Community dynamics during adaptation and upscaling of a secondary polysulfidic ore bioleaching process

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Abstract: Within European research project NEMO, a bioleaching strategy was developed for efficient metal extraction from secondary ore material currently heap-leached at Sotkamo by Terrafame (Finland) that still contains several sulfidic minerals and significant amounts of valuable metals (Ni, Zn, Co, Cu). A moderately thermophilic bioleaching consortium mainly composed of *Acidithiomicrobium* P2 and *Sulfobacillus thermosulfidooxidans* was adapted to the Sotkamo heap-leaching residue, grinded below 250 µm (d_{80}), in batch 2-L stirred tank reactors, at pH 1.7 and 55°C. Community composition was followed by t-RFLP molecular fingerprinting at various operating conditions (solid concentration, pH, process scale-up). Progressive increase of solid concentration (5%, 10%, 15% and 20% (w/v)) allowed the adaptation to high solid content, with efficient metal dissolution. Community temporal evolution was remarkably reproducible at 10% and 15% solids, with *Sb. thermosulfidooxidans* dominant and *Acidithiobacillus caldus* as minor strain while Eh increased, and *Acidithiomicrobium* P2 dominant over *Sb. thermosulfidooxidans* during stationary phase. At 20% solids, *Acidithiomicrobium* P2 was detected earlier and its relative abundance increased with time. A pH lower than 1.5 was detrimental to *Acidithiomicrobium* P2 and favoured *Sb. thermosulfidooxidans* that showed a better tolerance to acidification; however, no impact on metal dissolution was observed. The process was scaled-up to a 114-L continuous pilot, consisting of four stirred-tank reactors in cascade and operated at 50°C and 20% solids (d_{80} < 430 µm), in which dissolved metals monitoring confirmed a high metal extraction rate. The two dominant strains remained main actors, especially in primary reactor R1 and in R2, but other strains such as *At. caldus* and *Leptospirillum ferriphilum* were found, possibly favoured by a lower temperature. Community differed in R3 and R4; *L. ferriphilum* or *At. caldus* became codominant probably due to observed pH fluctuations. Efficient bioleaching of Sotkamo ore was demonstrated, as well as the resiliency and robustness of the selected moderate thermophilic consortium, in all conditions tested at laboratory and pilot scales.

Keywords: bioleaching, community evolution, moderate thermophilic bacteria, stirred reactors.

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