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Mass Spectrometry & Purification Techniques

Opinion Article

Bioleaching Process for Extraction of Microbial Groups

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DESCRIPTION

The capacity of various types of microorganisms to naturally convert solid metallic waste into soluble, extractable form is known as bioleaching. Numerous microbial species, including heterotrophic fungus (*Aspergillus sp.*, *Penicillium sp.*), autotrophic bacteria (*Thiobacilli sp.*), and heterotrophic bacteria (*Pseudomonas sp.*), can be employed for bioleaching. Although there are other bioleaching techniques, including one-step, two-step, and spent medium procedures, the latter technique has been proven to be the most effective in removing metals from e-waste. At room temperature, iron- and sulphur-oxidizing bacteria may both break down minerals and be utilised for bioremediation. Leaching of heavy metals from soil requires acidophilic microbes such *Acidithiobacillus thiooxidans*, *A. ferrooxidans*, *Leptospirillum ferrooxidans*, and *Sulfolobus sp.*

On the other side, thermophilic chemolithoautotrophic microorganisms can also be employed for bioleaching, including *Acidianus brierleyi*, *Metallosphaera sedula*, and *Sulfobacillus thermosulfidooxidans*. The oxidation of iron and sulphide produces sulfuric acid and ferric ions, both of which have the power to change insoluble sulphides into soluble sulphate forms. For the extraction of Au and Ag from e-waste, bacteria like *Chromobacterium violaceum*, *Acidithiobacillus sp.*, *Ferromicrobium sp.*, *Leptospirillum sp.*, *Acidiphilium sp.*, and *Pseudomonas fluorescens* have been utilised.

Most heterotrophs create organic acids and complexants that aid in the bioleaching process; they are used to treat moderately alkaline wastes because they can withstand a wide range of pH. For heterotrophic bioleaching, several bacterial species, including Bacillus, *Chromobacterium Pseudomonas*, and fungi, including Penicillium and Aspergillus, have been utilised.

In addition to these, cyanogenic heterotrophic microorganisms are essential for the bioleaching and metal extraction from e-waste. The common bacteria *Pseudomonas aeruginosa*, *P. fluorescens*, and *P. putida* generate a variety of compounds that are often employed in metals bioleaching. Several researchers have demonstrated Pseudomonas' ability to extract gold from crushed Waste from Electrical and Electronic Equipment (WEEE).

When used to remove metals from outdated SIM cards, *Chromobacterium violaceum* was successful in removing copper (13.79%), silver (2.55%), and gold (0.44%). However, using a double-step bioleaching technique and pre-treating the isolate with acid, the same isolate was able to recover about 72% of Cu.

The powdered spent batteries might be processed by *Acidithiobacillus thiooxidans* and *Leptospirillum ferriphilum* to extract Mn, Cu, and Zn. It has also been demonstrated that bioleaching by heterotrophic bacteria like *Cellulosimicrobium funkei* is a viable technique for removing gallium arsenide (GaAs) from a semiconductor. Contrarily, the process of metal leaching is aided by heterotrophic fungus species like *Aspergillus niger* and Penicillium. The majority of these heterotrophic fungus taxa create organic acids including malic, citric, gluconic, and oxalic acid that aid in the chelation and recovery of metals from various types of e-waste. Rare earth elements are also thought to be present in e-waste, and they are extracted using both fungus and bacteria.

From shreds of e-waste, up to 99% of cerium, europium, and neodymium and 48% of gold were extracted using *Pseudomonas putida* (WSC361) and *Acidithiobacillus thiooxidans* (DSM 9463). In addition, Au was recovered from used electronic scrap using *Desulfovibrio desulfuricans*, while copper was extracted using *Hymeniacidon heliophila* sponge. After adequate e-waste preparation, *Acidithiobacillus ferrooxidans* can help with the extraction of both Au and Cu. Cu was removed from PCBs using the bacterial combination of *Gallionella sp.*, *Acidithiobacillus sp.*, and *Leptospirillum sp.* Additionally, both direct and indirect leaching methods as well as bioleaching procedures may be utilised to remove metals like zinc. Most of the times, the bacteria is resistant to a variety of metals.

A thermophilic, acidophilic-chemolithotrophic bacteria called *Sulfobacillus thermosulfidooxidans* is employed for e-waste bioleaching. *A. niger* and *P. simplicissimum*, two metal-tolerant fungi, may be utilised to leach Au, Al, Cu, Pb, and Zn in addition to Ni. Despite being a cost-effective process, bioleaching has a number of drawbacks, including the need for a lot of time and a potential for partial metal recovery.

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