Design Project – SIE 2025

Evaluation of Green Chemistry Metrics for the recycling of gold via bioleaching

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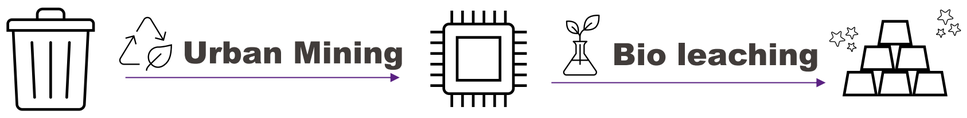
Introduction and Objectives

- With e-waste projected to reach 74.7 Mt by 2030 and less than 18% formally managed, there is an **urgent need** for sustainable precious metal recovery technologies. Switzerland's position as a global gold refining hub (70% of world capacity) provides an ideal foundation for pioneering advanced e-waste recovery methods.

- The **BioGold** process by PX Precinox is a R&D project that leverages microorganisms to extract gold from e-waste, offering a potentially sustainable alternative that aligns with circular economy principles. This research employs Green Chemistry Metrics and LCA methodologies to comprehensively evaluate the environmental, economic, and health impacts of the **BioGold** process compared to conventional methods for gold leaching.



Methodology

- Several Green Chemistry Metrics (GCMs) were selected to compare the BioGold process to the traditional leaching process : ***Yield, Atom Economy, E-Factor, Energy and Water Efficiency, Effective Mass Yield, Mass Productivity.***
- Review of the literature on gold extraction and selection of studies based on similarity with BioGold. We selected 6 studies and calculated average values to compare BioGold to.

- An attributional & consequential hybrid LCA was chosen.
- Cradle to Gate scope
- IMPACT World+Midpoint method
- EcoInvent Database
- Functional Unit : a run: a trial at pilot scale performed during an R&D project / Normalize to kg for comparison

Results Highlights

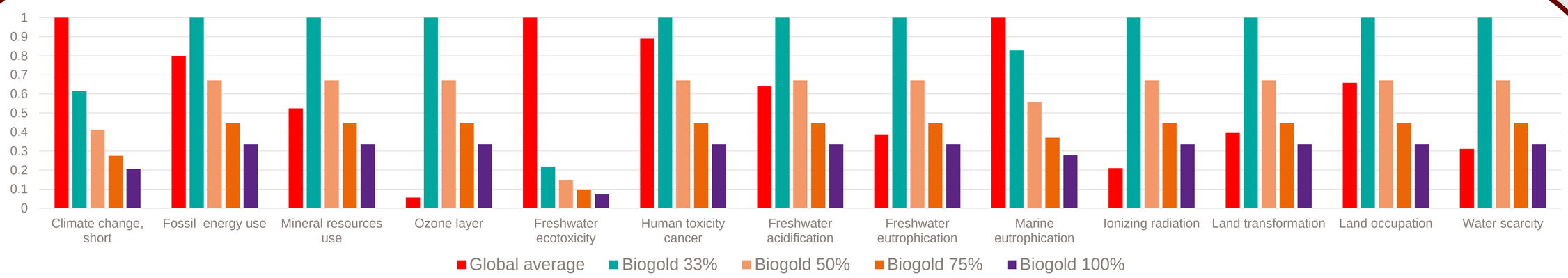


Fig: Sensitivity Analysis for Recovery Efficiency

LCA:

•Major Impact Contributors:
Leaching & Residues Treatment account for ~**78%** of environmental impacts.
•Current BioGold vs. Baseline:
Carbon emissions are just **61.55%** of traditional gold production.

Sensitivity & Optimization

• Renewables Have Limited Effect:
Switching to renewable energy reduces emissions by only **~10%**.
• Recovery Rate = High Leverage:
Increasing efficiency from **33% to 75%** drastically reduces impact.

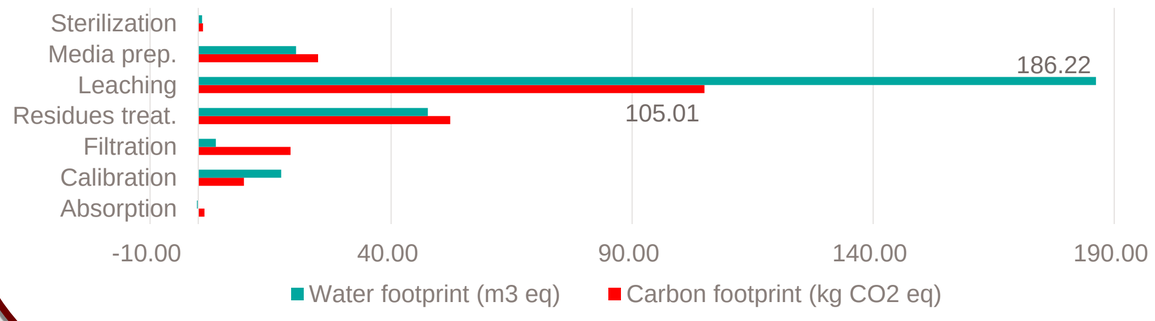


Fig: Footprints and their origins

Comparison of GCMs

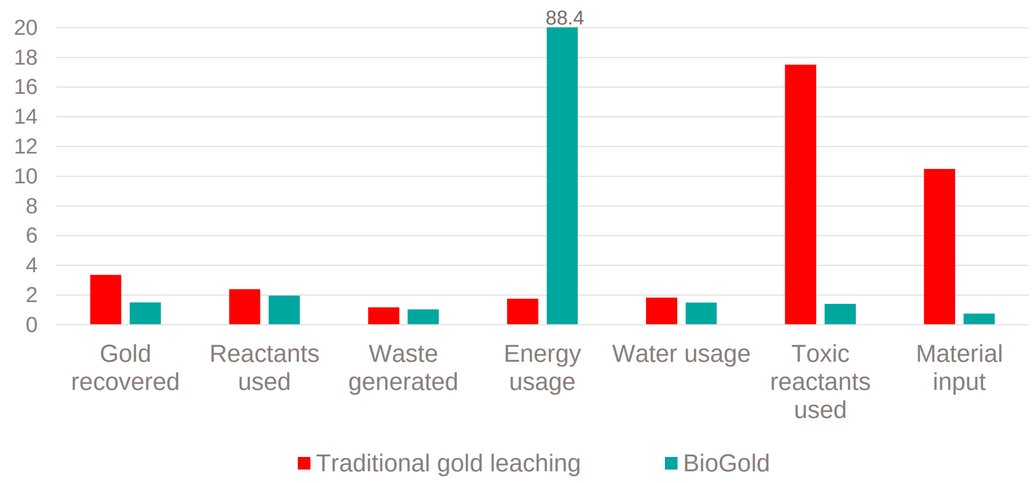


Fig: GCMs Components

Green Chemistry Metrics:

Compared to traditional gold leaching,

- BioGold's recovery yield and energy efficiency have to be improved
- BioGold uses less toxic reactants, and less material
- For other metrics, it is on par with traditional gold leaching

Conclusion and Recommendations

These results, obtained on a pilot scale installation, show that :

- BioGold already outperforms traditional methods in key areas like CO_2 emissions and uses fewer toxic reactants.
- Most of its impact comes from high electricity and O_2 demand in the leaching phase.
- Improving yield will have the greatest effect on the sustainability of the process.
- Further research could focus on how to improve yield and scale up.

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