Chapter 11
Interaction of Heavy Metal Ions With Nanomaterials:
A Remediation Process

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ABSTRACT

Increasing water pollution due to heavy metals is a major global concern, and favorable remediation techniques are required. Heavy metal contamination affects both flora and fauna as it enters the food web. The development of nanotechnology and novel nanomaterials production has attracted researchers worldwide. Both carbon- and metal-based nanomaterials proved great adsorbents for heavy metal remediation because of their unique properties such as thermal and chemical stability and high surface. Novel green route for nanomaterials synthesis make the nanomaterials production an environmentally friendly, low cost, and user-friendly approach. This chapter reviews the heavy metal pollution causes and utilization of different nanomaterials for the remediation process.

INTRODUCTION

Today approximately 663 million people lack access to safe drinking water all around the world (WHO, 2015). Heavy metal contamination is the major contributor to the world drinking water crisis, affecting millions of people worldwide. Major contributors for heavy metal pollution are lead (Pb), cadmium (Cd), arsenic (As),

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mercury (Hg) and chromium (Cr) as are most toxic and nonbiodegradable. Their presence above permissible limits in body can cause severe damages to vital organs of the body, such as kidney, liver and brain, reproductive and nervous system (Moreno-Castillaet al., 2004; Zhao et al., 2011). These heavy metals are widely utilized by many industries such as metal finishing, iron and steel, metallurgical, mining, battery producing industries etc. and are released in various water sources (Chen et al., 2007). Various technologies reported for remediation of metal ions from wastewater are solvent extraction, reverse osmosis, separation by membrane, ion exchange etc (Walsh et al., 1994; Xing et al., 2007; Ersahin et al., 2012). The available techniques have disadvantages such as high cost, high required investment and disposal of metal sludge; therefore, efforts have been made to synthesis low cost materials for removing heavy metals from aqueous solutions. Nowadays, nanomaterials (NMs) are recommended as effective, low cost and eco-friendly substitute to available treatment materials, in both resource conservation and environmental remediation (Zare et al., 2013; Gupta et al., 2015). The elimination of heavy metals from polluted sites using nanomaterials formed by plant, fungi and bacteria with the assistance of nanotechnology is called nanobioremediation. Green route for synthesis of nanoparticles has developed markedly to form novel materials that are eco-friendly, cost effective and stable. Although nanoparticles can be manufactured through a range of conventional processes but the biological route of synthesizing is more beneficial because of ease of fast production, low toxicity, control of size characteristics, low cost and eco-friendly approach (Mei et al., 2014). In the development of various remediation technologies for heavy metals, adsorption has already been proven to be an effective approach towards contamination removal (Tripathy et al., 2006; Onyangoa et al., 2006). The adsorption process mainly depends upon the applicability of the absorbent. The quality of the effluent generated is also better than the rest of the processes because the adsorbent has a high affinity towards the metal ions. Various types of adsorbents such as zeolites, activated carbons, chelating materials and nanoparticles have been developed for the remediation applications. The main selection parameters of adsorbents are the high adsorption capacity, fast kinetics and low cost (Wang et al., 2010; Cai et al., 2013; Gupta et al., 2015). With the development of technology, nanomaterials are utilized for heavy metal remediation due to their more surface area and low-cost synthesis and proved efficient adsorbents. Among all reported nanomaterials, remediation of heavy metals ions by metal oxide based nanocomposites and iron oxide based magnetic nanomaterials has been broadly utilized. Nano sized iron oxide particles exhibit super paramagnetism, an additional special property from common nanoparticles. Super paramagnetic nanoparticle have large surface area, are biocompatible, less toxic, chemically inert, offer small diffusion resistance and their surface can be modified with organic molecules, inorganic ions or some functional groups, which render

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