DOI: 10.46991/JISEES.2025.SI1.107

Bio-Recovery of Copper from Electronic Waste: Influence of PCB Particle Size

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ABSTRACT

The growing demand for electronic devices, combined with their increasingly short lifespans, has resulted in a sharp rise in electronic waste (e-waste), creating serious environmental and resource recovery challenges. Printed circuit boards (PCBs), a key component of electronic devices, are rich in valuable base and precious metals such as copper, aluminum, and gold - often in concentrations much higher than those found in natural ores. This study explores how particle size influences the bioleaching efficiency of metals from PCBs using a two-step approach. Bioleaching was carried out with biogenic ferric ions produced by *Acidithiobacillus ferrooxidans* 61. PCBs were crushed into four size fractions (≤125 µm, 125–630 µm, ≥800 µm, and 1000–1500 µm), pretreated, and subjected to bioleaching. The highest copper recovery was observed in the 125–630 µm fraction, where a balance between surface area and minimal particle agglomeration enhanced leaching efficiency. Zinc and aluminum recovery were also influenced by particle size: zinc leaching was more effective with larger particles (>800 µm), while aluminum dissolution was higher in the finest fraction (≤125 µm). Most of the metal recovery occurred during the first stage of bioleaching, which corresponded with higher oxidation-reduction potential (ORP) values and more active bacterial performance. These findings emphasize the importance of particle size optimization in improving bioleaching outcomes and support the viability of bioleaching as an eco-friendly alternative to traditional metal recovery methods. Through precise control of particle size and process conditions, bioleaching can contribute to sustainable e-waste recycling and effective resource recovery.

Keywords: PCBs, *Acidithiobacillus ferrooxidans*, bio-lixiviant, two-step bioleaching, particle size

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