Life Cycle Assessment in support of the benchmarking of metals production techniques: approaches for dealing with multifunctionality and implications for decision-making

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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 (e.g., hydrometallurgical processes such as bioleaching). 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 also allows comparison of different options.
Nevertheless, such comparison is not always straightforward, since the recovery of metals from polymetallic ores results in the production of several metals of interest, thus raising multifunctionality issues. The ISO standards describe different allocation criteria/substitution approaches to deal with multifunctionality in LCA, which can lead to significant differences in impact assessment (LCIA) results.

The goal of this study is to compare and discuss the different approaches for solving multifunctionality in the context of techniques benchmarking through a LCA case study. Two hydrometallurgical routes have been considered: atmospheric leaching and pressure leaching. The processed materials are two samples from a same bulk concentrate that eventually yield three metallic co-products: copper, zinc and lead. As copper is assumed to be the main metal in this case, the functional unit has been set as "the production of 1 ton of copper". The system boundaries include the leaching step and the downstream recovery of the three metals. To apportion the environmental burden to the copper (with respect to the functional unit), five multifunctionality-solving scenarios have been implemented in accordance with the ISO 14044: (i) partial subdivision combined with mass allocation; (ii) substitution by system expansion; (iii) mass allocation; (iv) economic allocation and (v) allocation to the main metal (i.e. copper). The discrepancy in LCIA results with respect to the five scenarios confirms that the choice of the allocation/substitution rules implemented affect the LCA conclusions. This should be studied through sensitivity analysis during the life cycle interpretation as it can strongly influence the subsequent decision that is to be supported by the LCA.