Biotechnology for Metal Recovery from Waste Streams

October 2009
Outline

- Overview about BioteQ
- Biotechnology for metal recovery
- Case studies
BioteQ is a water treatment company that applies innovative technologies and operating expertise to solve challenging water treatment problems.

- We have built 8 full scale plants employing sulfide technology at up to 1,000 m³/hr and up to 3.4 T/d S²⁻.
- We produce saleable metals and clean water that meets strict water quality criteria for discharge or re-use.
- We reduce or eliminate sludge liability and produce high quality water.
Services offered

- We provide water treatment services, tailored to suit customer needs:
  - Process development & design
  - Procurement
  - Construction management
  - Plant commissioning
  - Operator training
  - Operating services

- Our strength is our process design expertise and operations track record
BioteQ’s global customers

- Vale Inco
- Xstrata Copper
- Aditya Birla
- Koza Gold
- US EPA

Operations
- Under construction
- In development
- First commercial plants

Freeport-McMoRan
- Xstrata Nickel
- Jiangxi Copper
- Breakwater
- EPCOR

- Minto (Capstone) (Fees)
- Raglan (Xstrata) (Ni - Fees)
- Caribou (Zn, Pb, Cu - Fees)
- Caribou Tailings (Zn - Fees)
- Wellington Oro (US EPA) (Zn, Cd - Plant Sale)
- BioSulphide® Plant, USA (Cu - JV)
- Lluvia (NWM Mining) (Cu, CN - Fees)
- Dexing (Jiangxi Copper) (Cu - JV)
- Mastra (Koza Gold) (Fees)
- Mt Gordon (Aditya Birla) (Cu, Co, Ni - 90%)
- ChemSulphide® Plant, USA (Zn, Cd - Plant Sale)
- Sulf-IX™ Plant, USA (SO₄ - Fees)
Biogenic Sulfide for Metal Recovery
Biogenic sulfide for metal recovery

- Sulphide precipitation technologies
  - Selectively recover dissolved metals from wastewater for environmental compliance
  - Metals that can be removed include Cu, Ni, Zn, Co, Cd, Pb, Hg, Se, As, Sb, Mn, Fe
**Sulfide-based metal recovery process**

- **Bioreactor**
- **H₂S**
- **Contactor**
- **Clarifier**
- **Effluent**
- **Filter**
- **Product to Refinery**

**Components:**
- Sulfur
- Nutrients
- Reductant
- Feed water
- Leach solutions
- Groundwater
- Bleed streams
- Acid drainage
- Mine water

**Process Diagram:**
1. Feed water enters the bioreactor.
2. Sulfur, nutrients, and reductant are added to the bioreactor.
3. H₂S is generated.
4. The output from the bioreactor goes to the contactor.
5. The contactor filters the output.
6. Effluent is filtered and sent to the product to refinery.
7. Leach solutions and groundwater are processed.
8. Acid drainage and mine water are treated.
9. Bleed streams are handled separately.

**Renewable Energy Conversion Systems (RECS):**

TSX:BQE
Bioteq Environmental Technologies Inc
www.bioteq.ca
Benefits of sulfide metal recovery

- Reduces or eliminates waste sludge
- Reduces long-term liabilities
- Lowers life cycle cost of water treatment
  - Lower capital and operating costs
  - Generates revenue from metal by-products
- Produces clean water that meets strict water quality criteria for discharge or re-use
- Can be integrated with existing lime plants
- Efficient recovery of metals from low grade solutions
Biological H$_2$S generation

Sulfur Dissolution

$$2\text{HS}^- + S_8 = 2\text{S}_5^{2-} + 2\text{H}^+$$
**Chemistry**

### Sulfur Reduction

- \(4S^0 + CH_3COOH + 2H_2O = 4H_2S + 2CO_2\) \(8\) e\(^-\)
- \(6S^0 + C_2H_5OH + 3H_2O = 6H_2S + 2CO_2\) \(12\) e\(^-\)
- \(H_2SO_4 + CH_3COOH = H_2S + 2H_2CO_3\) \(2\) e\(^-\)

### Contactor - Trap Reactions

- \(CuSO_4 + H_2S = CuS\downarrow + H_2SO_4\)
- \(0.5 O_2 + H_2S = S^0\downarrow + H_2O\)
- \(2H_2S + Ca(OH)_2 = Ca(HS)_2 + 2H_2O\)
- \(CO_2 + Ca(OH)_2 = CaCO_3\downarrow + H_2O\)
Biogenic Sulfide Characteristics

- Biogas is 5-15% H₂S and 5-10% CO₂ remainder N₂
- Produced under ambient Temperature and Pressure
- Carbon steel or 304SS components
- Biogas can be used to produce Ca(HS)₂ or NaHS if site conditions dictate
- Produced ON SITE and ON DEMAND – low site inventory and lower risks of H₂S gas
Case Studies
BioSulphide® Plant – inactive mine site in US

Project Profile:
- Copper recovery plant
- Operating since 2004
- 500 m³/hr (2,200 usgpm) capacity
- 2008 results:
  - 1.3 million lbs copper recovered
  - 2.9 billion litres of water recycled
Heap Leach Plant Flowsheet

Stockpile

BioSulphide® Plant

Free acid

Concentrate to smelter (40-60% Cu dwb)
Heap Leach Plant Chemistry

\[ \text{CuSO}_4 + \text{H}_2\text{S} = \text{CuS} + \text{H}_2\text{SO}_4 \]

\[ \text{Fe}_2\text{SO}_4\text{H}_2 + \text{H}_2\text{S} = \text{S}^0 + 2\text{FeSO}_4 + \text{H}_2\text{SO}_4 \]

\[ \text{SO}_2 + \text{H}_2\text{O} = \text{H}_2\text{SO}_3 \]

\[ \text{Fe}_2\text{SO}_4\text{H}_2 + \text{H}_2\text{SO}_3 + \text{H}_2\text{O} = 2\text{FeSO}_4 + 2\text{H}_2\text{SO}_4 \]
Site outcomes

- Reduced environmental liability:
  - 1.3 million pounds of copper recovered and removed from site

- Site Maintenance:
  - $700,000 in net operating profit generated from water treatment operations (2008)
Wellington Oro WWTP

Wellington Oro, CO (US EPA, County and Town consortium)

- Zinc, cadmium removal for environmental compliance
- Site specific factors dictate that iron, aluminum and manganese are not targets for removal
- Sulfide process is BAT for the site according to the US EPA
- Commissioned in January 2009
Site Outcomes

- Operating results:
  - 150 gpm capacity; actual results < 75 gpm avg. flow in mine
  - Effluent T-Zn <20 ppb, T-Cd < 0.5 ppb
  - Zn Product >55% Zn dwb, and 70% solids, friable cake
  - Fully remote ops and support via Verizon (troubleshooting, PLC programming, data backups, automated callouts)

- HDS lime sludge 100 cu ft per day waste reduced 98% to 2.7 cu ft per day marketable product using sulfide precipitation technology

- Est. $1-4M savings in capital costs, at least $230k per year net operating savings due to reduced sludge disposal costs
Summary

- Biogenic sulfide processes have been proven to profitably recover dissolved metals from waste water, producing saleable metal products and clean water as well as to reduce sludge.
- BioteQ applies innovative technologies and operating expertise to solve challenging water treatment problems.
Ca(HS)$_2$ Production

Milk of Lime

Bioreactor

Sulphur
Nutrients
Reductant

H$_2$S

Trap

Clarifier

CaCO$_3$

Ca(HS)$_2$

Reagent