

Nanotechnologies for Environmental Remediation

Giusy Lofrano · Giovanni Libralato
Jeanette Brown
Editors

Nanotechnologies for Environmental Remediation

Applications and Implications

 Springer

Editors

Giusy Lofrano
Department of Chemistry and Biology
University of Salerno
Fisciano, Salerno
Italy

Jeanette Brown
Department of Civil and Environmental
Engineering
Manhattan College
Bronx, NY
USA

Giovanni Libralato
Department of Biology
University of Naples Federico II
Naples
Italy

ISBN 978-3-319-53161-8 ISBN 978-3-319-53162-5 (eBook)
DOI 10.1007/978-3-319-53162-5

Library of Congress Control Number: 2017930140

© Springer International Publishing AG 2017

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

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, ecotoxicology, 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.

Dr. Enrico Sabbioni
CeSI, Aging Research Center,
“G. d’Annunzio” University Foundation, Chieti, Italy

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-TiO₂-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.

Fisciano, Italy
Naples, Italy
Bronx, USA
December 2016

Giusy Lofrano
Giovanni Libralato
Jeanette Brown

Contents

Progress in Nanomaterials Applications for Water Purification	1
Diana Sannino, Luigi Rizzo and Vincenzo Vaiano	
Nanomaterials for Water Remediation: Synthesis, Application and Environmental Fate	25
Antonella De Luca and Bernardí Bayarri Ferrer	
The Use of Al and Fe Nanoparticles for the Treatment of Micropollutants	61
Idil Arslan-Alaton and Tugba Olmez-Hanci	
Environmental Nanoremediation and Electron Microscopies	115
Elisabetta Carata, Elisa Panzarini and Luciana Dini	
Adsorption and Desorption Properties of Carbon Nanomaterials, the Potential for Water Treatments and Associated Risks	137
Marinella Farré, Josep Sanchís and Damià Barceló	
Nanomaterials for Adsorption and Heterogeneous Reaction in Water Decontamination	183
Chun Zhao, Yuanyuan Liu, Yongjun Sun, Jiangya Ma, Yunhua Zhu, Zihua Sun, Zhaoyang Wang, Lei Ding, Guang Yang, Junfeng Li, Liqiang Zhou, Jun Wang, Guocheng Zhu, Peng Zhang, Huifang Wu and Huaili Zheng	
Nano Based Photocatalytic Degradation of Pharmaceuticals	221
Giusy Lofrano, Giovanni Libralato, Sanjay K. Sharma and Maurizio Carotenuto	

Removal of Copper, Iron and Zinc from Soil Washing Effluents Containing Ethylenediaminedisuccinic Acid as Chelating Agent Through Sunlight Driven Nano-TiO₂-Based Photocatalytic Processes	239
Laura Clarizia, Marco Race, Luca Onotri, Ilaria Di Somma, Nunzio Fiorentino, Roberto Andreozzi and Raffaele Marotta	
Impact of Silver Nanoparticles on Wastewater Treatment	255
Jeanette Brown	
Environmental Effects of nZVI for Land and Groundwater Remediation.	269
G. Libralato, A. Costa Devoti, A. Volpi Ghirardini and D.A.L. Vignati	
Use of Nanoparticles for Reduction of Odorant Production and Improvements in Dewaterability of Biosolids.	287
Jeanette Brown	
Presence, Behavior and Fate of Engineered Nanomaterials in Municipal Solid Waste Landfills	311
Ceyda Senem Uyguner-Demirel, Burak Demirel, Nadim K. Coptu and Turgut T. Onay	