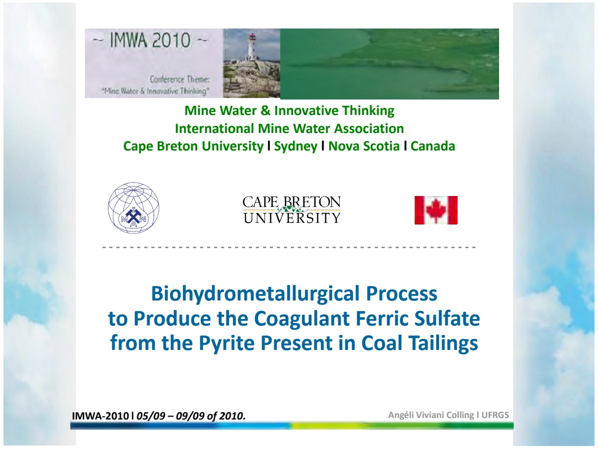
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Conference Theme: "Mine Water & Innovative Thinking"
Mine Water & Innovative Thinking
International Mine Water Association
Cape Breton University I Sydney I Nova Scotia I Canada
CAPE BRETON UNIVERSITY
Biohydrometallurgical Process
to Produce the Coagulant Ferric Sulfate
from the Pyrite Present in Coal Tailings
IMWA-2010 I 05/09 – 09/09 of 2010.
Angéli Viviani Colling I UFRGS


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WHO ARE WE?
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RIO GRANDE DO SUL
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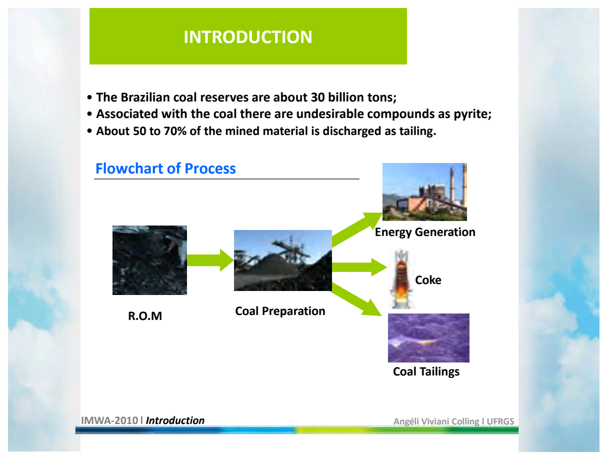
INTRODUCTION
• The Brazilian coal reserves are about 30 billion tons;
• Associated with the coal there are undesirable compounds as pyrite;
• About 50 to 70% of the mined material is discharged as tailing.
Flowchart of Process
R.O.M
Coal Preparation
Energy Generation
Coke
Coal Tailings
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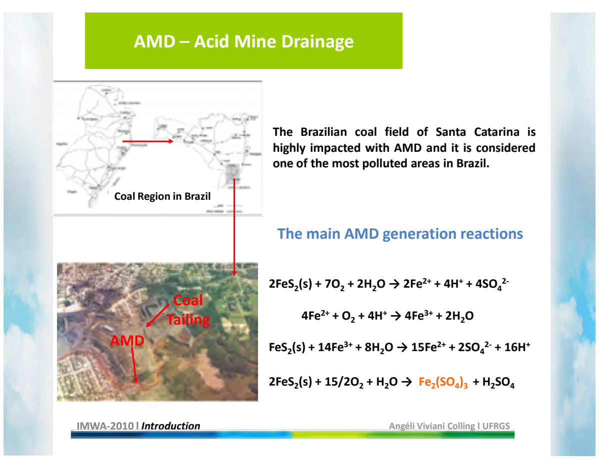
AMD – Acid Mine Drainage
Coal Region in Brazil
The Brazilian coal field of Santa Catarina is highly impacted with AMD and it is considered one of the most polluted areas in Brazil.
Coal Tailing
AMD
The main AMD generation reactions
$2FeS_2(s) + 7O_2 + 2H_2O \rightarrow 2Fe^{2+} + 4H^+ + 4SO_4^{2-}$
$4Fe^{2+} + O_2 + 4H^+ \rightarrow 4Fe^{3+} + 2H_2O$
$FeS_2(s) + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H^+$
$2FeS_2(s) + 15/2O_2 + H_2O \rightarrow Fe_2(SO_4)_3 + H_2SO_4$
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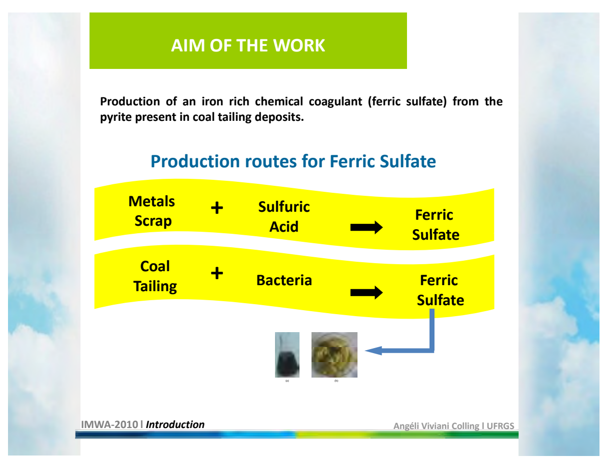
AIM OF THE WORK
Production of an iron rich chemical coagulant (ferric sulfate) from the pyrite present in coal tailing deposits.
Production routes for Ferric Sulfate
Metals Scrap + Sulfuric Acid → Ferric Sulfate
Coal Tailing + Bacteria → Ferric Sulfate
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COAGULATION

• The main reagents used as coagulant are the aluminum sulfate, aluminum chloride, ferric sulfate and ferric chloride;

• Currently, there is a trend to replace the aluminum salts for iron salts (the presence of residual amounts of aluminium in drinking water has been controversially implicated to neurological diseases);

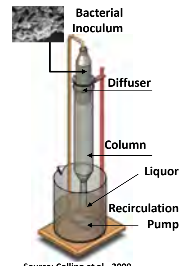
• The ferric chloride is a highly corrosive reagent;

• So, the ferric sulfate is a good option.

EXPERIMENTAL

1. COAGULANT PRODUCTION

• A pyrite concentrate obtained from coal tailings containing 23% pyrite was used in the experiments;
• The material was crushed and sieved to reach the granulometry between 2 and 6 mm;
• The leaching conditions were: sterile, non-sterile, inoculated, and inoculated + micronutrients;
• The bacteria inoculums were 10 mL of an acid mine drainage (AMD) obtained from the coal site, containing 6.8 x 105 cells/mL of *A. ferrooxidans*.
• After eight weeks of leaching, the liquor was evaporated to reach the iron concentration of 9 - 12%.



Source: Colling et al., 2009.

EXPERIMENTAL

2. COAGULANT CHARACTERIZATION

Total iron, Fe^{+3}, Fe^{+2}, sulfate, other metals, TOC, pH.

3. COAGULANT APPLICATION

• Studies involving water treatment were carried out with raw water from Guaiba Lake (Porto Alegre, RS, Brazil) using a conventional Jar Test apparatus;

• The reagents used were the ferric sulfate (FS) produced from coal tailings and two commercial reagents, ferric sulfate (PFS) and aluminum sulfate (PAS);

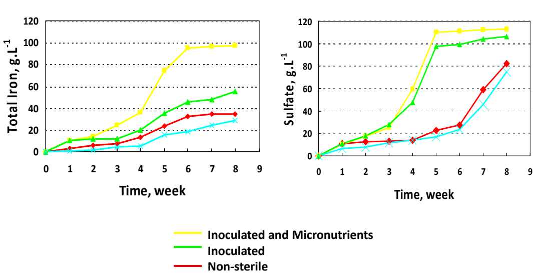
• The raw water and treated water was analyzed for pH, turbidity, color, metals (Fe, Al, Mn and Zn), hardness, and sulfate.

LEACHING COLUMNS

Sterile | Non-Sterile | Inoculated | Inoculated and micronutrients

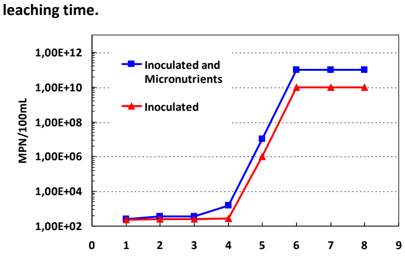
Total Iron and Sulfate

Concentration of iron and sulfate as a function of leaching time.



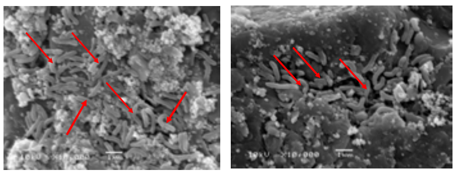
Acidithiobacillus ferrooxidans

MPN of suspended cells of *A. ferrooxidans* as a function of leaching time.



Acidithiobacillus ferrooxidans

Photos of Scanning Electron Microscopy showing the attached cells of *A. ferrooxidans*.



Coagulants Produced

Characteristics of FS coagulant produced by the bioleaching of coal tailing (column 1 to 4) after evaporation and the commercial PFS.

Parameter	Column 1	Column 2	Column 3	Column 4	Commercial
Fe, $g.L^{-1}$	95.7	96.4	112.4	122	115
SO_4^{-2}, $g.L^{-1}$	168	176	178	182	131
pH	1.4	1.3	0.8	0.7	1.8
Al, $g.L^{-1}$	1.3	1.1	1.6	3.1	4.4
Ca, $g.L^{-1}$	1.0	1.3	1.6	2.7	5.7
Mn, $g.L^{-1}$	1.7	1.6	1.6	1.6	1.6
Zn, $mg.L^{-1}$	22.9	23.6	26.1	24.1	22.4
TOC, mg. L^{-1}	< 0.1	< 0.1	0.2	0.6	104

Ferric Sulfate Produced

Final Reagent
Ferric Sulfate

Liquid

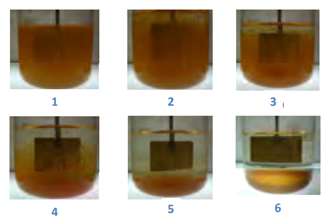
Solid

Water Treatment Tests

Fases of the coagulation and sedimentation in water treatment.

BEFORE
Color:
44 Hazen

Turbity:
81 NTU



AFTER
Color:
2 Hazen

Turbity:
0.4 NTU

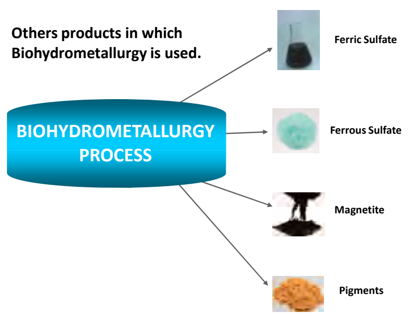
Water Treatment Tests

Parameter	Raw Water	Treated With FS coagulant Column 4	Treated with PFS	Treated With PAS	Brazilian standards for drinking water
pH	6.8	7.0	7.0	7.0	6.0-7.0
Turbidity, NTU	81	0.4	0.5	0.3	5
Color (Hazen)	44	2.0	2.0	2.0	15
Hardness, $mg.L^{-1}$	22	183	134	86	500
Fe, $mg.L^{-1}$	1.2	0.04	0.04	0.04	0.3
Al, $mg.L^{-1}$	0.08	0.08	0.08	0.08	0.2
Mn, $mg.L^{-1}$	0.02	0.02	0.02	0.02	0.1
Zn, $mg.L^{-1}$	0.04	0.02	0.02	0.11	5
Sulfates, $mg.L^{-1}$	7.8	223	83	60	250

So…

Our Products from Coal Tailings Leamet/UFRGS

Others products in which Biohydrometallurgy is used.



IMWA-2010 l *Results* Angéli Viviani Colling l UFRGS

CONCLUSION

- **Through the biohydrometallurgical process studied in this research, it was possible to obtain a coagulant rich in ferric sulfate from the coal tailings;**
- **The acidophilic bacteria intensified the process of pyrite oxidation reducing the leaching time and energy consumption;**
- **The water treatment tests proved that this coagulant was at least as effective as the coagulants conventionally used in water treatment plants;**

IMWA-2010 l *Conclusion* Angéli Viviani Colling l UFRGS

CONCLUSION

- **The process has environmental benefits, because it reduces the volume of waste and decreases the amount of pyrite in the material, minimizing the potential for generation of acid mine drainage.**
- **In the Brazilian coal field areas, the concentration of pyrite and the production of ferric sulfate coagulant could provide economical incomes for the mining companies and avoid costs incurred in acid effluent treatment.**

IMWA-2010 l *Conclusion* Angéli Viviani Colling l UFRGS

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THANK YOU VERY MUCH!

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