Chapter 7
Biogenic Sorption: An Intelligent and Sustainable Approach to Reclaiming and Reutilizing Heavy Metals in the Modern Era

Periasamy Palanisamy
https://orcid.org/0000-0003-1069-5822
Nehru Institute of Engineering and Technology, Anna University, India

M. Kumaresan
Nehru Institute of Engineering and Technology, Anna University, India

M. Maheswaran
Nehru Institute of Engineering and Technology, Anna University, India

ABSTRACT

The treatment of heavy-metal-bearing wastewaters is a critical environmental challenge, as access to clean drinking water becomes increasingly difficult due to pollution and rising water treatment costs. Traditional adsorbents derived from fossil fuels are not sustainable and can contribute to secondary pollution. To address this issue, researchers have turned to biogenic sorbents made from modern biomass as a promising alternative. These biosorbents utilize biological waste materials that would otherwise contaminate water systems, promoting a circular economy and sustainable water treatment practices. This chapter explores the potential of biogenic sorbents for water decontamination, focusing on their use in the removal of heavy metals from contaminated waters. Further, this chapter delves into the preparation methods, adsorbent types, adsorption mechanisms, and regeneration techniques employed with these biosorbents.

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1. INTRODUCTION TO BIOSORBENTS FOR HEAVY METAL REMOVAL

Heavy metal pollution is a substantial environmental distress, from the industries particularly mining, metallurgy, and energy harvesting units releases large quantities of toxic metals into the environment (Vardhan et al., 2019). Those heavy metals, including mercury (Hg), lead (Pb), chromium (Cr), and cadmium (Cd), cause a serious menace to living bodies' health and ecosystems(Vardhan et al., 2019). Conventional methods for eradicating heavy metal ions from aqueous solutions, such as chemical precipitation and electrochemical treatment, are habitually unproductive and produce large amounts of slurry. Therefore, different approaches are being required to address this persistent concern. One such methodology is biosorption, which utilizes biological materials to remove heavy metals from aqueous solution(Eccles, 1995; Sheng et al., 2004). Biosorption is the method in which living or dead biomass as well as cellular products like polysaccharides, sequesters metal ions through various physicochemical mechanisms(Veglio' & Beolchini, 1997; Volesky & Holan, 1995; Witek-Krowiak et al., 2011). It provides numerous advantages over traditional methods, comprising high efficiency, quick metal removal, and cost-effectiveness. Biosorption has multiplied its significant attention in recent years as a prospective solution for the treatment of high volume, low-concentration complex waste waters having heavy metals(Zouboulis et al., 2002).

The background mechanisms accountable for biosorption are not yet fully understood but are supposed to involve ion exchange, complexation, coordination, adsorption, electrostatic interaction, chelation, and micro precipitation. Biomass materials for example bacteria, fungi, yeast, and algae have been comprehensively experimented as potential biosorbents owing to their metal-binding capabilities. These biosorbents can meritoriously sequester heavy metal ions from dilute complex solutions, making them energetic candidates for the treatment of wastewater. Biosorption can take place through both metabolic and non-metabolic pathways(Reddy et al., 2012). Metabolic biosorption includes the active uptake of metal ions by living biomass. Non-metabolic biosorption, in contrast, take place through impulsive physicochemical processes and does not necessitate the expenditure of ATP. Both living and deceased biomass have been found to demonstration of biosorption properties which making them suitable for metal removal applications(Vijayaraghavan & Yun, 2008; Witek-Krowiak & Harikishore Kumar Reddy, 2013).