Chapter 31
Advanced Nanomaterials for Water Engineering and Treatment:
Nano-Metal Oxides and Their Nanocomposites

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ABSTRACT

Loading of water with multifarious pollutants has dwindled the availability of quality fresh water and put questions on reliability and efficacy of conventional water treatment technologies. Also the quest for developing robust and cost-effective methods with minimum impact on environment had driven the focus of researchers and technologists on new technological developments. Nanotechnology – better referred as Aqua-nanotechnology in this regard provides scientists a new dimension to deal this big problem with small particles having application in 1) water treatment, 2) remediation, and 3) pollution prevention. This chapter will focus on fabrication and use of advance nanomaterials categorized as nanoadsorbents and nanoatalysts for these three main areas. A range of materials exploited in this regard are single and mixed metal oxides and their composites with polymer, clay, carbon based materials etc. while keeping focus on technological developments taken place over the period in regard with treating water and waste water.

INTRODUCTION

The importance of clean and safe water cannot be negated but a famous quote by Jacques Cousteau portrays the true reality about today's world approach that *We forget that the water cycle and the life cycle are one*. As per a report published by World Business Council for Sustainable Development (WBCSD) (Fry, 2005), there is a considerable increase in water consumption with an increase in the industrial

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revolution. All this development has no doubt made human life easy but on other hand has raised serious concerns over the sustainability of clean water as it caused limited share accounting for only 11% of water available for domestic consumption. Water pollution scenario is creating hype in the world and with its cross-border perspective water pollution is not an issue to be addressed and solved by some countries independently but it requires a consolidated approach to mitigate the pollution jinni. According to United Nations World Water Development report 2014, with depleting world water reservoirs and an anticipated rise of 55% in global water demand by 2050; an appreciable number of people are expected to have no access to clean water and improved sanitation (WWDR, 2014). With the development of new materials, chemicals, and technologies, the pollution scenario is getting worse. Also, the application of stringent laws and requirement of reduced levels of minimum contamination levels have put a question mark on the effectiveness of simple biological processes and conventional water treatment technologies (Zhou et al., 2002). Therefore, with the advent of technological innovations, there is a need to revolutionize methods for water treatment and remediation.

With its growing realm, Nanotechnology provides scientists a new dimension to deal with the ever rising problem of clean water availability (Bora et al., 2014; Qu et al., 2013). Also, the quest for developing robust new methods at lower cost, less energy, minimum use of chemicals and least impact on the environment, had driven the focus of environmentalist, water technologists, and engineers on nanotechnology revolution for rejuvenating the polluted fresh water reservoirs by implication of new materials and technologies. Already, the technology had put in a dramatic impact on water quality research and with its broad and diverse range of applications it offers various opportunities and challenges to further stimulate positively in this area of water engineering and treatment.

BACKGROUND

Access to safe and adequate water is the right of every individual living in this world but still 0.8 billion people according to WHO do not have access to quality drinking water and further 2.5 billion people lack access to improved sanitation. The industrial revolution in addition to bestowing us with amenities of life had also resulted in the production of diverse nature of new chemicals and materials which degradation is becoming a serious concern. Hence, loading of water with these diverse nature of pollutants including disinfectants and their byproducts, inorganic and organic chemicals, radionuclides and even resistant strains of microbes has not only limited the fresh water availability but has greatly impacted the water quality. All this resulted in inadequate drinking water, sanitation, and hygiene, which are estimated to cause more than 0.8 million diarrheal disease deaths per year and contribute substantially to several other diseases. Loading of the above-mentioned diverse range of pollutants and emerging of new contaminants also requires new treatment technologies to address the provision of safe water – the search lead to utilization of nanotechnology for water cleanup and remediation.

AQUA-NANOTECHNOLOGY

"Aqua-nanotechnology" has now been recognized as a branch of nanotechnology that deals with the application of nanomaterials for 1) water treatment, 2) remediation and 3) pollution prevention (Tratnyek et al., 2006). Nanotechnology-enabled treatment of water and wastewater provides the much needed