LULEÅ UNIVERSITY OF TECHNOLOGY

The Effectiveness of Using Sewage Sludge as a Sealing Layer on Sulphide-rich Mine Tailings: A Pilot-scale Experiment, Northern Sweden

Peter Nason

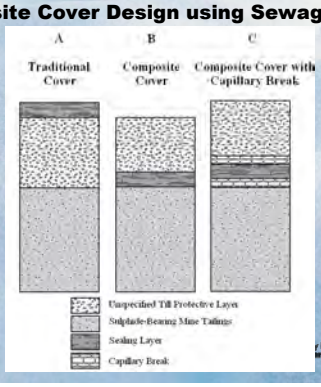
Luleå University of Technology, Department of Chemical Engineering and Geosciences, SE-97187, Luleå, Sweden

peter.nason@ltu.se

The northernmost University of Technology in Scandinavia
World-class research and education

LULEÅ UNIVERSITY OF TECHNOLOGY

A Remedial Solution to ARD: Composite Cover Design using Sewage Sludge



LULEÅ UNIVERSITY OF TECHNOLOGY

Aim of the Study

Evaluate the long-term effectiveness of using sewage sludge as a sealing layer to prevent oxygen diffusion to underlying sulphide-bearing mine tailings

LULEÅ UNIVERSITY OF TECHNOLOGY

Advantages of using Sewage Sludge

- Protective physical barrier reduces sulphide oxidation:

$$FeS_2 + {}^{15}/_4O_2 + {}^7/_2H_2O \leftrightarrow Fe(OH)_3 + 2SO_4^{2-} + 4H^+$$

- Organic matter consumes oxygen:

$$CH_2O + O_2 \leftrightarrow H_2O + CO_2$$

- Organic matter reduces sulphate:

$$2CH_2O + SO_4^{2-} + 2H^+ \leftrightarrow 2H_2CO_3 + H_2S \quad (pH<7)$$
$$2CH_2O + SO_4^{2-} + H^+ \leftrightarrow 2H_2CO_3 + HS^- \quad (pH>7)$$

- The reduced conditions may promote precipitation of metal sulphide:

$$Me^{2+} + H_2S \leftrightarrow MeS + 2H^+$$

- Neutral pH environment may further immobilise elements

LULEÅ UNIVERSITY OF TECHNOLOGY

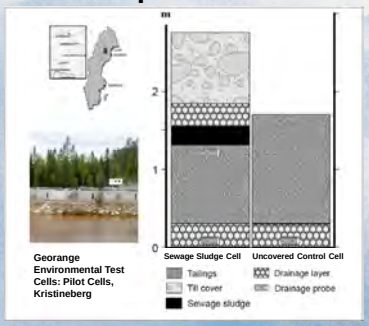
Disadvantages of using Sewage Sludge

- High concentrations of metals (Al, Fe, Mn, Cu, Ni, Zn, Cd)
- Organo-complexes may form altering the mobility of some metals
- May release elevated ion concentrations: NO_3 PO_4 and NH_4
- Degredation of organic matter occurs:

Layer thickness and integrity is compromised

LULEÅ UNIVERSITY OF TECHNOLOGY

Site Description and Materials



Georange Environmental Test Cells: Pilot Cells, Kristineberg

LULEÅ UNIVERSITY OF TECHNOLOGY

Original Material Composition

	Tailings (ppm)	Sewage Sludge (ppm)
Major Elements		
Si	166878	-
Al	21435	52200
Ca	34091	10300
Fe	94423	10600
K	5197	1350
Mg	22011	1400
Mn	767	232
Na	2070	-
P	168	18900
Ti	1103	-
Minor Elements		
As	3610	<10
Ba	128	219
Cd	8.19	0.97
Co	81.6	<2
Cr	25.1	34
Cu	1480	219
Hg	2.84	0.51
Ni	12.8	9.13
Pb	1270	48.5
S	209000	-
Zn	5330	377

The northernmost University of Technology in Scandinavia
World-class research and education

LULEÅ UNIVERSITY OF TECHNOLOGY

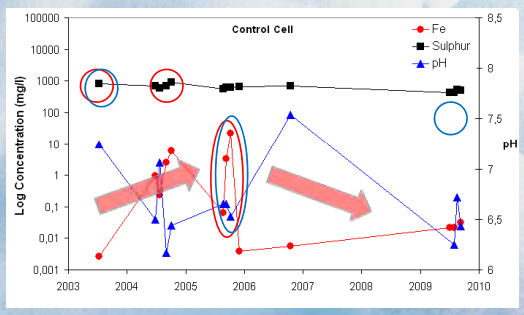
Sampling and Analysis

- Basal leachate samples (KC1, KC6) collected May-September 2003, 2004, 2005, 2006 and 2009
- Dissolved (<0.22µm) elemental fraction collected using nitrocellulose membrane filters and analysed using ICP-AES and ICP-SFMS
- NO_3^-, SO_4^{2-} and alkalinity HCO_3^- were sampled and analysed in 2009 using ion chromatography
- pH and dissolved Oxygen

The northernmost University of Technology in Scandinavia
World-class research and education

LULEÅ UNIVERSITY OF TECHNOLOGY

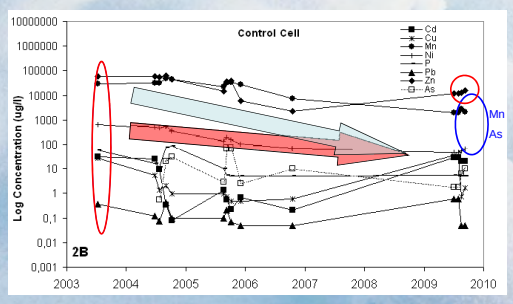
Results and Discussion: Dissolved Iron and Sulphur



The northernmost University of Technology in Scandinavia
World-class research and education

LULEÅ UNIVERSITY OF TECHNOLOGY

Results and Discussion: Heavy Metal Concentrations



The northernmost University of Technology in Scandinavia
World-class research and education

LULEÅ UNIVERSITY OF TECHNOLOGY

Sulphate, Alkalinity and Calcium

	SO_4^{2-}	HCO_3^-	Ca^{2+}	Dissolved O_2
Sewage Sludge	142	750	220	2.64
Uncovered Control	1390	88	583	6.00

Mean Leachate Concentrations in 2009 (mg/L)

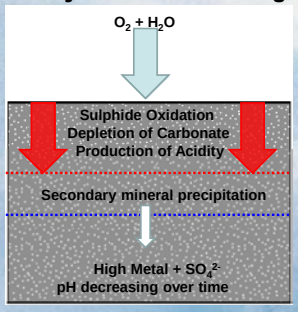
$CaCO_3 + 2H^+ \leftrightarrow Ca^{2+} + H_2CO_3$

$Ca(OH)_2 + 2H^+ \leftrightarrow Ca^{2+} + 2H_2O$

The northernmost University of Technology in Scandinavia
World-class research and education

LULEÅ UNIVERSITY OF TECHNOLOGY

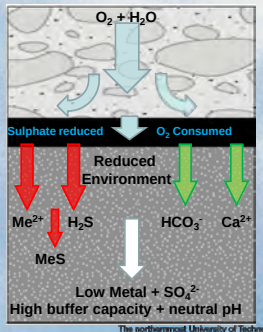
Summary: Uncovered Tailings



The northernmost University of Technology in Scandinavia
World-class research and education

LULEÅ UNIVERSITY OF TECHNOLOGY

Summary: Sewage Sludge Remediated Tailings



The northernmost University of Technology in Scandinavia
World-class research and education

LULEÅ UNIVERSITY OF TECHNOLOGY

Conclusions

- Sewage Sludge is effective for reducing oxygen diffusion to underlying tailings for the study period of 8 years
- The sealing layer cover efficiency has not been compromised over time proven by continually lowering metal and sulphate concentrations in the effluent leachate
- Metal concentrations in the uncovered tailing effluent are 2 orders of magnitude higher in contrast, due to sulphide oxidation
- Continued oxidation in the uncovered tailings may consume the remainder carbonates and produce an acidic, metal rich leachate in the future
- In contrast the sewage sludge ensures a high buffering capacity, reduced environment with a neutral pH, promoting the removal of metals in the tailings profile

The northernmost University of Technology in Scandinavia
World-class research and education

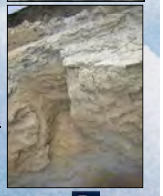
LULEÅ UNIVERSITY OF TECHNOLOGY

Further Research

Sediment Profiles Geochemistry
- Oxidation
- Precipitation
- Sealing layer integrity

Ageing effects of Sewage Sludge
- Evolution over time

Groundwater dispersion of sewage sludge constituents
- How it effects mobility of heavy metals



The northernmost University of Technology in Scandinavia
World-class research and education

LULEÅ UNIVERSITY OF TECHNOLOGY

Acknowledgements

GEORANGE
BOLIDEN

Any Questions?

Peter Nason

Luleå University of Technology, Department of Chemical Engineering and Geosciences, SE-97187, Luleå, Sweden

peter.nason@ltu.se

The northernmost University of Technology in Scandinavia
World-class research and education