Chapter 9
Nano-Remediation of Heavy Metals From Polluted Soils

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ABSTRACT

Uncontrolled rapidity with anthropogenic activities industrialization have led to significant contamination of soils and streams with accumulated non-biodegradable heavy metals such as arsenic (As), mercurous ion (Hg22+), cadmium (Cd), chromium (Cr), plumbous (Pb4+), and thallium (TI) at intolerable toxic concentrations. This necessitates the remediation of these heavy metals from the environment, as they could mix with different environmental elements, leading to disturbance in the food chain of living organisms. Several experimental studies and technologies have been performed towards the sustainable treatment utilising novel approaches and technologies based on nanotechnology. This chapter addresses the effects and sustainable treatment using nanoparticles in the remediation of heavy metal effected environment

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INTRODUCTION

Heavy metals can be defined as metallic elements that occur naturally and have a density five times greater than water, as well as a relatively high atomic weight. Metalloids, on the other hand, possess properties of both metals and non-metals and are typically classified as heavy metals (Bánfalvi G., 2011). The metals in question have a density exceeding 4 g/cm3, and are therefore classified as "heavy metals and metalloids." Arsenic (As), lead (Pb), cadmium (Cd), chromium (Cr), mercury (Hg), and nickel (Ni) have attracted significant attention due to their contamination in concentrations exceeding critical values established by agencies such as ATSDR (Substance Priority List Resource Page. ATSDR. Available from: https://www.atsdr.cdc.gov/spl/resources/index.html). These heavy metals and metalloids have been the focus of concern among researchers.

Mercury, cadmium, and lead are considered the most dangerous substances compared to others. They are commonly referred to as the "big three" due to their significant environmental impact (Kahlon SK, et al.,2018).These substances are regarded as highly troublesome since they do not break down naturally and have a tendency to accumulate in organisms when consumed. As a result, they are included in the Environmental Protection Agency's roster of priority pollutants (Dominguez-Benetton et al., 2018, Lesmana et al., 2009). Exceeding the established limits for Cd, Pb, Hg, Cr, and as intake can have severe health consequences, including bone abnormalities, elevated blood pressure, lung cancer, harm to the nervous system, accumulation of toxic substances in the body, gastrointestinal issues, and other important ailments (Morais et al., 2012 and Jomova et al., 2011).

The issue of heavy metal contamination is a significant concern since it can have harmful effects, even at low doses. Heavy metals are substances that cannot be broken down by living organisms, and they have the ability to build up in tissues and increase in concentration as they go up the food chain. (Grey, J.S. 2002) Geological bedrock weathering and volcanic eruptions can release heavy metals into the surrounding environment (Wuana RA, Okieimen FE. 2011) The presence of heavy metals in the rock substratum is influenced by various factors, such as the composition of the bedrock/soil, climate conditions, soil characteristics and composition, and human activities in the area (Grey JS. 2002, Tchounwou PB et al., 2012). The working versions' release and the entrance of heavy metals into the food chain depend on the level of concentration and absorption by the fauna and flora of the area. Atmospheric deposition is a significant contributor to the accumulation of deposits in urban and suburban regions. Figure 1 categorises the sources of heavy metal. Heavy metal contamination arises from various sources, including industrial activities (such as tanneries, electroplating, dyeing, and mining), agricultural areas, sewage sludge, and waste treatment facilities. Recent research has confirmed that the prolonged utilisation of untreated wastewater originating from industrial sources can have a negative impact on the quality of water, rendering it unsuitable for human consumption (Grey, J.S. 2002)). Unprocessed industrial wastewater commonly exhibits pigmentation, foaming, and is laden with perilous substances such as heavy metals, toxic dyes, acids, alkalis, and other noxious chemicals (Kaushik et al., 2005 Jul). The pollution that ensues has detrimental effects on the well-being of inhabitants and poses occupational health risks for workers (Jarup L. 2003 Dec). The electroplating business discharges toxic wastewater with high concentrations of heavy metals (Srisuwan G, et al., 2002). Untreated effluents from electroplating plants have been found to exceed the allowable limits for heavy metals, including chromium (Cr) and nickel (Ni). The references cited are Srisuwan G, et al., 2002 and Orescanin V, et al., 2013. Tannery wastewater contains heavy metals such as copper (Cu), chromium (Cr), iron (Fe), manganese (Mn), and zinc (Zn) (Devi R. 2011). Numerous studies have examined the level of heavy metals in in-

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