Acid mine drainage multi-step passive treatment system: the Lorraine case study

Goldschmidt 2012 – Wednesday, June 27th 2012

Thomas Genty, Bruno Bussière, Mostafa Benzaazoua, Gérald J. Zagury and Carmen M. Neculita

Université du Québec en Abitibi-Témiscamingue - Institut de recherche Mines et Environnement
École Polytechnique de Montréal - Department of civil, geological and mineral engineering
Outline

- Introduction
- The Lorraine mine site
- Passive system design
- System construction
- First results
Introduction

- **Acid mine drainage generation (AMD)**
  - FeS$_2$ + 7/2 O$_2$ + H$_2$O → Fe$^{2+}$ + 2 SO$_4$$^{2-}$ + 2H$^+$
  - AMD effluents have high acidity and dissolved metal contents.

- **Active treatment** like lime neutralisation plants is the most used technology to mitigate AMD.

- For closed or abandoned mines, **passive treatments** are preferred because:
  - Low initial and operating cost,
  - Reproduce natural remediation process,
  - But performances vary with the time.

Genty, 2009
The Lorraine mine site

- The Lorraine mine site is located in the Temiscamingue area (Quebec).

- The mine was operational during the 60’s and then abandoned.

- The mine site is relatively small with approximately 10 ha.

- The tailing are rich in pyrite, pyrothite, chalcopyrite, pentlandite and thus have a high acid generating potential.
The Lorraine mine site

- The site was reclaimed with a oxygen barrier in 1999 to limit the production of AMD.
- Three dolomitic drains were built to treat the highly contaminated AMD.
  - In 2011, Iron was 2000 mg/L, sulphate near 5000 mg/L and pH was close to 3.
- However, the performance of the treatment system is low at Dol-3 AMD is still very concentrated.
Passive system design

- The literature proposes to use multi-step passive system for highly concentrated AMD treatment not just only one step like dolomitic drain built on the site.

- Based on previous research results (e.g. Cocos, 2002, Neculita, 2008, Potvin, 2009, Genty, 2012, etc.), we propose the replacement of one of the three dolomitic drains by a three-step passive treatment pilot.
  - Step 1: Sulphate reducing passive biofilter (SRPB1)
  - Step 2: Wood ash filter
  - Step 3: Sulphate reducing passive biofilter (SRPB2)
Passive system design

- 3 sections:
  - SRPB 1: 50% Organic mixture (sawdust, wood chips, manure, compost, sand) + 50% of calcite
    - Objectives: Neutralize acidity, remove metal by sulphate reduction, sorption, precipitation
  - Wood ash filter
    - Objectives: Mainly remove iron by sorption and precipitation
  - SRPB 2: Organic mixture / polishing step
    - Objectives: Remove residual metals and sulphates by sulphate reduction
Passive system design

- Design criteria
  - Flow rate: 5 L/min
  - Hydraulic retention time: 12 days (same as in the lab study)

- SRPB 1: 50 m³, 36 t of material
- Wood ash filter: 50 m³, 30 t of material
- SRPB 2: 60 m³, 29 t of material
System construction

Before excavation

System excavation

SRPB material mixing

AMD drain collection

Genty, 2012
System construction

Inferior HDPE membrane placement

Material placement

Superior HDPE membrane

System recovered by the soil
Working time: 5 days to build the system
The system is approximately $3 \text{ m}^2$ cross section by 1 m height and 40 m length.
First results

- Water treatment efficiency

- Flow rate: 0.8 L/min
- pH: 5 → 6.5
- Iron: 2018 → 161 mg/L
- $S_{total}$: 1578 → 617 mg/L
- Al: 0.7 → <0.01 mg/L
- Mn: 9.4 → 7.5 mg/L
- Ni: 0.8 → 0.3 mg/L
- Pb: 0.3 → 0.03 mg/L
- Zn: 0.3 → 0.1 mg/L
First results

- Water treatment efficiency

- Flow rate: 0.8 L/min
- pH: 5 → 6.5
- Iron: 2018 → 161 mg/L
- \( S_{\text{total}} \): 1578 → 617 mg/L
- Al: 0.7 → <0.01 mg/L
- Mn: 9.4 → 7.5 mg/L
- Ni: 0.8 → 0.3 mg/L
- Pb: 0.3 → 0.03 mg/L
- Zn: 0.3 → 0.1 mg/L
First results

- Water treatment efficiency

- Flow rate: 0.8 L/min
- pH: 5 → 6.5
- Iron: 2018 → 161 mg/L
- S_total: 1578 → 617 mg/L
- Al: 0.7 → <0.01 mg/L
- Mn: 9.4 → 7.5 mg/L
- Ni: 0.8 → 0.3 mg/L
- Pb: 0.3 → 0.03 mg/L
- Zn: 0.3 → 0.1 mg/L
Conclusion

- The three-step passive treatment improves water quality at a low cost.
- Natural and by-product materials were used successfully to treat AMD.

A black liquid flows from the system with a strong hydrogen sulphide odor since last years.

- However, further works are required for better understanding of the hydraulic behaviour of the system.
Thank you for your attention