Chapter 72
Recent Trends and Advancement in Nanotechnology for Water and Wastewater Treatment:
Nanotechnological Approach for Water Purification

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ABSTRACT

Fast growing demand of fresh water due to increasing population and industrialization dictated research interests towards development of techniques that offers highly efficient and affordable methods of waste-water treatment. In recent decades water treatment using nano-technological based expertise have gained significant attention. Varieties of nanoparticles were synthesized and proficiently used in treatment of wide range of organic and inorganic contaminants from waste streams. This chapter encompasses recent development in nano-technological approach towards water and wastewater treatment. The authors tried to compile up to-date development, properties, application, and mechanisms of the nanoparticles used for decontamination purpose. This piece of work offer a well organized comprehensive assessment of the technology that delineates opportunities as well as its limitation in water management practices moreover few recommendations for future research are also proposed.

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INTRODUCTION

"Water water everywhere, not any drop to drink" a famous quote by Samuel Taylor Coleridge always reminds us about the importance of fresh water. It is well-known that most of earth's water is saline and availability of world's fresh water resource is less than 1% on which whole global population relies. Water therefore, signifies as a precious resource which helps in sustaining life on earth. However, galloping population, increasing industrialization and unsustainable agricultural practices makes the freshwater resources highly vulnerable for pollution. It is therefore necessary to protect and conserve these resources and keep it free from pollution stress. In this regard, reuse and recycling of the wastewater is one of the best sustainable practices of water management. Moreover, wastewater recycling considered as a pre-eminent option for the nations reeling under the burden of fresh water crisis. Everyday millions of tons of wastewater have been generated worldwide as a result of various house hold, agricultural and industrial activities (Mane et al., 2011; Gautam et al., 2013; Banerjee et al., 2014). Hence, wastewater comprises of varieties of organic, inorganic and biological pollutants and these pollutants have deleterious effect on biological system (Raouf et al., 2012). Organic pollutants such as dyes, pesticides, fertilizers, hydrocarbons, detergents, oils and pharmaceuticals were detected frequently from polluted aqua reservoirs (Pedersen et al., 2003). These contaminants have severe impact on hydric environment and its organisms, as these compounds are highly toxic, persistent and almost non-degradable in nature (Puvaneshwari et al., 2006). Among inorganic pollutants, some of the heavy metals ions such as arsenic, mercury, chromium, cadmium, selenium and lead considered as highly toxic contaminants if their concentration in waste streams exceeds the safe permissible limits (Mohan & Pittman, 2007; Boening, 2000; Owlad et al., 2009; Godt et al., 2006; Hamilton, 2004; Papanikolaou et al., 2005). Presence of the anionic species such as nitrate, phosphate, fluoride, chloride, sulfate and oxalate in wastewater contributes to significant threat to human health (Bhatnagar & Sillanpaa, 2011; Huang et al., 2008; Mohapatra et al., 2009; Gopal et al., 2007; Silva et al., 2002; Brady, 2011). Moreover, presence of large number of microbial population such as viruses, bacteria, protozoa, algae and fungi in wastewater results in transmission of several water-borne diseases. Therefore wastewater laden with such sorts of pollutants required to be treated immediately prior to its discharge into receiving streams (Kyzas & Kostoglou, 2014). During the past four decades several water treatment techniques have been reported as well as successfully implemented such as adsorption, coagulation, chemical oxidation, cloud point extraction, froth floatation, ozonation, reverse osmosis, membrane filtration, solvent extraction, ion-exchange, ultrafiltration etc. Among treatment technologies, adsorption considered as the most suitable and proven technology having wide prospective applications in both water and wastewater treatment (Ali & Gupta, 2007). This process is becoming an attractive option because of its simplicity, ease of operation, high efficiency, sludge free operation, insensitivity to toxic substances and outstanding regeneration capacity (Jain et al., 2010; Sharma & Uma, 2010). The term "adsorption" defined as a process of accumulation or separation of substance from an aqueous/gaseous phase onto a solid phase (Bajpai & Rajpoot, 1999). The substance that accumulates at the interface is called adsorbate and the solid on which adsorption occurs is adsorbent (Dabrowski, 2001). Therefore in adsorption process physical and chemical characteristics of the adsorbent material such as surface area, porosity, pore size, surface charge density and zero point charge considered to play noteworthy role.

Ranges of adsorbent were synthesized and tested by researchers for its potential in removal of hazardous organic/inorganic substances from aqueous solution. Among several, activated carbon considered as one of the most popular and versatile adsorbent due to its high surface area and porosity therefore