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

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The demand for metals is expected to follow an exponential increase in the years to come to satisfy an ever-growing market for manufactured goods. In the meantime, the depletion of metals-rich deposits requires to develop new beneficiation and extraction processes in order to recover metals from low-grade/complex ores. In addition to technical and economic performances, the environmental sustainability of such new techniques must be assessed. For this purpose, Life Cycle Assessment (LCA) is a widely accepted tool that allows the assessment of a product/process "environmental performance" along its life cycle.

The present case study focuses on a copper open-pit mine owned by Cobre Las Cruces (CLC) in Spain. The deposit comprises copper sulphides containing different metals in addition to copper. The mine site is equipped with "Mine-to-Metal" (M2M) technologies allowing on-site ore processing and downstream metals recovery through the implementation of a newly developed hydrometallurgical process: Silver Catalyzed Atmospheric Leaching (SICAL). The goal of this study is to assess, by use of LCA, the potential environmental impacts induced by the recovery of different metals (copper, zinc, silver and lead) through SICAL. The functional unit is "process-specific" and is calculated based on the material balance of the process. It is defined as "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". The system boundaries include all the steps from the run-of-mine (ROM) ore input (0.99 % Cu, 3.35 % Zn, 2.42 % Pb, 57 ppm Ag) to the output metals:

- Mineral processing (including comminution, flotation, thickening);
- Tailings disposal (impoundment);
- Atmospheric leaching (SICAL);
- Copper recovery by SX-EW (solvent extraction – electrowinning);
- Zinc recovery by SX-EW;
- Lead and silver recovery (including Pb/Ag leaching, silver cementation, lead precipitation).

The foreground system is modelled by use of on-site data at pilot scale, while the background system is modelled by use of the ecoinvent v3.4 database. The LCIA (Life Cycle Impact Assessment) calculations are performed using the SimaPro v8.5.2 software, considering nine midpoint impact categories recommended by the ILCD.

The LCIA results show that most of the impacts in terms of climate change, ozone depletion, photochemical ozone formation, acidification, terrestrial and marine eutrophication are generated by the lead and silver recovery steps. In terms of toxicity-related impacts, tailings disposal is responsible for the largest share of the environmental burden. The contributions analysis highlights that these toxicity-related impacts are caused by potential metals emissions to ground and surface waters from the tailings pond. Regarding the other impact categories, the consumption of reagents such as sodium hypochlorite (NaClO) for Pb/Ag leaching or oxygen for atmospheric leaching appears to be the main contributor to the impacts.

As a conclusion, this study assesses the environmental burden induced by the newly developed SICAL process and identifies the main environmental hotspots on which the effort would need to be focused with respect to a future eco-design approach.