Life Cycle Assessment of new innovative hydrometallurgical processes: a case study

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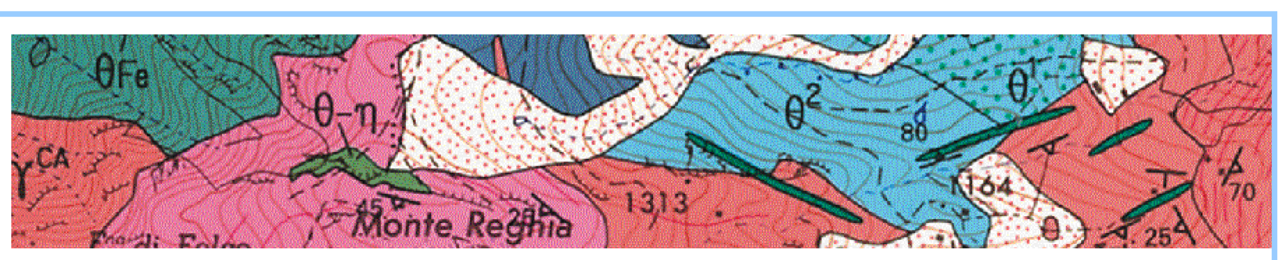

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Context & purpose

- The increasing global demand for metals is expected to keep on growing in the future, while metal-rich deposits are declining.
  It is therefore necessary to develop **new extraction and beneficiation processes to recover metals** from low-grade or complex ores.
  To ensure sustainability of such processes, their environmental balance should be assessed in order to:
  - Highlight the key environmental issues along the process chain;
  - Improve the process by means of **eco-design**.
- This case study concerns the environmental assessment through LCA of an innovative hydrometallurgical process: the **Silver Catalyzed Atmospheric Leaching** (SICAL).
  The deposit considered is located in Spain, where Cobre Las Cruces (CLC) runs an open-pit mine to recover copper and other metals as co-products (zinc, silver and lead).

Raw copper from the CLC mine © BRGM - Guillaume Bertrand

CLC pit panorama © BRGM - Guillaume Bertrand

Method

- **Goal of the study:** assess the potential environmental impacts of recovering metals through SICAL by means of LCA.
- Process-specific **functional unit** (based on the material balance of the process): *The co-production of 1 ton copper cathode and 6 tons zinc cathode, combined with the further recovery of 2.65 tons lead and 0.045 ton silver under precipitates forms.*
- **System boundaries:** from the run-of-mine ore input to the output metals (Figure 1).
- **Apportionment** of the environmental burden between co-products: partial subdivision combined with economic allocation (using the metals market price).
- **System modelling**: on-site data at pilot scale (foreground) and ecoinvent v3.4 database (background).
- Life Cycle Impact Assessment (**LCIA**) considering 9 midpoints environmental impact categories recommended by the ILCD guidelines (JRC, 2011) (Table 1).

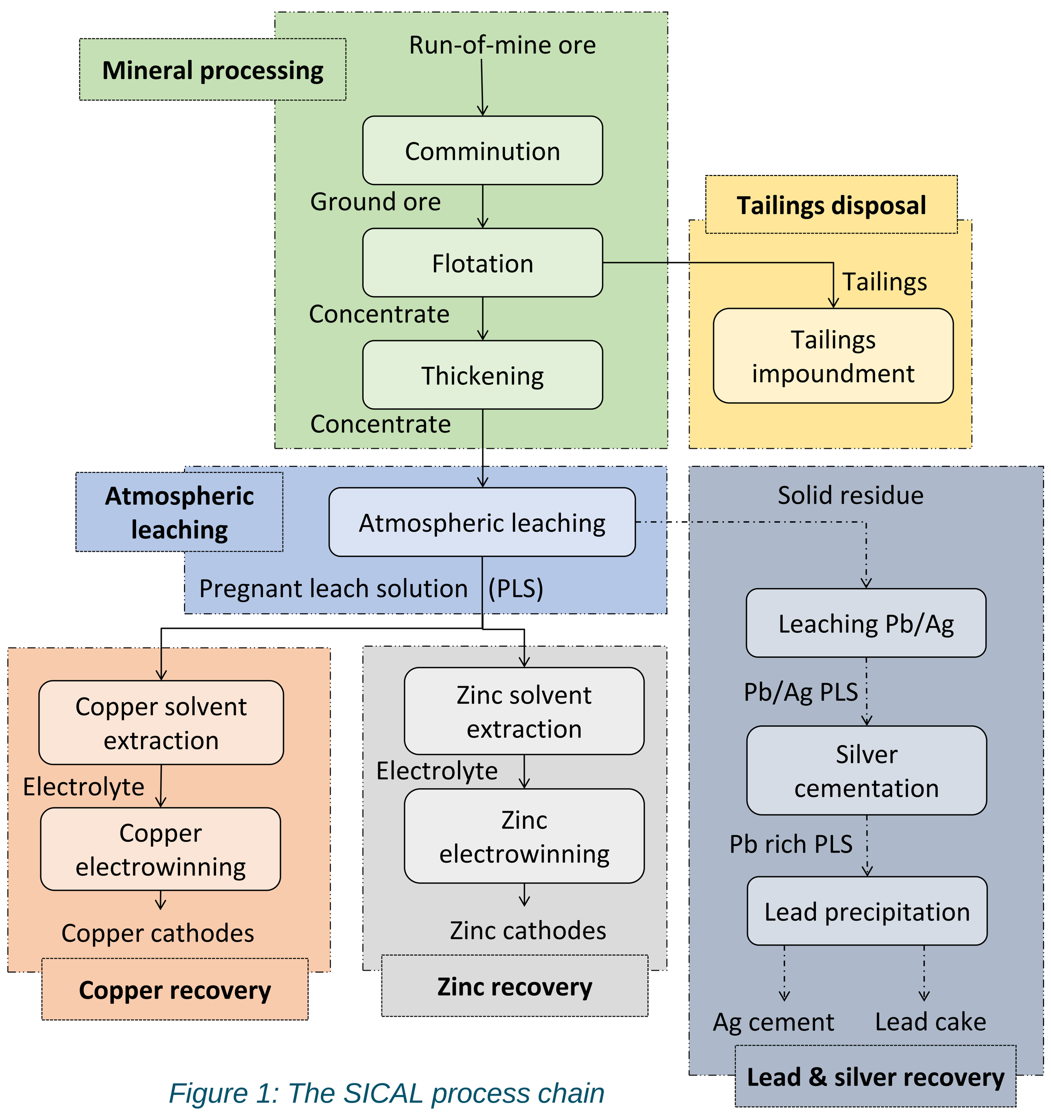

Figure 1: The SICAL process chain

Table 1: Overall LCIA results – total impacts relative to the functional unit

	Climate change (CC)	Ozone depletion (OD)	Human toxicity, non-cancer effects (HTnc)	Human toxicity, cancer effects (HTc)	Photochemical ozone formation (POF)	Acidification (A)	Terrestrial eutrophication (TE)	Marine eutrophication (ME)	Freshwater ecotoxicity (FE)
TOTAL	9.04E04 kg CO2 eq	1.54E-02 kg CFC-11 eq	6.97E-01 CTUh	9.78E-03 CTUh	2.23E02 kg NMVOC eq	5.83E02 molc H+ eq	8.95E02 molc N eq	7.92E01 kg N eq	2.84E07 CTUe

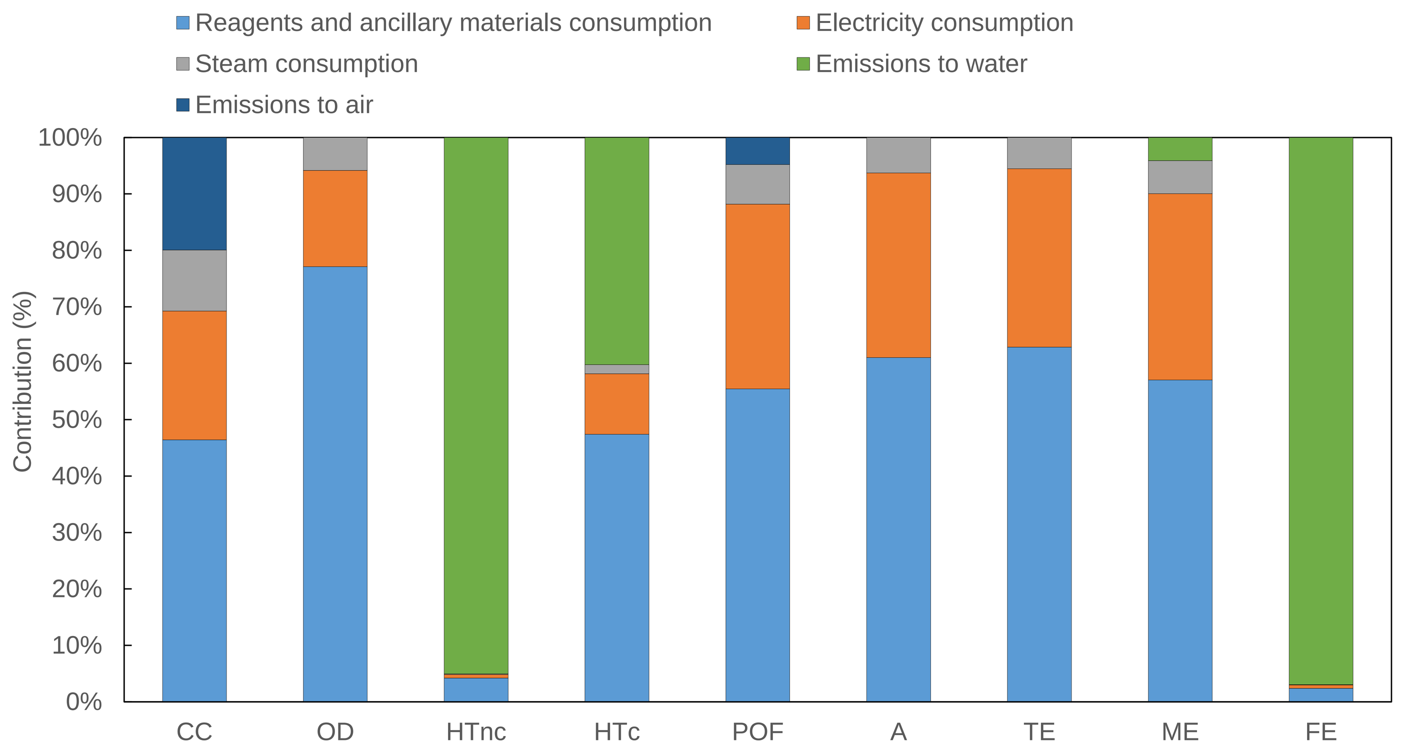

Figure 2: Contributions analysis per type of flows

Table 2: Share of the environmental burden between the co-products

	Quantity recovered	% of total burden (*)
Silver	0.045 t Ag	40-60%
Zinc	6 t Zn	10-40%
Lead	2.65 t Pb	10-15%
Copper	1 t Cu	5-10%

(*) Depending on the environmental impact categories

Results

Contribution of the different process steps

- The **lead and silver recovery** bears most of the impacts in terms of climate change, ozone depletion, photochemical ozone formation, acidification, terrestrial and marine eutrophication. This step also contributes to the human toxicity, cancer effects category.
- **Tailings disposal** is responsible for the largest share of the burden in terms of toxicity-related impacts.
- The copper recovery and mineral processing steps generate relatively limited environmental impacts.

Environmental hotspots

Several flows can be singled out (Figure 2):

- Regarding reagents consumptions: **sodium hypochlorite (NaClO)** consumed in the Pb/Ag leaching step and **oxygen** consumed in the atmospheric leaching step;
- **Electricity** consumed throughout the whole process chain;
- Potential **metals emissions** to ground and surface waters that can happen as a consequence of tailings disposal (impoundment is assumed in this case).

Environmental burden of each output metal

- Silver bears the largest share of burden regarding all impact categories except for climate change which is mainly borne by zinc.
- The share of impacts attributed to copper and lead is relatively limited.

Conclusions

The environmental balance of a newly developed hydrometallurgical process was established following the standardized LCA methodology.

The SICAL carbon footprint allocated to the production of 1 ton copper cathode is **6.5 t CO_2 eq/t Cu**, i.e. the same order of magnitude as results from previous LCA studies: 6.2 t CO_2 eq/t Cu (Norgate et al., 2007); 4.8 t CO_2 eq/t Cu (Haque and Norgate, 2014).

Those results can help technology developers to improve the SICAL performances by **mitigating the identified environmental hotspots.**

Eco-design of such innovative hydrometallurgical processes is of major importance as it aims to recover metals from low-grade or complex ores with controlled impact to the environment.

References

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