



Titre: Erratum: Improving process granularity of life cycle inventories for battery grade nickel
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Author Correction: Improving process granularity of life cycle inventories for battery grade nickel



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In the version of the article initially published, there was a miscalculation during the mass allocation procedure for the concentrate processing portion of the tailings bioleaching life cycle inventory. Therefore, allocated life cycle inventory flows by kg of metal have increased by a factor of 5.13 for the concentrate processing portion. Life cycle impacts for the tailings bioleaching pathway were recalculated with the corrected life cycle inventory (available in the updated Supplementary Note 4), which results in updates of Figures 1, 2 and 4.

As a result of the corrected life cycle inventory, the direct energy demand of the tailings bioleaching route increases from 9.8 to 15.2 MJ/kg of nickel in the final product (updated in Figure 1 and Supplementary Table 27). The tailings bioleaching pathway remains the less energy-intensive of all modelled pathways. The equivalent driving distance for direct embodied energy of tailings bioleaching increases from 900 to 1300 km (updated in Supplementary Table 32).

Changes (in bold) in the main text regarding the energy consumption of the tailings bioleaching pathway are as follows:

- Section 2.1: the first paragraph should now state “The RKEF-NPI route is $\sim 9\times$ more energy intensive than its laterite hydrometallurgy processing counterpart, and $\sim 50\times$ more than sulfidic tailings bioleaching.”
- Section 2.4, second paragraph: “The equivalent distances range from **1300** km for tailings bioleaching to 65,000 km for RKEF-NPI”.

Most importantly, climate impacts for the tailings bioleaching pathway have now increased from 10.2 to 40.5 kgCO_{2eq}/kg Ni in final product with the corrected allocation procedure (updated in Figure 2 and Supplementary Tables 28 and 29). Therefore, the tailings bioleaching route becomes the sulfide pathway with the highest carbon footprint.

Changes (in bold) in the main text regarding the climate impacts of tailings bioleaching are as follows:

- Section 2.2, first paragraph: “It is found that all nickel sulfide ore processing pathways modeled in this work **except tailings bioleaching** exhibit lower climate change impacts than theecoinvent dataset, the latter offering values of 12.0 kgCO_{2eq}/kg Ni_{eq} for the smelting route and 19.0 for the global market (GLO) (refer to Figure 2). This discrepancy can be explained by the majority of these pathways representing hydrometallurgy and **bioheap** leaching flowsheets, which exhibit lower emissions for concentrate processing (dark blue sections).”
- Figure 2 caption: “The four modelled sulfide concentrate processing pathways are ranked from lowest (POX leaching at 4.8 kgCO_{2eq}/kg Ni_{eq}) to highest (**tailings bioleaching at 40.5 kgCO_{2eq}/kg Ni_{eq}**) cumulative climate impacts per kg of nickel in nickel sulfate hexahydrate, battery-grade.”
- Section 2.2, last paragraph: “Similarly, when examining the results for tailings bioleaching, it is found that even if the mining stage is avoided, the extensive use of chemicals for concentrate processing, including limestone and its associated high share of process emissions, makes it **more** carbon intensive **than** flash smelting.”
- The sensitivity analysis performed on chemical sourcing, which is part of the discussion section, paragraph 6, should now read as follows: “For instance, for the bioleaching of sulfidic mine tailings, switching the emission factor for electricity from the Swedish production mix (0.02 kgCO_{2eq}/kWh) to electricity production from hard coal (1.10 kgCO_{2eq}/kWh) negligibly impacted the overall climate change impacts from **37.6 to 37.9** kgCO_{2eq}/kg Ni in nickel sulfide, or **0.8%** change. Conducting a sensitivity analysis on the sourcing market (changing from European (RER) to a global market (RoW)) of the three main contributing chemicals to climate impacts of tailings bioleaching, in decreasing order: calcium carbonate, ammonia and sulfuric acid, results in a **2%** increase (from **40.5 to 41.4** kgCO_{2eq}/kg Ni in nickel sulfate).”

The full life cycle impact assessment results were updated in Figure 4 and Supplementary Tables 33, 34 and Supplementary Figures 1 and 2.

Changes (in bold) in the main text regarding the potential burden shifting risks identified in the tailings bioleaching route are as follows:

- Section 2.5, fifth paragraph: “Even if the mining stage is avoided, tailings bioleaching **could** present a significant risk of burden shift **for mineral resource use (+322%) when applying the IMPACT WORLD + v.1.29 method but the risk disappears (-81%) with the updated CF in the v.2.01 version. While the magnitude of the impact differs in both methods, mineral resource use impacts are attributed to intensive consumption of precipitated calcium carbonate and cement for stabilization of residual tailings material. Finding a replacement for precipitated calcium carbonate will be key in mitigating climate impacts (+109-118%) and ozone depletion potential (+112%) in addition to mineral resource use risks. Land use and toxicity impacts of tailings bioleaching are not exhibiting significant risks in both IMPACT WORLD + methods in comparison to global nickel sulfate production from primary extraction (in ecoinvent).** It is to note that air emissions were modelled according to the refining permit for nickel sulfide from bioheap leaching of sulfide ores⁵¹.”
Lastly, the discussion section on tailings bioleaching is updated as follows (in bold):
- Discussion, paragraph 11: “In addition to repurposing a waste resource which otherwise poses a significant risk of leakage of heavy metals to the environment, tailings bioleaching promises to reduce energy consumption by ~ 50× and ~ 5× compared to the dominant RKEF-NPI and HPAL processing routes. **While climate impacts of tailings bioleaching are 3× lower than those of RKEF-NPI, they are comparable to those of the coal-powered HPAL route. High climate impacts for tailings bioleaching stem from the carbon intensive precipitation of calcium carbonate required to purify tailings, which is then allocated to nickel.**”

These corrections have been made to the HTML and PDF versions of the article.

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