Treatment and Rehabilitation of Acidic Waste Rock and Tailings – A 14 Year Case Study

Presented by

James M. Castro
Original Paper:
Common Problems at Precious and Base Metal Mines with Sulfide Ores:

- Acid rock drainage
- Neutral metal leaching

A possible solution to these problems originated as a waste product in the aluminum industry.
Bauxite is refined using the Bayer Process

Bayer-process

- Bauxite
  - crushing
  - milling
- Pressure vessel
  - NaOH
- Na[Al(OH)₄]
  - filtering
  - red mud
  - cooling
- Crystallization
  - Al(OH)₃ as crystallization seed
- Aluminium oxide
- Rotary kiln
  - water
Red Mud Properties

- pH ~ 13
- Gelatinous, high water content; hard to drain.
- Hard to reclaim the ponds.
- Depending on source of bauxite, may contain heavy metals in addition to Fe.
- Few industrial applications.
Queensland Alumina Red Mud Handling

• As a fresh water conservation measure, the red mud is piped to the pond in a slurry with seawater.
• The pond is also flushed with tidewater every day.
• As a result the red mud at QAL is neutralized by seawater.
Virotec International

• Seawater-neutralized red mud was commercialized by Virotec.
• The company was formerly known as Mount Carrington Mines.
• The trademark for the seawater-neutralized red mud products is Bauxsol™
Properties of Bauxsol

• Moderate pH
  – Saturated paste pH ≈ 10
  – 1:5 soil reaction pH ≈ 8.6
• Metal binding capacity almost 1500 mg/kg
• Alkalinity is primarily solid (e.g., carbonates)
• Acid neutralizing capacity = 4-7 mol/kg @ pH 7
Major Minerals in Bauxsol

- Hematite (Fe₂O₃)
- Boehmite (γ-AlOOH)
- Gibbsite (Al(OH)₃)
- Sodalite (Na₈Al₆Si₆O₂₄Cl₂)
- Quartz (SiO₂)
- Cancrinite (Na₆Ca₂Al₆Si₆O₂₄(CO₃)₂)
- Hydrotalcite [Mg₆Al₂(CO₃)(OH)₁₆·4H₂O]
Minor Minerals in Bauxsol

- Meixnerite \([\text{Mg}_6\text{Al}_2(\text{OH})_{18}\cdot4\text{H}_2\text{O}]\)
- Anatase \([\text{TiO}_2]\)
- Aragonite, calcite \([\text{CaCO}_3]\)
- Brucite \([\text{Mg(OH)}_2]\)
- Diaspore \([\alpha\text{-AlOOH}]\)
- Ferrihydrite \([(\text{FeOOH})_5(\text{H}_2\text{O})_2]\)
- Gypsum \([\text{CaSO}_4\cdot2\text{H}_2\text{O}]\)
- \(\rho\text{-Aluminohydrocalcite \([\text{CaAl}_2(\text{CO}_3)_2(\text{OH})_4\cdot3\text{H}_2\text{O}]\)}\)
- Low-solubility trace minerals
Binding of Specific Metals

Hematite | Sodalite | Gibbsite | Anatase | Hydrotalcite

???

10 µm
Mount Carrington Mine

- Au + Ag mine at Drake, N.S.W.
- Country rock contained subeconimic levels of Cu, Zn, and Pb.
- Waste rock was highly acid-generating.
- Drainage water from waste piles contained significant Cd, Cu, Zn, and Pb.
- Mine was closed in 1990.
Location of Mount Carrington Mine
Mount Carrington Mine Study (2000-2013): 3 Programs

1. Rehabilitation in 4 acidic waste rock areas
2. A second acidic waste rock study: variations of treatment with 5 subplots
3. Tailings beach treatment
Program #1:
3 different intervention strategies over 14 years.

1. Untreated control
2. Waste rock + CaCO$_3$ + biosolids
3. A standard capping treatment (semipermeable clay + topsoil cover)
4. Mixture of waste rock + Terra B (Bauxsol)
Program #1

- Each plot 50 m X 35 m.
- Particle size distribution in each plot ranged from fine clay to boulders (≤ 1 m diameter).
- Areas 2 & 4 mixed with treatment (5% v/v) to 1 ft depth.
- Area #3 capped with 1 ft clay + topsoil.
Program #1

- All 4 areas were planted immediately after treatment in 2000 with native tree species (Grey ironbark and golden wattle)

- Tree growth (density and height) monitored by research team.
Eucalyptus paniculata (grey ironbark)
Acacia fimbriata (golden wattle)
Program #2

- On an acidic waste rock dump ~ 1 mile SE of Program #1
- One control + 4 treatments
- Each plot 25 m X 25 m
Program #2

1. Control
2. 8% Terra B
3. 8% Terra B + 2% biosolids
4. 12% Terra B + 3% biosolids
5. 2% biosolids only
Program #2

All 5 areas monitored for

• Soil pH

• Metal concs (Al, Mn, Fe, Zn, Cu, Ca, K, Mg, and Na as %) in leaves compared with *E. paniculata* growing in undisturbed Australian woodlands.

• Tree growth.
Eucalyptus crebra
(Narrow-leafed green ironbark)
Program #3
Tailings beach treatment

- Exposed tailings beach treated in 2001 with Terra B
- 3% (v/v) of Terra B added to tailings (1 ft depth)
- 100 m X 100 m area treated
Results
# Program #1
## Total Actual Acidity (mmol/kg)

<table>
<thead>
<tr>
<th>Year</th>
<th>Control</th>
<th>CaCO$_3$ + biosolids</th>
<th>Clay + topsoil</th>
<th>Bauxsol</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 (before treatment)</td>
<td>87</td>
<td>87</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td>2013</td>
<td>--</td>
<td>45</td>
<td>24</td>
<td>0</td>
</tr>
</tbody>
</table>
# Program #1

Total Potential Acidity (%) (Peroxide Method)

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>CaCO3 + biosolids</th>
<th>Clay + topsoil</th>
<th>Bauxsol</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 (before treatment)</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>2013</td>
<td>--</td>
<td>0.18</td>
<td>0.68</td>
<td>0.08</td>
</tr>
</tbody>
</table>
Program #1
Tree growth in Area 1 (control)
2000  2013
Program #1
Tree growth in Area 2 in 2013 (limestone + biosolids)
Program #1
Tree growth in Area 3 in 2013
(Clay/Topsoil Cap)
Program #1
Tree growth in Area #4 in 2013
(Bauxsol)
Program #2
Soil pH over an 8 month period
Program #2
Al & Heavy Metals in Leaves at 2 Years
Program #2
Major Metals in Leaves at 2 Years
Program #3
Tailings Beach before Treatment
Program #3
Tailings Beach in 2013
Program #3
Colonizing of Tailings Beach, 2013

Shrub (bottlebrush)  Spotted python
Conclusions

• Bauxsol (Terra B) was effective at promoting reclamation of acidic waste rock as indicated by soil pH, tree growth, and reduced heavy metal uptake by trees.

• Limestone, biosolids, and clay-topsoil cap were much less effective

• A single application of Bauxsol in the upper foot of an acidic tailings beach promoted plant growth and colonization.
For further information

Enviremed (U.S. sales)  Virotec Global Solutions

info@enviremed.com  http://virotec.com/

EnviRemed Website:
http://enviremed.com
Questions?