Selective Bioleaching of Critical and Precious Metals from Northern Queensland Mine Waste Using Indigenous Bacteria

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Mine waste in Northern Queensland poses environmental challenges due to reactive metals released via sulfide oxidation, which drives acid and metalliferous drainage (AMD). These wastes also serve as secondary sources of valuable metals, including copper (Cu), zinc (Zn), and gold (Au). Efficient extraction methods that minimize waste and environmental harm are essential. Bioleaching, an eco-friendly metal extraction technique, leverages microbes to recover metals with minimal ecological harm. However, the use of indigenous microbes for selective recovery of valuable metals and bioremediation of toxic elements like arsenic (As) and lead (Pb) in varied mine waste compositions remains underexplored.

This study evaluated indigenous and inoculated iron- and sulfur-oxidizing bacteria for metal extraction from mine waste at Baal Gammon (BGA) and Rishton (RSA) in Northern Queensland, aiming to limit toxic metal mobilization. Shaker flask bioleaching experiments used Fe- and S-oxidizing microbes from the abandoned Mt. Morgan mine. Complementary tests—net acid generation (NAG), acid consumption, and paste pH—evaluated AMD potential to optimize bioleaching conditions.

The results highlighted RSA, with high clay and feldspar content, was non-acid forming (NAG pH 7.5, paste pH 7.8), naturally attenuating AMD. Conversely, BGA, rich in sulfides, was potentially acid forming (NAG pH 2.1, paste pH 3.5), favoring bioleaching. Further, RSA mobilized Au (15%) > Cu (2.1%) > Pb (1.7%) > As (0.5%), while BGA yielded Cu (28.2%) > Zn (22.2%) > Pb (3%) > As (0.4%). Acid consumption tests showed RSA required 21 days and 800 µL of acid per 10 g of material in 100 mL lixiviant to reduce pH from 7.7 to 2.0, necessitating acid pre-treatment for efficient bioleaching.

This study demonstrates that indigenous microbes enable selective metal recovery from mine waste, supporting resource valorization and mine closure. By tailoring bioleaching to site-specific properties (e.g., AMD-potential, mineralogy), this approach maximizes metal extraction and minimizes environmental harm.