Chapter 10
Wastewater Treatment in Removal of Heavy Metals:
Nanotechnology Applications in Environmental Engineering

Tehseen Yaseen
Pakistan Council of Scientific and Industrial Research, Pakistan

Anum Yaseen
University of Punjab, Pakistan

ABSTRACT

Nanotechnology is the area of nano science that shows great potential to establish a new process for wastewater treatment. It has been applied on a nanometer scale level. Currently, limited water resources and real treatment of wastewater is a chief requirement for the growing economy. It is in great demand to introduce the progressive wastewater treatment technologies. Therefore, the modern innovative processes in nanomaterial sciences have been appealing the target of scientists. The chapter addresses the developments in nanotechnology with respect to wastewater treatment, especially the removal of heavy metals and to the environmental applications. It will discuss the application of different classes of nanomaterials for wastewater treatment in removal of heavy metals and its possible effects to the environment. Therefore, the scope is to offer an overview of how nanomaterials are causing concerns related to heavy metal removal for water and in the surrounding environment.

INTRODUCTION

Advancement in science and technology are always a source of great attention for scientists and researchers to all over the world, specifically when the emphasis is on some particular area. In recent years, as a growing field, the Nanotechnology has been used in various applications. Similarly, new nano structures and materials are in great demand (Baruah & Dutta, 2009). Among the natural resources, water is the most abundant and important, but only about 1% of that resource is available for human consumption

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(Grey et al., 2013; Adeleye et al., 2016). It is calculated that about 1.1 billion people faces deficiency of adequate drinking water (WHO, 2015), due to the increasing cost of potable water, rising populations, and diversity in climatic and environmental concerns (Adeleye et al., 2016). The obvious test in the water supply chain is regular contamination of freshwater resources by a number of inorganic and organic pollutants (Schwarzenbach et al., 2006). However, the previously used methods of treatment are less reliable to completely eliminate the evolving contaminants like heavy metals and fulfill the need of strict water quality standards (Qu et al., 2012). This can be obtained either by the establishment of new methods or by refining the existing methods through some intercessions. Among these emerging technologies, developments in nanotechnology has proved an incredible potential for the remediation of water contamination and various other environmental issues (Zare, Najafi, & Sadegh, et al., 2013; Gupta et al., 2015). Nanotechnology and nano-science have been shown the significant development in different fields and producing new and advance materials. Nanotechnology has been mentioned, in other different works, as one of the reliable method for water management (Stone et al., 2010; Zhang, & Fang, 2010). It could be categorized on the basis of nano-materials characteristics into different classes: nano-catalysts, nano-adsorbents and nano-membranes (Zhang et al., 2014; Mohmood et al., 2013) Furthermore, there is a significant need for advanced water technologies to ensure a high quality of water, eliminate chemical and biological pollutants, and intensify industrial production processes of wastewater. In this regard, nanotechnology is one of the ideal options for advance wastewater treatment processes. Furthermore, these nano-particles can be joined with biological processes (anaerobic digestion, algal membrane, microbial fuel cell) to enhance the water purification process. Each process has its own merits and specific pollutant removal efficiency (Theron, Zussman, & Yarin, 2004).

Heavy metals are considered to be the main contaminants in wastewater especially at high concentrations causing health problems in human beings and raising serious environmental issues (Chowdhury et al., 2016). These metal ions have toxicity potential, and might cause carcinogenicity in living organisms. The rapid development of industries leads to the production of huge amount of toxic heavy metals ion. They are directly or indirectly added into the water resources specifically in developing countries. As an effect of their non-biodegradability nature and the potential to aggregate in living organisms, treatment of industrial wastewaters is a particular concern for removing toxic heavy metals such as PbII, CdII, NiII, CoII, MnII.etc. At high and the low level concentrations (Fu & Wang, 2011). There are many different techniques used for eliminating heavy metal ions as revealed by literature. Such as activated carbon (Rao et al., 2002; Kadirvelu et al., 2001) was used for the elimination of contaminants in the water that has been replaced by less expensive adsorbing materials. There are several other adsorbents, such as fly ash (Rao et al., 2002), zeolite (Sheta et al., 2003), seaweeds (Vijayaraghavan et al., 2005), have been employed by different researchers and informed for the elimination of metal based pollutants in the wastewaters. Unfortunately, all these techniques have drawbacks including cost and sludge issues. Therefore, nanotechnology has been widely used to overcome the drawbacks of traditional methods and to meet the needs of current wastewater treatment. There are different research and development policies regarding nanotechnology perceptions are in development to increase the accuracy and efficiency of traditional methods (Contreras et al., 2017). It is clear with recent findings that nanotechnology can change the applications and properties of research and industrial materials, which are achieved because of the size of nano particles.

Currently, a great consideration has been dedicated to the application and creation of nano-materials to remove toxic and heavy metal ions from wastewater. The need to produce and control the nano-particles discovers use in enlightening the quality of water in the environment. For the importance of water quality