

Chapter 2

Mechanisms of Biosorption: An Overview

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ABSTRACT

Biosorption is the method to remove heavy metals from the ecosystem, and it has replaced the use of other physical and chemical methods that are used for removal of heavy metals. The main cause of heavy metal pollution is industrialization. The industrial waste that contains heavy metal leads to pollution in aquatic life systems. It is also poisonous to humans and other animals. The major highlight of this chapter will be the mechanism of various biosorption processes with the help of different biosorbents such as several micro-organisms, non-living biomass, and some herbal plants. It is eco-friendlier as well as cost effective. Nowadays, vegetable waste and fruit peels are also used as biosorbents for the removal of heavy metals.

1. INTRODUCTION

Nowadays the rapid increase in modernization of society and development of different industries leads to the pollution of heavy metal in environment. The increase in heavy metal pollution increases danger to the human being, animals, plants and life under water i.e. aquatic life. It disturbs almost all normal ecosystems in the nature. It gives rise to major illness to human. Major portion of the heavy metal pollution involves with water pollution due to industrial and agricultural use. Increase in heavy metal pollution also leads to the metal poisoning in human and living creatures. However, the use of heavy metal is essential in various industries, but pollution because of them is one of the serious issue because heavy metals are non-degradable in nature and it is accumulated in nature year after year (Perumal et al., 2021; Bilal et al., 2018).

DOI: 10.4018/979-8-3693-1618-4.ch002

The heavy metal can be classified as essential and non-essential heavy metal based on their requirement. Some heavy metal like Copper, Nickel and Zinc are classified as essential heavy metal which is required by some plants and animals in little amount. However, its excessive level in body is dangerous (Mustapha et al., 2015). The other remaining metals are non-essential heavy metal such as Cadmium, Mercury, Arsenic and Lead. The heavy metal can be removed by various physical and chemical method such as ultra-filtration, chemical precipitation, sludge reduction, chemical oxidation-reduction, ion exchange, reverse osmosis, evaporation etc. However, these methods are neither very productive nor it is cost effective and become impossible to use based on the pollutant concentration, volume and characteristics of aqueous solution (Ahn et al., 2009; Patron-Prado et al., 2010). So, these methods can be replaced by some biological method such as biosorption and bioaccumulation. These biological methods are very much productive in terms of their efficiency, cost effectiveness, very promising and fast process. The biosorption is the process of adsorption of heavy metals on the surface of different biomass. In biosorption, generally dead biomass is used because it has many advantages over the living one. So, it is called as passive method (Swiatek et al., 2014). The process of biosorption is better method over many other methods which are used for removal of pollutants such as heavy metals from aqueous solution specially when dealing with low concentrations. However, in bioaccumulation, living biomass is used for the removal of heavy metal. So, it is called active method.

In these chapter, we will mainly focus on different methods of biosorption and its mechanism to remove heavy metals from different sources of aqueous solution. The mechanism of heavy metal biosorption process is influenced by the status of biomass, types of biomaterials, chemical properties of metal solution and environmental conditions such as pH and temperature (Das et al., 2008). Mechanisms of biosorption mainly depends on the types of biosorbent used. Bioaccumulation is the metabolism dependent process also can be called as extracellular accumulation or cell surface adsorption. Whereas Intracellular metabolism is dependent on cell metabolism where transport of metal takes place across the cell membrane (Ahalya et al., 2003; Ahluwalia and Goy, 2007; Javanbakht et al., 2014). Biosorption is the metabolism independent process that is faster and reversible in comparison to metabolism dependent bioaccumulation (Tiwari et al., 2022).

2. GENERAL ASPECT

Most of the heavy metals occur naturally in the environment or on the earth surface and earth crust. The heavy metal can be defined as metals with density higher than water or high atomic weight, or atomic number (Brathwaite and Rabone, 1995; Helmenstine, 2018). It can be introduced into the environment through natural sources, which involve volcanic emissions, forest fires etc. or it can be introduced through anthropogenic sources, which involves mining, smelting, painting industries, leather tanning, battery manufacturing, petroleum refining, metal manufacturing, paints, coating industries, tanneries, printing, pesticides, agricultural runoff, etc. Typically, the presence of heavy metals is of low concentration in agricultural soils, water of rivers and lakes, but not on earth. Heavy metals are extracted from the earth's crustal ores and anthropogenic activities contribute to their migration to areas where they are naturally found in low concentrations. Due to their non-degradable nature, they are considered to be very harmful to living organisms. Heavy metals are classified in two categories, one is essential and another is non-essential heavy metals (Shamim, 2018).

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