cadmium Compounds (t/year)</td>
<td>58</td>
</tr>
</tbody>
</table>

- 80 abandoned mine drainage treatment plants are currently in operation.
- The total amount of mine drainage treated is 62 million m³/year.
- 80% of the total heavy metals is soluble iron, 10% is zinc, and 7% is manganese.

The Budget for Mine Pollution Prevention (1971~2007)

- From 1973 to 1980, the budget increased sharply.
- Approximately 80% of the total budget is spent for the mine drainage treatment.

Effluent Standards in Japan

- | Pollutants | Standards |
- | pH of mine drainage discharged, excluding into open sea | 5.0~8.0 |
- | H₂SO₄ and CO₂ | Maximum: ≤160mg/L, Daily average: ≤120mg/L |
- | Suspended solids | Maximum: ≤200mg/L, Daily average: ≤150mg/L |
- | Mineral oil | ≤5mg/L |
- | Animal and vegetable oil | ≤10mg/L |
- | Phenol | ≤5mg/L |
- | Copper | ≤1mg/L |
- | Candle | ≤2mg/L |
- | Soluble iron | ≤10mg/L |
- | Soluble Manganese | ≤10mg/L |
- | Total Chromium | ≤2mg/L |
- | Number of colonies of E.coli | ≤1,000 colonies/mL |

- The Ministry of Environment of Japan revised the effluent standards of the water pollution control law in December 2006.
- The upper limit of zinc content in factory effluence and business activity sites including metal mines was reduced from 5.0 mg/L to 2.0 mg/L.
- The drainage of a few mines have common features, such as relatively higher zinc content than iron content. Thus, the removal of zinc by co-precipitation with iron hydroxide is not sufficient to meet this standard.

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Zinc ions are removed by "adsorption". The "settlement process" using coagulants and reagents increases the precipitation rate, producing hydroxide.

In order to precipitate zinc as a hydroxide, it is necessary to increase the pH of the drainage to 9.0 or higher.

However, zinc can be removed at a pH lower than 9.0 if the mine drainage contains iron and other various metals.

In order to remove zinc by the settlement process in mine drainage that contains only zinc without iron, it is necessary to add iron for co-precipitation.

A laboratory test for iron sulfide and iron chloride was conducted to identify a more cost-effective reagent for iron sources.

Cost of iron sulfide and iron chloride

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Cost of adding reagents (US$/m³)</th>
<th>Cost of reagents (US$/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron sulfide</td>
<td>0.03 US$/m³</td>
<td>0.02 US$/kg</td>
</tr>
<tr>
<td>Iron chloride</td>
<td>0.12 US$/m³</td>
<td>0.02 US$/kg</td>
</tr>
</tbody>
</table>

An excess ratio of 1.24 times compared with current cost.

The results showed that 50 mg/L of iron was required to maintain the zinc concentration within the target value of 2.0 mg/L.
A confirmed effective method is that the optimal additive amount of iron chloride is 6.0 mg/L on an iron basis.

- The additive amount of a high-polymer coagulant changes according to the flow rate.
- The cost for drainage treatment based on this method was up to 1.39 times higher than the current cost (i.e., 1.2 times below the target cost).

### Conclusion

- Though laboratory test and on-site tests a lower-cost treatment method for meeting the new regulations was formulated by the adsorption and settlement process in drainage containing zinc without iron.
- Increased consolidation of the precipitate generated with the addition of zeolite resulted in a lower quantity of precipitate than that with only slaked lime.
- As a result, the addition of iron chloride and the increasing of the high-polymer coagulant reduced the concentration of zinc in treated water to under 2.0 mg/L. Accordingly, the treatment did not exceed the target cost of a maximum 20% increase of the current expense.