

Chapter 9

Application of Magnetic Nanomaterials for Water Treatment

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ABSTRACT

The availability of clean drinking water becomes a critical issue for all the people of the world due to a rapid increase in population and industrialization. The water bodies get contaminated due to the discharge of wastewater, that will not only disturb the aquatic life but also badly affect human health. Therefore, different methods are adopted to treat the contaminated water to make it clean and safe for people. In last few years, the nanomaterials have gained much attention for water treatment because of their unique properties. Among all nanomaterials, magnetic nanomaterials are considered more efficient and attractive because of their easy separation and reusable property. In this chapter, a brief review related to synthesis and characterization of MNM was studied along with their application in removal of dyes, heavy metals, and microbes from wastewater through simple adsorption processes.

INTRODUCTION

The access to clean water has become one of most serious issue facing people all over the world. As the world's population is expected to hype from 6.5 billion and to 9 billion by the year 2025, the demand for water is also expected to increase. The water quality is affected very badly due to anthropogenic activities (Xu et al., 2012). Both organic and inorganic pollutants are present in water because of agriculture, domestic and industrial activities, which effect the human health and in turn deteriorate the ecosystem (Gupta, Kumar, Nayak, Saleh, & Barakat, 2013).

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Water is a basic necessity of all life available on earth; only 3% of the total water comprises of freshwater and a small proportion i.e. 0.01% of this freshwater is accessible for human use. Exploitation of water resources due to lack of proper management for sustainable use, deterioration of ecosystems coupled with the environmental pollution resulted in scarcity and depletion of water reservoirs. Use of contaminated water affects all the biotic components of ecosystem (Azizullah, Khattak, Richter, & Häder, 2011). Polluted water can cause mutagenic, teratogenic, carcinogenic, reproductive etc. impairments in living organisms due to the presence of toxic substances like heavy metals, dyes, pesticide, phosphates, nitrates etc (Nabeela et al., 2014).

Major sources of these toxic compounds are industrial effluents, disposal of sewage sludge and run-off from agricultural fields. Once pollutants enter the water bodies, they either get dissolved into the water or may remain suspended, and then they enter the food chain which may result into bioaccumulation or biomagnification. The presence of toxic substances poses threat to overall ecosystems. Trace amounts of some elements are essential for water quality, but when their concentration exceeds permissible levels, they become toxic compounds affecting the environment (Brabec, Schulte, & Richards, 2002).

Currently different methods are developed and practiced to treat and remove pollutants from the water to make it reusable. For water and wastewater treatment commonly physical, chemical and biological methods are applied/ used. In these methods, different techniques like adsorption, membrane filtration and catalytic degradation are employed to make them more efficient (Burkhard, Deletic, & Craig, 2000). Although these methods are effective, but are expensive, time consuming and require more land and man power for their operation (Anjum, Miandad, Waqas, Gehany, & Barakat, 2016). To combat with this above scenario, there is a dire need to develop and adopt new technology to remove contaminants and to ensure availability of safe and clean water to people.

Nanotechnology and Nanomaterials

Nanotechnology is emerging as an interdisciplinary research and provides innovative solutions for the recent problems. Nanotechnology is “the design, fabrication and application of nanostructures or nanomaterials and the fundamental understanding of the relationships between physical properties or phenomena and material dimensions”. Nanomaterials are the important factors in the revolution of nanotechnology to elucidate the water issues globally (Qu, Brame, Li, & Alvarez, 2013).

Nanomaterials have unique physicochemical properties due to their small size and large surface area, which make them attractive for their application in water treatment (Amin, 2009). Different kind of nanomaterials like metal, magnetic, carbon based and clay based nanomaterials are used for the treatment of water. These nanomaterials can be synthesized by top down and bottom up approach. Two different approaches are used for synthesis of nanocomposites (Figure 1) i.e. top-down approach which includes physical methods and bottom up approach includes wet methods (Ajayan, 2003; Oliveira & Machado, 2013).

The benefit of physical methods is production of large amount of nanocomposites, while synthesis of equal sized nanocomposites is difficult to attain through top-down approach. In comparison, wet chemical methods give uniformity in size of nanocomposites where controlled particle size can be achieved. Although by varying conditions of reaction, different shapes (nano-rods, nanowires, nanotubes etc.) of nanocomposites can be synthesized.

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