Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.20165

Comparison of biostimulation and bioaugmentation treatments for recovering of critical metals from tungsten mine residues.

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The recovery of metals from secondary resources, such as mining wastes, is increasingly seen as an interesting solution to overcome the difficulties in supplying critical metals from mining. The controlled alteration of minerals with specific bacteria to recover critical metals is an innovative approach to include mining waste in a circular economy, i.e. as a secondary raw material. In the framework of the REVIVING project (H2020 ERAMIN2), we studied a process of oxidation of the minerals of Panasqueira mine tailings (Portugal) with the aim of recovering metals of interest (Cu, Mn, Mg, Zn and W) by controlled bioleaching. The development of a leaching process for several metals simultaneously is complex due to their distinct intrinsic biogeochemical properties, especially for the tungsten anion.

The objective of this study was to compare ferro- and sulfo-biooxidation-based bioaugmentation and biostimulation approaches. A microbial consortium obtained from Panasqueira mine tailings was enriched with ferro- and sulfo-oxidizing acidophilic microorganisms and was used in the bioaugmentation treatment. In addition, several amendments (iron and/or sulfur) were applied to stimulate the ferro- and sulfo-oxidizing microorganisms of the tailings. The nutrient biostimulation treatment was designed to stimulate the growth and activity of the native tailings microbiome. Abiotic and biotic leaching tests were performed in batch reactors for 60 days during which physicochemical and biological parameters (pH, O2, metal concentrations, DNA quantities, Metabarcoding...) were analyzed.

The results demonstrated efficient bioleaching of metals with both bioaugmentation and biostimulation approaches compared to abiotic controls. The recovery yields were close to 100% for Zn, Mg and Mn, up to 30% for Cu and up to 13% for W with both approaches. The (expensive) addition of sulfur and iron to the bioaugmentation treatments did not significantly improve metal recoveries compared to biostimulation. Biostimulation was therefore found to be as effective as bioaugmentation in simultaneously recovering all metals of interest in a single bioleaching process. It should therefore be considered a better candidate for further studies. A metabarcoding analysis of the bacterial community established under the two treatments is in progress and will allow identifying the main bacteria involved in metals bioleaching with biostimulation and bioaugmentation.