Environmental Chemistry for a Sustainable World

Volume 51

Other Publications by the Editors

Books
Environmental Chemistry
http://www.springer.com/978-3-540-22860-8

Organic Contaminants in Riverine and Groundwater Systems
http://www.springer.com/978-3-540-31169-0

Sustainable Agriculture
Volume 1: http://www.springer.com/978-90-481-2665-1
Volume 2: http://www.springer.com/978-94-007-0393-3

Book series
Environmental Chemistry for a Sustainable World
http://www.springer.com/series/11480

Sustainable Agriculture Reviews
http://www.springer.com/series/8380

Journals
Environmental Chemistry Letters
http://www.springer.com/10311

More information about this series at http://www.springer.com/series/11480

Inamuddin • Mohd Imran Ahamed
Eric Lichtfouse • Abdullah M. Asiri
Editors

Methods for Bioremediation of Water and Wastewater Pollution

Springer

Editors
Inamuddin
Department of Chemistry
King Abdulaziz University
Jeddah, Saudi Arabia

Department of Applied Chemistry
Aligarh Muslim University
Aligarh, Uttar Pradesh, India

Eric Lichtfouse
Aix-Marseille University, CNRS,
IRD, INRAE, Coll France, CEREGE
Aix-en-Provence, France

Mohd Imran Ahamed
Department of Chemistry
Aligarh Muslim University
Aligarh, Uttar Pradesh, India

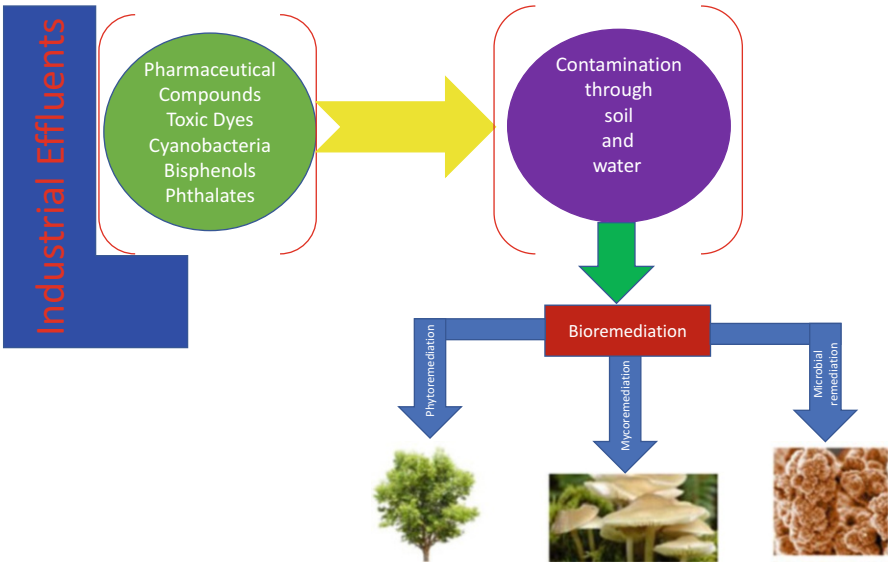
Abdullah M. Asiri
Department of Chemistry
King Abdulaziz University
Jeddah, Saudi Arabia

ISSN 2213-7114 ISSN 2213-7122 (electronic)
Environmental Chemistry for a Sustainable World
ISBN 978-3-030-48984-7 ISBN 978-3-030-48985-4 (eBook)
https://doi.org/10.1007/978-3-030-48985-4

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

Preface

The rapid growth of population and industrialization has resulted in the disposal of harmful chemicals into the environment, thus inducing health issues for life. The major sources of contamination include industries, agrochemistry, mining activities and waste disposal. Remediation of environmental media using biological methods is actually a fast-developing research field because bioremediation is considered as a cheap, sustainable, green and socially acceptable way of cleaning. Scientists have designed many remediation mechanisms such as detoxification, immobilization, degradation, concentration, disposal and recycling by the action of microorganisms or enzymes. Bioremediation strategies include natural attenuation, biostimulation by encouraging natural processes of biodegradation and bioaugmentation by adding beneficial microorganisms. This book presents strategies, concepts and methods for bioremediation of metals, dyes and organic pollutants. The structure, classification, properties, ecotoxicology and bioremediation of various pollutants are discussed. This book is a good reference guide for faculty, postgraduates, researchers and industrial professionals who are linked to environmental science, analytical chemistry, biotechnology, nutrition, photochemistry and toxicology.



Chapter 1 discusses the bioremediation of samples contaminated by lead, cadmium or chromium using *Pseudomonas*-based biosorbents. Additionally, the modelling of the biosorption process of heavy metals, the efficiency of new biosorbents and toxicological limits are highlighted. Chapter 2 discusses world scientific paradigms on water pollution remediation, as the author believes that environmental catastrophes are a consequence of how the scientific society looks at nature. Chapter 3 introduces anaerobic processes for the removal of pollutants. Chapter 4 presents an alternative approach for remediating dyes and metals by sorption using bacterial strains and metabolites. Chapter 5 focuses on bacterial biofilm-based strategies for metal sequestration, with emphasis on biofilms, quorum sensing and functional bacterial items. Chapter 6 reviews laccase for immobilization of dyes. Chapter 7 describes economical, eco-friendly and efficient biochemical water purification methods, with focus on removal efficiencies of various microorganisms, and on the effect of temperature, pH and initial dye concentration. Wastewater bioremediation of metals, dyes and pigments by plants, bacteria, fungi and algae are presented in Chap. 8.

Chapter 9 details the application of microorganisms to remove metals from wastewater, with focus on biosorption and mechanisms. Sorption of metals on exopolymeric substances from bacteria is then discussed in Chap. 10. Chapter 11 presents the bioremediation of bisphenols and phthalates by chelation with nanoparticles from soil microbiota, plants and fungi (Figure). Metal phytoextraction is discussed in Chaps. 12 and 16. Chapter 13 reviews the use of bark and extracts to decrease metal contamination. Chapter 14 discusses dye history, classification,

properties, remediation and environmental impact. Natural remediation techniques such as vegetative filter strips, phytoremediation and constructed wetlands are presented in Chap. 15. Chapter 17 focuses on nickel and cadmium removal from aqueous solutions using microorganisms. Biological strategies for the removal of metals using microorganisms and plants are presented in Chap. 18.

Jeddah, Saudi Arabia — Inamuddin
Aligarh, India
Aligarh, India — Mohd Imran Ahamed
Aix-en-Provence, France — Eric Lichtfouse
Jeddah, Saudi Arabia — Abdullah M. Asiri

Contents

Contributors

B. Abadi Department of Biosystem Mechanics Engineering, Faculty of Agriculture, University of Maragheh, Maragheh, Iran

Soukhya Channapatana Adishesh Department of Biotechnology, Dayananda Sagar College of Engineering, Bengaluru, Karnataka, India

Sheriff O. Ajala Frank H. Dotterweich College of Engineering-Sustainable Energy, Texas A&M University-Kingsville, Kingsville, TX, USA

Aramide M. Akintunde Department of Environmental Engineering, Texas A&M University-Kingsville, Kingsville, TX, USA

Zufeshan Nahar Ali Department of Biotechnology, Dayanandasagar College of Engineering, Bengaluru, Karnataka, India

Muhammad Altaf Department of Chemistry, GC University Lahore, Lahore, Pakistan

Embalil Mathachan Aneesh Communicable Disease Research Laboratory (CDRL), St. Joseph's College, Irinjalakuda, Kerala, India

A. N. Anoopkumar Department of Zoology, Christ College, University of Calicut, Irinjalakuda, Kerala, India
Communicable Disease Research Laboratory (CDRL), St. Joseph's College, Irinjalakuda, Kerala, India

Raja Shahid Ashraf Department of Chemistry, GC University Lahore, Lahore, Pakistan

Syed Salman Ashraf Department of Chemistry, College of Arts and Sciences, Khalifa University, Abu Dhabi, United Arab Emirates

Farrukh Azeem Department of Bioinformatics and Biotechnology, Government College University, Faisalabad, Pakistan

Eriola Betiku Department of Chemical Engineering, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria

Muhammad Bilal School of Life Science and Food Engineering, Huaiyin Institute of Technology, Huaian, China

Parameswaran Binod Microbial Processes and Technology Division, CSIR-National Institute of Interdisciplinary Science and Technology (CSIR-NIIST), Trivandrum, Kerala, India

Caleb Cheah School of Science, Monash University Malaysia, Bandar Sunway, Selangor Darul Ehsan, Malaysia

Sriparna Datta Department of Chemical Technology, Rajabazar Science College, University of Calcutta, Kolkata, India

Elsa Devassy Communicable Disease Research Laboratory (CDRL), St. Joseph's College, Irinjalakuda, Kerala, India

Moulay Abderrahim El Mhammedi Polydisciplinary Faculty, Laboratory of Chemistry, Modeling and Environmental Sciences, Sultan Moulay Slimane University, Khouribga, Morocco

Olayomi A. Falowo Department of Chemical Engineering, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria

Meghana Ganta Department of Biotechnology, Dayananda Sagar College of Engineering, Bengaluru, Karnataka, India

Anca Giorgiana Grigoras "Petru Poni" Institute of Macromolecular Chemistry, Iasi, Romania

Rafig Gurbanov Department of Molecular Biology and Genetics, Bilecik Şeyh Edebali University, Bilecik, Turkey
Biotechnology Application and Research Center, Bilecik Şeyh Edebali University, Bilecik, Turkey

Muhammad Ajaz Hussain Department of Chemistry, University of Sargodha, Sargodha, Pakistan

Sabir Hussain Department of Environmental Sciences and Engineering, Government College University, Faisalabad, Pakistan

Hafiz M. N. Iqbal Tecnologico de Monterrey, School of Engineering and Sciences, Campus Monterrey, Monterrey, Mexico

Puneet P. Jain Department of Biotechnology, Dayanandasagar College of Engineering, Bengaluru, Karnataka, India

Helen Karasali Laboratory of Chemical Control of Pesticides, Department of Pesticides Control and Phytopharmacy, Benaki Phytopathological Institute, Athens, Greece

Ali Khadir Young Researcher and Elite Club, Yadegar-e-Imam Khomeini (RAH) Shahre Rey Branch, Islamic Azad University, Tehran, Iran

Rajeswari M. Kulkarni Department of Chemical Engineering, M. S. Ramaiah Institute of Technology, Bangalore, Karnataka, India
Department of Chemical Engineering, National Institute of Technology, Surathkal, Karnataka, India

P. Senthil Kumar Department of Chemical Engineering, SSN College of Engineering, Chennai, Tamil Nadu, India
SSN-Centre for Radiation, Environmental Science and Technology (SSN-CREST), SSN College of Engineering, Chennai, Tamil Nadu, India

Shinomol George Kunnel Department of Biotechnology, Dayananda Sagar College of Engineering, Bengaluru, Karnataka, India

Bhanu Revathi Kurella Department of Biotechnology, Dayananda Sagar College of Engineering, Bengaluru, Karnataka, India

Faisal Mahmood Department of Environmental Sciences and Engineering, Government College University, Faisalabad, Pakistan

Zahid Maqbool Department of Environmental Sciences and Engineering, Government College University, Faisalabad, Pakistan

Ali Mardy Faculty of Civil Engineering, K. N. Toosi University of Technology, Tehran, Iran

Adeel Mehmood Department of Chemistry, GC University Lahore, Lahore, Pakistan

Afsaneh Mollahosseini Research Laboratory of Spectroscopy & Micro and Nano Extraction, Department of Chemistry, Department of Chemistry, Iran University of Science and Technology, Tehran, Iran

Gulzar Muhammad Department of Chemistry, GC University Lahore, Lahore, Pakistan

Saima Muzammil Department of Microbiology, Government College University, Faisalabad, Pakistan

Habibullah Nadeem Department of Bioinformatics and Biotechnology, Government College University, Faisalabad, Pakistan

Mehrdad Negarestani Department of Civil and Environmental Engineering, Iran University of Science and Technology, Tehran, Iran

Babatunde Oladipo Department of Chemical Engineering, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria

Samuel O. Olatunji Department of Environmental Engineering, Texas A&M University-Kingsville, Kingsville, TX, USA

Brahim Oudra Faculty of Sciences Semlalia, Laboratory of Biology and Biotechnology of Microorganisms, Environmental Microbiology and Toxicology Unit, Cadi Ayyad University, Marrakech, Morocco

Ashok Pandey CSIR-Indian Institute for Toxicology Research (CSIR-IITR), Lucknow, Uttar Pradesh, India

George Pavlidis Laboratory of Chemical Control of Pesticides, Department of Pesticides Control and Phytopharmacy, Benaki Phytopathological Institute, Athens, Greece

Sreedev Puthur Communicable Disease Research Laboratory (CDRL), St. Joseph's College, Irinjalakuda, Kerala, India

K. Kavya Raj Communicable Disease Research Laboratory (CDRL), St. Joseph's College, Irinjalakuda, Kerala, India

Muhammad Arshad Raza Department of Chemistry, GC University Lahore, Lahore, Pakistan

Sharrel Rebello Communicable Disease Research Laboratory (CDRL), St. Joseph's College, Irinjalakuda, Kerala, India

Ishika Saha Department of Chemical Technology, Rajabazar Science College, University of Calcutta, Kolkata, India

Sana Saqrane Polydisciplinary Faculty, Laboratory of Chemistry, Modeling and Environmental Sciences, Sultan Moulay Slimane University, Khouribga, Morocco

A. Saravanan Department of Biotechnology, Rajalakshmi Engineering College, Chennai, Tamil Nadu, India

Dipanjan Sengupta Department of Chemical Technology, Rajabazar Science College, University of Calcutta, Kolkata, India

Feride Severcan Department of Biological Sciences, Middle East Technical University, Ankara, Turkey
Department of Biophysics, Faculty of Medicine, Altinbaş University, Istanbul, Turkey
Biomedical Sciences Graduate Programme, Altinbaş University, Istanbul, Turkey

Muhammad Shahid Department of Bioinformatics and Biotechnology, Government College University, Faisalabad, Pakistan

Munazza Shahid Department of Chemistry (SSC), University of Management and Technology, Lahore, Lahore, Pakistan

M. Shahvali Department of Agricultural Extension and Education, Agricultural College, University of Shiraz, Shiraz, Iran

Tanvir Shahzad Department of Environmental Sciences and Engineering, Government College University, Faisalabad, Pakistan

K. Vidya Shetty Department of Chemical Engineering, National Institute of Technology, Surathkal, Karnataka, India

Anuradha Shilli Department of Biotechnology, Dayananda Sagar College of Engineering, Bengaluru, Karnataka, India

Muhammad Hussnain Siddique Department of Bioinformatics and Biotechnology, Government College University, Faisalabad, Pakistan

Raveendran Sindhu Microbial Processes and Technology Division, CSIR-National Institute of Interdisciplinary Science and Technology (CSIR-NIIST), Trivandrum, Kerala, India

Srishti J. Sisodiya Department of Biotechnology, Dayanandasagar College of Engineering, Bengaluru, Karnataka, India

G. Srinikethan Department of Chemical Engineering, National Institute of Technology, Surathkal, Karnataka, India

Memory Tekere Environmental Science Department, University of South Africa, Johannesburg, South Africa

Adeline Su Yien Ting School of Science, Monash University Malaysia, Bandar Sunway, Selangor Darul Ehsan, Malaysia