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A multiscale approach for critical metals recovery from mine waste by bioleaching

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Exploiting primary resources results in the production of large quantities of waste from mining activities. Innovative approaches consider mining waste as secondary raw materials in a circular economy concept. As part of the European REVIVING project, which aims to apply bioleaching processes to waste from a tungsten mine in Portugal in a bioengineering process, the aim is to transpose the small-scale optimized acid mine drainage biological process to medium and large scales via manipulation of the waste's indigenous microbiome. We tested the application of isolated bacterial strains in 20g batches, as well as nutrient biostimulation of the waste's indigenous microbiome (eg ferro-oxidant and sulfo-oxidant micro-organisms), and their bioaugmentation, through culture in a specific medium. Unconvincing, the bacterial monoculture approach was abandoned, whereas the 2 last approaches were very efficient for bioleaching metals of interest (Cu, Mn, Mg, Zn, W and Mo). For the sake of simplicity and efficiency, and because of important cells' filtration through the waste, biostimulation was selected for the process upscaling (x100) in 2Kg waste columns subject to controlled operating conditions (liquid and air flow) with a monitoring including water saturation, pH, O2, geochemistry, microbial community abundance and structure. Our tests validated the efficiency of the metal bioleaching process, compared with abiotic conditions. A second scale-up (x100) of the process was efficiently initiated in a 200Kg pilot set-up at the Portuguese-mine, and is still in progress after 4-months of operation using the same biostimulation process and monitoring. A biophysical-chemical process is currently being developed for the recovery of bioleached critical metals. The whole process aims to meet circular economy objectives by valorizing mining waste both through the secondary production of critical metals and of metal-free mineral material for potential civil engineering applications.