



A sustainable froth flotation process: A Chilean case study

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Introduction: Ore concentration in Chile



Chile is a South American country. Its economy is based on natural resources.

The Chilean mining industry is the main driving force of economic growth

For example:

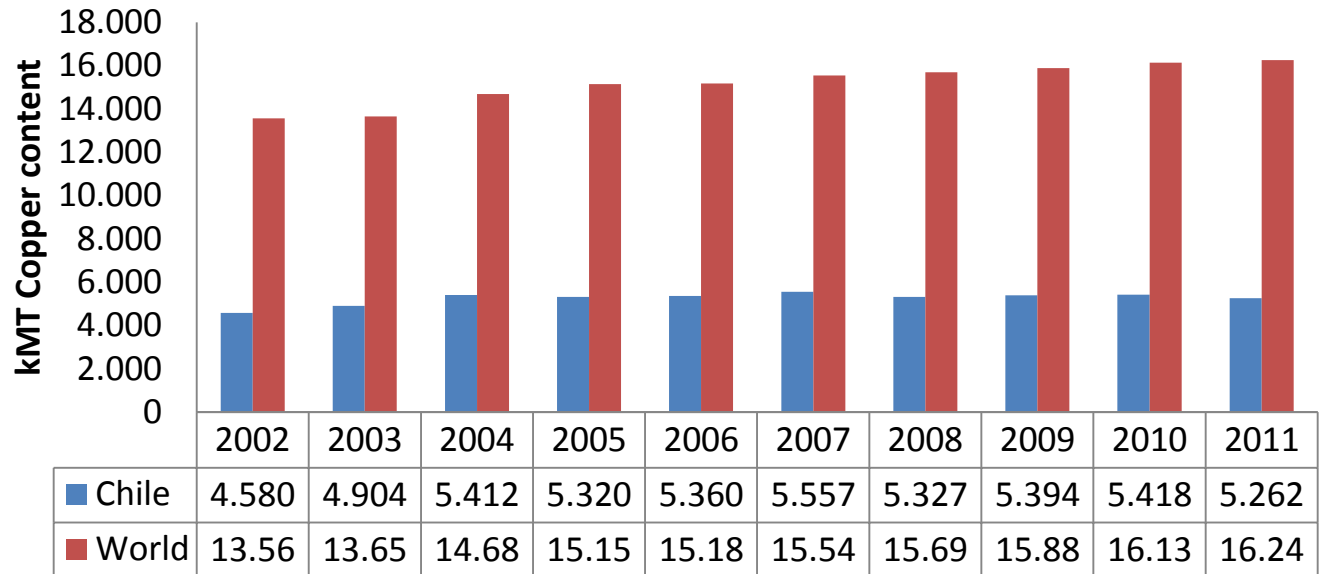
$$GDI_{2012} = \text{US\$ } 18.419$$

$$GDI_{2012 \text{ w/o copper}} = \text{US\$ } 10.130$$

Introduction: Ore concentration in Chile



Global Copper mine production



Yearbook Cochilco, 2011.

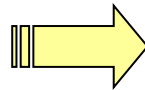
Chile produces a third of global copper. Nevertheless, relationships between mining industry and society have been historically complex due to its continuous environmental impacts.

Introduction: Ore concentration in Chile

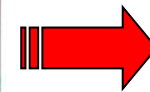
The reagents used in froth flotation are characterized as expensive and hazardous materials due to its high environmental risks with strong potential health effects.



Ore milled +
Chemical
reagents +
water +
energy



Concentrates



**Tailings +
CO₂ + dust**

Mining industry needs to move ahead to try to find new environmentally-friendly reagents for froth flotation.

Introduction: Wastewater treatment plants



Activated sludge, main technology used in Chile.

This technology produces huge volumes of organic wastes such as sewage sludge or biosolids.

Biosolids' production (adapted from LeBlanc, et al. 2008)

Country	Biosolids' production (dry metric tons)	Population
Brazil	372	188,078,000
Canada	550	33,100,000
Chile*	490,000	17,000,000
China	2,966,000	1,313,974,000
Germany	2,000,000	82,422,000
Italy	1,000,000	58,134,000
Japan	2,000,000	127,464,000
USA	6,514,000	298,444,000

* Biosolids' density around 700 kg/m³. Source: SISS, 2012.

Introduction: Main component of biosolids used in the mining processes

Investigating the efficacy of biosolids and its main component as collector and frother agents for concentration of copper sulphide ores by froth flotation.

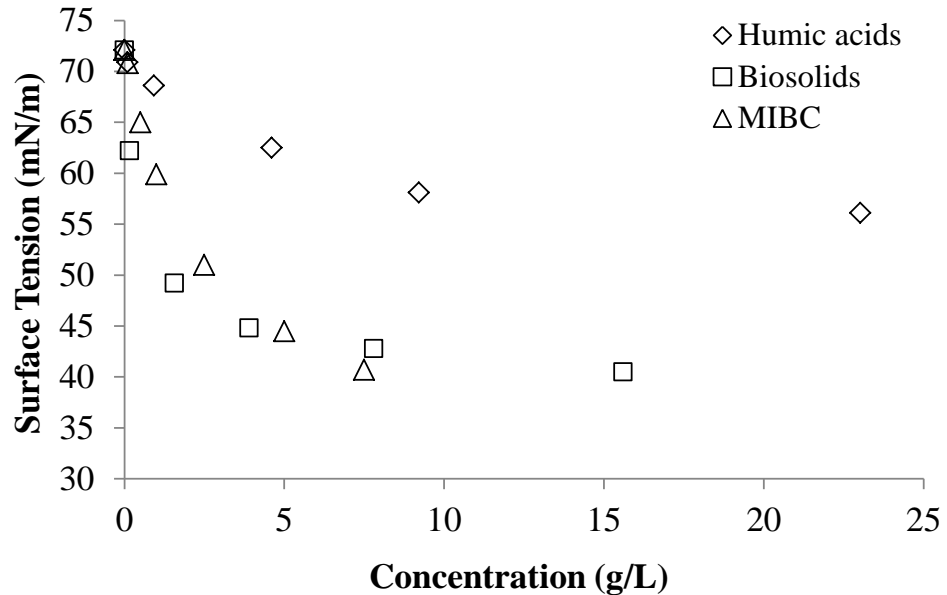


Sustainable mining practices (Laurence, 2011)

Use of wastes as frother agents



- Surface tension measurements
 - room temperature
 - Different solution concentrations
 - pH 7 and 10



- Bikerman test were performed to verify capacity for generation and stability foam.
 - Significant amounts of foam were found at different concentrations of MIBC, BS, and CHA.
 - CHA and BS showed a tensioactive activity at different stabilities.

Use of wastes as collector agents

- Film Flotation technique: room temperature; different solution concentrations.



	without reagents	humic acid	biosolids	chemical reagents
Copper sulphide ore				
Chalcopyrite				
Pyrite				

Film flotation results for 100% water experimental condition

The natural floatability of copper sulphide ore and mineralogical species such as chalcopyrite and pyrite are low.

Use of main component of biosolids as froth flotation reagents



Biosolids

Polyssaccharides (i.e, starch, dextrin, carboxymethyl cellulose)

Use as dispersant and/or depressant agents

Proteins (i.e., glycine)

Use a Pyrite depressant /chalcocite, galena and pyrite concentration

Humic Acids

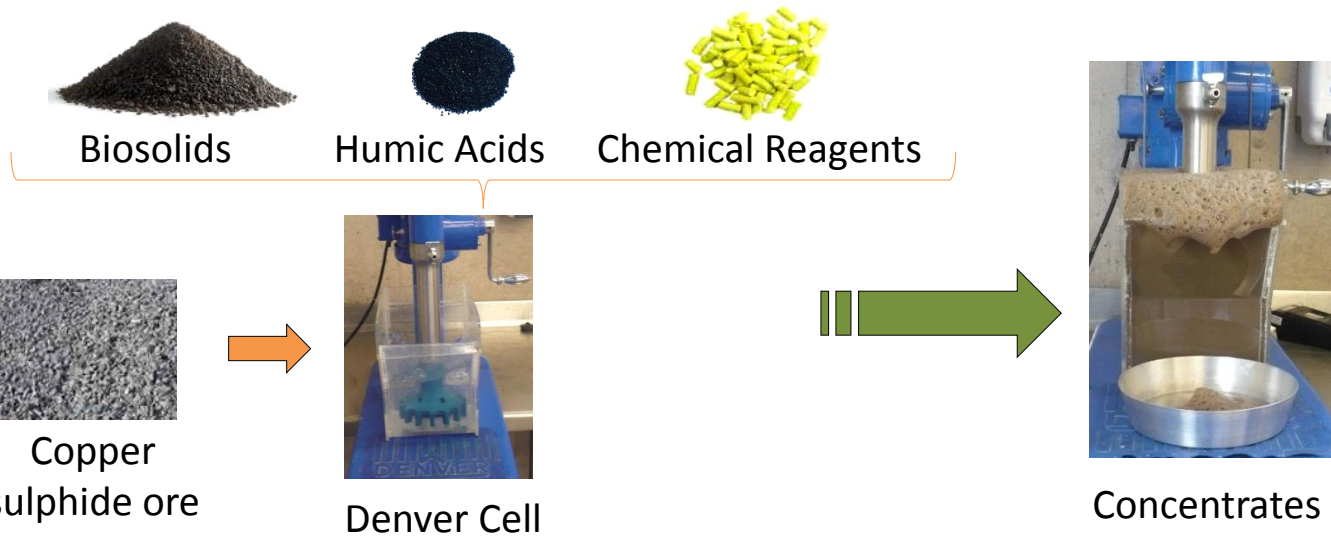
Use as collector as frother of sulphide ores

- These types of reagents are natural and non-toxic agents representing an environmentally friendly alternative to use inside mineral concentration processes.

Froth flotation in Denver Cell

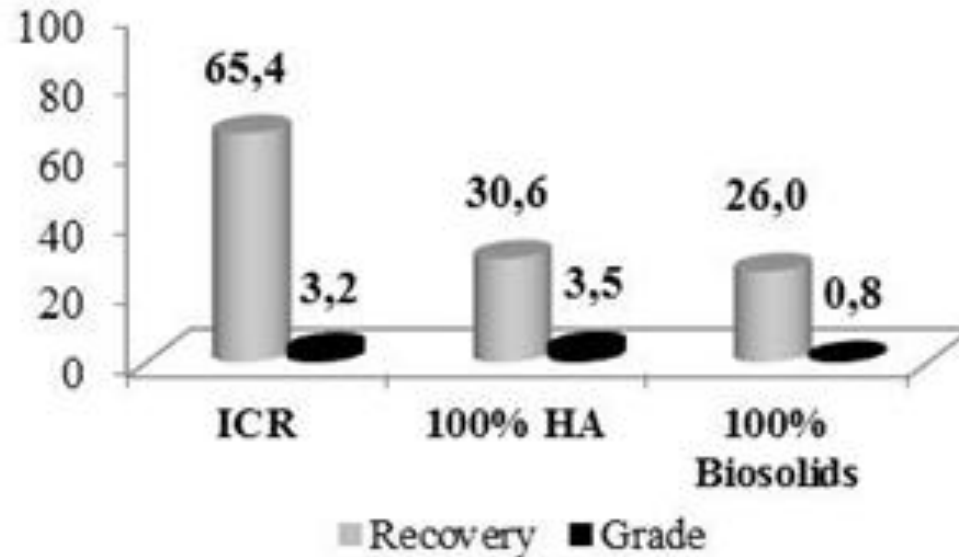
Rougher flotation test carried out at lab scale:

- pH 10.0
- Collector and Frother:
 - Industrial chemical agents
 - Biosolids (10% w/w, dry basis)
 - Humic Acid (1.5% w/w, dry basis)



Total replacement of froth flotation reagents.

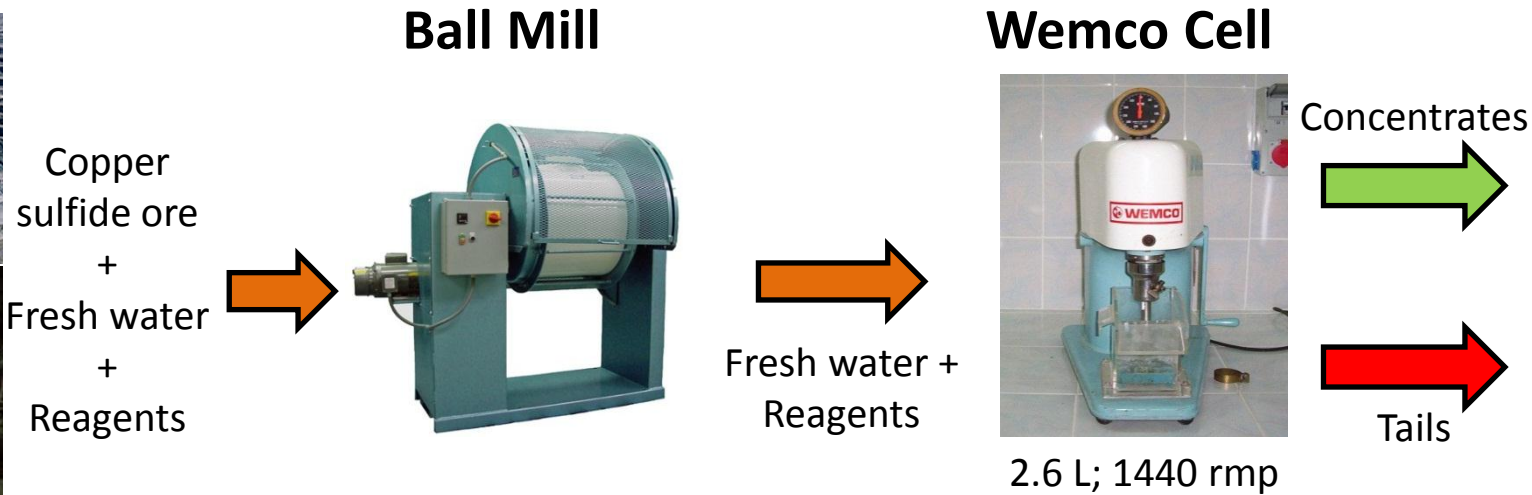
Froth flotation in Denver Cell



- Biosolids: Recovery 26.0%; grade 0.81%
- Humic acids: Recovery 30.6%; grade 3.47%
- Current chemical industrial reagents: Recovery 65.4%; grade 3.15%.

Humic acids acting as both collector and frother seem to have more affinity for copper-bearing mineral species

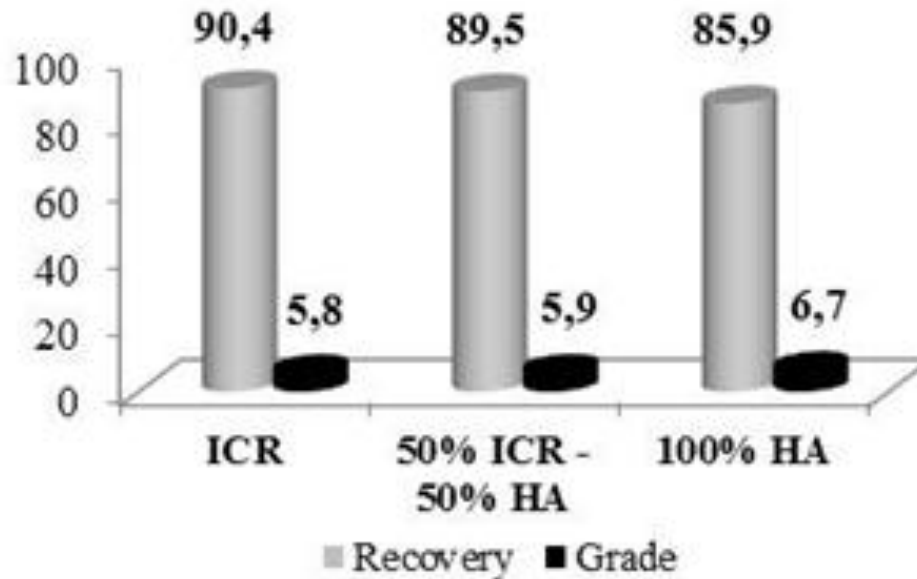
Froth flotation in Wemco Cell



Experimental conditions

Ball mill step		Froth flotation step
Parameter	Value	Value
Copper sulfide ore	1 Kg	
Fresh water	0.50 L	1.74 L
Reagents	12 g/t Diesel oil	
	38 g/t main collector	10 g/t collector (i.e. xanthate)
	CaO (pH 9.5)	12 g/t frothers (i.e. MIBC)
Conditioning time	5 minutes	30 s
Flotation time		12 minutes

Current Assays: Main results



- 0% replacement of main collector: Recovery 90.4%; grade 5.8%
- 50% replacement of main collector: Recovery 89.5%; grade 5.9%
- 100% replacement of main collector: Recovery 85.9%; grade 6.7%

Humic acids as collector indicate that this material has potential to substitute conventional chemical collectors used in the current Chilean mining processes

Final Remarks

Wastes as frother

Biosolids and humic acid solutions are able to change surface tension of aqueous solutions, significantly. Biosolids dosages around 4 g/L showed a similar behaviour to MIBC.

Wastes as collector

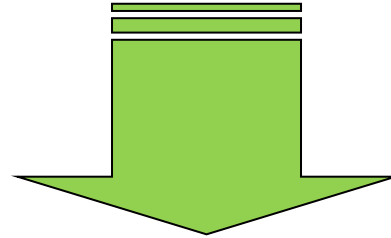
Film flotation results shown that biosolids and its humic fraction can adsorb on the surfaces of the sulphide ores, and improve their hydrophobicity.

Therefore, the main component of biosolids open an opportunity to be used in copper sulphide flotation plants replacing conventional collectors and frothers.



Final Remarks

The feasible end-use of organic wastes (i.e., biosolid and humic acids) could be a new environmentally-friendly organic agent inside the mining industry.



improving environmental
sustainability by replacement of
chemical reagents

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Thank you for your attention

Questions?

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