Chapter 1
Heavy Metal Pollution and Biosorption

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ABSTRACT

The escalation of environmental pollution by heavy metals has emerged as a global concern in recent years, posing a significant threat to public health. This phenomenon is exacerbated by the ongoing rise in anthropogenic activities, notably industrial processes and urbanization, which indiscriminately release pollutants into the environment without effective control and mitigation measures. Subsequently, these metals traverse the food chain, impacting animals and humans. Elevated levels of heavy metals can have deleterious effects on organisms and plants, disrupting the metabolic functions of vital organs and glands. Continuous assessment and monitoring of heavy metal levels in the environment are imperative due to the escalating anthropogenic activities. The primary objective of this chapter is to provide an illustrative discussion on important heavy metals, environmental pollution caused by heavy metals, encompassing air, soil, and water. Various toxic effects on human health have been considered, and corresponding remedies have been presented.

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INTRODUCTION

Water is the essential resource required to sustain life on this planet. Water plays a major role in the civilization, growth and economy of developed and developing countries (Paul and Sinha, 2013). Rapid industrialization, increasing population, urbanization and careless utilization of natural resources is one of the most frequent reasons of water pollution and presently being the most emerging problem of each developing country (Carolin et al., 2017; Vardhan et al., 2019). This is due to large amount of industrial effluent, dyes, organic matter, radio-nuclides, pharmaceutical, pesticides, heavy metals, plastics, suspended solids, parasites and pathogens being present and disposed into the natural water bodies (Villarín and Merel, 2020). Sewage and slugs are also part of above environmental pollutants which cause danger to aquatic biota and deteriorates water quality (Sinha and Paul, 2014). Actually, the quality of water is a critical concern for living beings and it is directly associated with human welfare. Industrial waste water is source of heavy metals like cadmium (Cd), chromium (Cr), lead (Pb), arsenic (As), mercury (Hg), cobalt (Co), zinc (Zn), copper (Cu), silver (Ag), iron (Fe) and platinum (Pt). These toxic heavy metals are every day released into the water from different natural and anthropogenic sources.

Among these, some heavy metals like Cu, Fe, Cr and Zn are required as nutrients in trace amounts for different life processes in living organisms including plant, animals and microorganisms but become toxic at higher concentrations (Tchounwou et al., 2012). On the other hand, heavy metals like Pb, As, Hg, and Cd have no biological function (Dudka and Adriano, 1997; Ghannam et al., 2015). These are nonbiodegradable and accumulate in the plants, animal as well as human bodies through food chain and their higher concentration leads to adverse effects (Praveena et al., 2010; Paul and Sinha, 2015; AzehEngwa et al., 2019). World health Organization (WHO), Food and Agriculture Organization (FAO), and United States Environmental Protection Agency (USEPA) has reported that long term exposure of heavy metals have been associated with muscular dystrophy, multiple sclerosis, Alzheimer's disease, osteoporosis, and cancer (Fu and Xi, 2020; Gerardo et al., 2020; Srivastava et al., 2017), retarded central nervous activities, damage to the lung tissues, nasal mucous membranes and pharynx congestion, liver, kidney associated nephritis, renal tumour, extensive lesions in the kidneys, anuria, cardiovascular diseases, changes blood composition, increases blood pressure and headache are some of the heavy metals associated risks reported by several authors (Florea and Büsselberg, 2006; Jaishankar et al., 2014; Vaishaly et al., 2015). The nature of toxicity along with degree of change in organ system will depend on the heavy metal ion concentration, and route of exposure that interrupts biochemical as well as metabolic processes of body (Bobaker et al., 2019; Mokarram et al., 2020). Therefore, removal of heavy metal from water and food should be essential to prevent the problem of bioaccumulation and biomagnifications. Three main approaches to remove heavy metals are physical, chemical and biological. Physical and chemical methods involved are precipitation, sedimentation, coagulation, membrane filtration, ion exchange, reverse osmosis etc (Rawat et al., 2013; Sahmoune, 2018). These traditional techniques are effective at higher concentration of metal ions, generate excessive slugs, are expensive and ineffective at very low concentration of dissolved metals on the order of 1–100 mg/L (Tang et al., 2008). However, compared with the traditional physical and chemical techniques, biological technique has a broad application prospect in view of its high efficiency, economy, environment-friendly and ability to biosorb heavy metal even at very low concentration i.e. about 1-100 mg/L (Wang et al., 2020; Yin et al., 2018). The heavy metals significantly affect the microbial community in the environment. Studies have shown that numerous microorganisms are tolerant to heavy metals and play important roles in removal and remediation of heavy metals (Gadd 1990). In recent years, heavy metal bioremediation technology based on lactic