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Exploring the Potential of Microbial-mediated Bioleaching of Metals from E-waste

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The demand for electronics is rapidly growing as modern society strives for greater global connectivity. This growth, however, is significantly constrained by the uneven distributions of, and limited access to, critical raw materials (CRMs), as well as the geopolitical complexities of their movement through global supply chains. As a result, securing alternative sources of these materials has become a strategic priority. In addition, electronic waste (e-waste) is one of the fastest growing waste streams worldwide, with only 17.4% of all e-waste properly collected and recycled. Most e-waste is either landfilled or improperly disposed thereby releasing heavy metals and toxic compounds into the surrounding environment. To promote resource resilience and environmental sustainability, upcycling conventional waste as a resource is necessary. In this regard, e-waste can be a valuable source of CRMs including copper, nickel, gold, silver, palladium, and rare earth elements. Current recycling methods, such as hydro- and pyrometallurgy, are energy intensive requiring large amounts of resources (e.g., water, chemicals, or fuel) leading to high operational costs as well as several negative impacts on the environment (e.g., additional waste and greenhouse gasses). Bioleaching facilitated by redox-active microorganisms offers a sustainable and economically viable alternative more suitable for reclaiming these valuable elements. In this study, we set out to assess the potential of redox-active bacteria to bioleach critical raw materials from electronic waste using a multi-analytical approach. In doing so, the capability of acidophilic iron(II)-oxidizing bacteria (*Acidithiobacillus ferrooxidans*) and iron(III)-reducing bacteria (*Geobacter metallireducens*, *Geobacter sulfurreducens*, *Shewanella oneidensis*) to leach a variety of metals from printed circuit boards (PCBs) was analysed in batch incubations. All experiments were performed in parallel with abiotic controls. Soluble and precipitated metal concentrations were monitored via Inductively Coupled Plasma – Mass Spectrometry and Optical Emission Spectroscopy. Overall, redox-active bacteria proved to enhance metal (i.e., iron, copper, nickel, praseodymium, caesium) release from PCB's, with varying effects between strains. Oxidative metal dissolution appeared to be more effective than reductive metal dissolution. *A. ferrooxidans* and *G. metallireducens* were identified as promising candidates for bioleaching metals from PCB's, potentially contributing to the sustainable recovery of critical raw materials from e-waste.