
Title: Biotechnological strategies for the recovery of valuable and critical raw materials from waste electrical and electronic equipment (WEEE) – A review

Authors: Arda Işıldar, Eric D. van Hullebusch, Markus Lenz, Gijs Du Laing, Alessandra Marra, Alessandra Cesaro, Sandeep Panda, Ata Akcil, Mehmet Ali Kucuker, Kerstin Kuchta

PII: S0304-3894(18)30739-8
DOI: https://doi.org/10.1016/j.jhazmat.2018.08.050
Reference: HAZMAT 19674

To appear in: *Journal of Hazardous Materials*

Received date: 17-1-2018
Revised date: 14-8-2018
Accepted date: 16-8-2018

Please cite this article as: Işıldar A, van Hullebusch ED, Lenz M, Du Laing G, Marra A, Cesaro A, Panda S, Akcil A, Kucuker MA, Kuchta K, Biotechnological strategies for the recovery of valuable and critical raw materials from waste electrical and electronic equipment (WEEE) – A review, *Journal of Hazardous Materials* (2018), https://doi.org/10.1016/j.jhazmat.2018.08.050

# Biotechnological strategies for the recovery of valuable and critical raw materials from waste electrical and electronic equipment (WEEE) – A review

## Authors

Arda Işıldar[1,2,*], Eric D. van Hullebusch[1,3], Markus Lenz[4,5], Gijs Du Laing[6], Alessandra Marra[7], Alessandra Cesaro[7], Sandeep Panda[8], Ata Akcil[8], Mehmet Ali Kucuker[9], Kerstin Kuchta[9]

**Affiliations**

[1] IHE Delft Institute for Water Education, Delft, The Netherlands

[2] Université Paris-Est, Laboratoire Geomatériaux et Environnement (LGE), EA 4508, UPEM, 77454 Marne-la-Vallée, France

[3] Institut de Physique du Globe de Paris, Sorbonne Paris Cité, University Paris Diderot, UMR 7154, CNRS, F-75005 Paris, France

[4] Fachhochschule Nordwestschweiz, University of Applied Sciences and Arts Northwestern Switzerland, Brugg, Switzerland

[5] Sub-Department of Environmental Technology, Wageningen University, 6700 AA Wageningen, The Netherlands

[6] Department of Applied Analytical and Physical Chemistry, Ghent University, Belgium

[7] Sanitary Environmental Engineering Division (SEED), Department of Civil Engineering, University of Salerno, Italy

[8] Mineral-Metal Recovery and Recycling Research Group, Mineral Processing Division, Department of Mining Engineering, Suleyman Demirel University, TR32260 Isparta, Turkey

[9] Institute of Environmental Technology and Energy Economy, Technical University of Hamburg, Germany

* Corresponding author

Abstract: Critical raw materials (CRMs) are essential in the development of novel high-tech applications. They are essential in sustainable materials and green technologies, including renewable energy, emissionfree electric vehicles and energy-efficient lighting. However, the sustainable supply of CRMs is a major concern. Recycling end-of-life devices is an integral element of the CRMs supply policy of many countries. Waste electrical and electronic equipment (WEEE) is an important secondary source of CRMs. Currently, pyrometallurgical processes are used to recycle metals from WEEE. These processes are deemed imperfect, energy-intensive and non-selective towards CRMs. Biotechnologies are a promising alternative to the current industrial best available technologies (BAT). In this review, we present the current frontiers in CRMs recovery from WEEE using biotechnology, the biochemical fundamentals of these bio-based technologies and discuss recent research and development (R&D) activities. These technologies encompass biologically induced leaching (bioleaching) from various matrices,biomass-induced sorption (biosorption), and bioelectrochemical systems (BES).

Keywords: Biotechnologies; bioleaching; biosorption; bioprecipitation;
critical metals; electronic waste