Nanotechnologies for Environmental Remediation

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Applications and Implications

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Foreword

Nanotechnology, the science of a few billionths of a meter, is today one of the fastest growing fields in engineering, being considered the emblem of the twenty-first century innovation. In particular, the feverish development of engineered nanoscale materials (NMs) represents a technological revolution for the development of innovative material and new productive sectors at the service of citizens. Because of their high surface area per unit mass and due to a high reactivity NMs that exhibit properties different from those exhibited on macroscale leading to extraordinary properties that enable unique applications. In this context, there is a strong belief that nanotechnology could provide solutions also to a number of environmental challenges including the use of nanosized reactive products to degrade or immobilize contaminants (environmental nanoremediation) by reacting with target contaminants at a faster rate than would larger particles and so leading to marked improvements in efficiency and ecocompatibility compared with conventional techniques. Environmental nanoremediation of various contaminants has been recently reported for the treatment of surface water, groundwater, wastewater, and for soil and sediment cleanup from toxic metal ions, organic and inorganic solutes, and emerging contaminants, such as pharmaceutical and personal care products. One emerging nanotechnology, nanosized zero valent iron and its derivatives, has reached the commercial market for field-scale remediation. Interestingly, nanoremediation technology had been documented in at least more than 40 cleanup sites around the world, predominantly in the United States. Unfortunately, in spite of the great excitement about the potential benefits offered by the introduction of environmental nanoremediation several safety-related questions, e.g. the induction of toxic effects due to uncontrolled release of NMs into the environment, remain unsolved and we must be careful about the potential risk of econanotoxicity.

This book comprises 12 state-of-the-art chapters concerning salient aspects of the use of NMs in environmental applications including nanoremediation and wastewater treatment. It represents a valuable reference source for nanotech industries as well as for practicing scientists, research professionals working in

research and development laboratories, graduate students and university professors working in the field of environmental sciences and engineering, ecology, econanotoxicology, public health and environmental control. I hope that it will be of interest not only to the international scientific community but also to the competent authorities and officers entrusted with responsibilities in regulatory issues concerning the environmental risk assessment of NMs.

There is a common feeling that the magnitude of the research effort in the development of environmentally friendly NMs throughout their lifecycle and their potential environmental effects is bound to increase greatly in the coming years. Thus, it is expected that this book will contribute to spur the interest of all those wishing the development of "green nanoproducts" and the application of such nanoproducts in supporting environmental sustainability in the pursuit of scientific and social ends. This book is addressed to everyone who is concerned about the use and the environmental impact of NMs.

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Preface

Nanotechnology holds a great potential in advancing water and wastewater treatment general performance boosting water supply through the safe use of unconventional water sources such as treated wastewater. Similarly, nanoremediation could drastically improve subsurface in situ remediation efficiency increasing the contaminant degradation and detoxification and minimizing off-site or ex situ activities.

The aims of developing nano-based techniques and later on technologies to remediate polluted waters, groundwater and soil/sediment are in growing harmony with the principles of Green Chemistry, and more broadly, Green Engineering and Technology. In the book framework, worldwide investigators present and discuss the continuing efforts to better understand the recent development in applying nanoscience, nano-engineering and nanotechnology for environmental remediation.

Candidate nanomaterials, properties and mechanisms that enable the applications, advantages and limitations as compared to existing processes, and barriers and research needs for commercialization are presented in the Chapters "Progress in Nanomaterials Applications for Water Purification"–"The Use of Al and Fe Nanoparticles for the Treatment of Micropollutants". Chapter "Environmental Nanoremediation and Electron Microscopies" will compile aspects related to electron microscopy applied to nanomaterials detection. The application of nanomaterials in photocatalysis processes and as adsorbents is discussed in Chapters "Adsorption and Desorption Properties of Carbon Nanomaterials, the Potential for Water Treatments and Associated Risks"–"Removal of Copper, Iron and Zinc from Soil Washing Effluents Containing Ethylenediaminedisuccinic Acid as Chelating Agent Through Sunlight Driven Nano-TiO_2-Based Photocatalytic Processes", whereas the effect of nanoparticles in the wastewater treatment and activated sludge is discussed in Chapters "Impact of Silver Nanoparticles on Wastewater Treatment" and "Use of Nanoparticles for Reduction of Odorant Production and Improvements in Dewaterability of Biosolids". Chapter "Environmental Effects of nZVI for Land and Groundwater Remediation" will present the environmental effects of nZVI for land remediation. Finally, the risk associated with the presence of nanoparticles in the environment will be evaluated in Chapter "Presence, Behavior and Fate of Engineered Nanomaterials in Municipal Solid Waste Landfills".

All chapters include fundamentals of the processes investigated that will offer students, technicians and academicians the opportunity to evaluate and select the technologies that lead to be aware of the risk and benefit related to the application of nanotechnologies for environmental remediation.

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