

Bioremediation of Industrial Waste for Environmental Safety

Ram Naresh Bharagava • Gaurav Saxena
Editors

Bioremediation of Industrial Waste for Environmental Safety

Volume II: Biological Agents and Methods
for Industrial Waste Management

 Springer

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This book is truly dedicated to my parents for their unfailing patience, contagious love, forgiveness, selflessness, and endless support; my wife for trusting and believing in me; and my kids for always being a reminder that there is hope to move forward in life.

Ram Naresh Bharagava

This book is truly dedicated to my parents for their unfailing patience, contagious love, forgiveness, selflessness, and endless support and for nurturing and educating me to date. Without them I would not be the person I am today.

Gaurav Saxena

Foreword



Safeguarding the environment and a sustainable future in the wake of rapid industrialization is a key challenge worldwide. Industries are the fundamental drivers in the world economy, but they can also be major polluters discharging potentially toxic and hazardous wastes into the environment. Conventional physico-chemical remediation techniques are known to be costly and environmentally destructive and can result in secondary pollution and disturb the natural environment. In contrast, bioremediation is a low-cost and eco-friendly alternative to conventional remediation technologies for the treatment and management of industrial wastes.

Bioremediation has been identified by the US Environment Protection Agency (USEPA) to promote the sustainable development of our society with low environmental impact. The applications and scope of bioremediation technologies are ever-expanding. For instance, the development of constructed wetlands (CWs) has revolutionized the way contaminated wastewater is treated and managed and its reuse in wastewater treatment facility. The Putrajaya wetland in Putrajaya city of Malaysia represents an excellent example of the commercial success of CWs in developing countries.

Bioremediation of Industrial Waste for Environmental Safety: Biological Agents and Methods for Industrial Waste Management (Volume II), edited by Dr. Ram

Naresh Bharagava and Mr. Gaurav Saxena, is particularly useful to researchers working in the fields of bioremediation, phytoremediation, and waste management. All the chapters are contributed by leading experts in the field. This book provides excellent source materials on the different aspects of biodegradation and bioremediation of industrial wastes. It introduces the readers to the potential toxic effects of various pollutants in industrial wastes and their environmental impacts. It examines the role of biological agents (such as bacteria, fungi, algae, plants, microalgae, and genetically modified organisms) in biodegradation and biotransformation of a variety of organic and inorganic pollutants (e.g., phenols, chlorophenols, petroleum hydrocarbons, polychlorinated biphenyls, organic solvents, azo dyes, pesticides, recalcitrant compounds, toxic metals, to name but a few), as well as their potential in electricity production, biofuel generation, and phytomining (where plants are used to recover valuable metals from contaminated sites).

I appreciate the editor's effort in editing this valuable book, which will go some way to make our planet greener and cleaner. I congratulate the book editors for bringing out this valuable compilation with up-to-date knowledge in the field of industrial waste bioremediation. I wish this book a great success as it is of great value to the stakeholders, including researchers, academicians, students, environmentalists, and policy makers. It also makes a fine companion to the volume I of this book title.

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Preface

Environmental issues have been always at the forefront of sustainable development and have become a serious matter of concern in the twenty-first century. Environmental sustainability with rapid industrialization is one of the major challenges of the current scenario worldwide. Industries are the key drivers in the world economy, but these are also the major polluters due to the discharge of partially treated/untreated potentially toxic and hazardous wastes containing organic and inorganic pollutants, which cause environmental (soil and water) pollution and severe toxicity in living beings. Among the different sources of environmental pollution, industrial wastes are considered as the major source of environmental pollution because industries use cheap and poorly or nonbiodegradable chemicals to obtain good quality of products within a short period of time and in an economic way; however, their toxicity is usually ignored. Ensuring the safety of chemicals used in many industrial processes is a major challenge for environmental safety. The governments around the globe are also strictly advocating for the mitigation of environmental pollution due to industrial wastes to promote the sustainable development of our society with low environmental impact. Being a low-cost and eco-friendly clean technology, bioremediation can be an eco-sustainable alternative to conventional technologies for the treatment and management of industrial wastes to protect public health and the environment.

Bioremediation is a waste management approach that utilizes microorganisms, plants, or their enzymes to degrade/detoxify organic and inorganic pollutants such as phenols, chlorophenols, petroleum hydrocarbons, polychlorinated biphenyls, organic solvents, azo dyes, pesticides, recalcitrant compounds, toxic metals, etc. from contaminated soils and wastewaters. There has been an increasing concern regarding the release of various hazardous chemicals along with industrial wastes, which are considered highly toxic for the environment and living beings. Some of these chemicals are classified as priority pollutants by the United States Environmental Protection Agency (USEPA) and other environmental pollution control agencies. The biological removal of a wide range of pollutants from contaminated sites requires our increasing understanding of different degradation pathways and

regulatory networks to carbon flux for their degradation and detoxification, which is utmost important for environmental safety. Therefore, this book provides a comprehensive knowledge of the fundamental, practical, and purposeful utilization of bioremediation technologies for the treatment and management of industrial wastes. The book describes the microbiological, biochemical, and molecular aspects of biodegradation and bioremediation, including the use of “omics” technologies for the development of efficient bioremediation technologies for industrial wastes/pollutants to combat the forthcoming challenges.

This book *Bioremediation of Industrial Waste for Environmental Safety: Biological Agents and Methods for Industrial Waste Management (Volume II)* describes the toxicity of various organic and inorganic pollutants in industrial wastes, their environmental impact, and bioremediation approaches for waste treatment and management. For this book, many relevant topics have been contributed by experts from different universities, research laboratories, and institutes from around the globe in the area of biodegradation and bioremediation. In this book, extensive focus has been relied on the recent advances in bioremediation and phytoremediation technologies, including the use of an array of microbes for environmental remediation, aquatic macrophytes for phytoremediation of toxic metals from contaminated industrial wastewaters, constructed wetlands for degradation and detoxification of industrial wastewaters, genetically modified organisms (GMOs) for degradation and detoxification of environmental pollutants, bioremediation of toxic metals and radionuclides in contaminated environments, algae as a phycoremediation tool for the removal of heavy metals from industrial wastewaters, electro-bioremediation and nano-bioremediation for the treatment and management of contaminated soil, application of microbial fuel cell (MFC) for the treatment and remediation of highly polluted wastewaters and power generation, application of plant-microbe interactions in the remediation of environmental pollutants and agro-ecosystem development, the role of endophytes in heavy metal (HM) phytoremediation, microalgae for the treatment of industrial wastewaters with value-added product potential, phytotechnologies for wastewater treatment and management, the role of cyanobacteria in the remediation of wastewaters, bioremediation of pulp paper mill wastewater and heavy metals like cadmium, etc. Researchers working in the field of bioremediation, phytoremediation, waste management, and related fields will find a compilation on the progress made in bioremediation technologies for industrial waste treatment and management for environmental sustainability. To get richer in the knowledge on the topic, readers may visit our first volume of this book series, i.e., *Bioremediation of Industrial Waste for Environmental Safety: Industrial Waste and Its Management (Volume I)*.

At the end, we hope that the book will be of great value to researchers, environmental chemists and scientists, microbiologists and biotechnologists, eco-toxicologists, waste treatment engineers and managers, environmental science managers, administrators and policy makers, industry persons, and students at

bachelor's, master's, and doctoral levels in the relevant field. Thus, in this book, readers will find updated information, as well as the future direction for research in the field of bioremediation.

Lucknow, Uttar Pradesh, India
Lucknow, Uttar Pradesh, India
May 2018

Ram Naresh Bharagava
Gaurav Saxena

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The edited book *Bioremediation of Industrial Waste for Environmental Safety: Biological Agents and Methods for Industrial Waste Management (Volume II)* is the outcome of long dedicated efforts of many individuals who directly or indirectly supported us during the compilation and upbringing of this valuable edition, many of whom deserve special mention.

Editors are thankful to all the national and international contributing authors for their valuable submissions and cooperation and for providing most up-to-date information on the diverse aspects of the subject regardless of their busy schedules; Prof. Diane Purchase, Middlesex University, London, England (United Kingdom), for writing an opinion foreword for the book; Dr. G. D. Saratale, Dongguk University-Seoul, Seoul (Republic of Korea), and Dr. Sikandar I. Mulla, Chinese Academy of Sciences (CAS), Xiamen (People's Republic of China), for the meaningful collaboration, cooperation, and support; Dr. Jay Shankar Singh, Department of Environmental Microbiology (DEM), Babasaheb Bhimrao Ambedkar (Central) University (BBAU), Lucknow (India), for the better advice and helpful discussion on the subject, and Mr. Surya Pratap Goutam and Mr. Rajkamal Shastri, Doctoral Fellow, Department of Applied Physics; Roop Kishor, Doctoral Fellow, DEM, BBAU, and Mr. Akash Mishra, Doctoral Fellow, Defence Research and Development Organization (DRDO)-Defence Institute of Bioenergy Research (DIBER), Haldwani (India), for helping us in various ways during the book project.

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We are also heartily thankful to the Almighty God for helping us through the entire journey and making the experience enjoyable. Further, we hope that the book volume will be of great value to researchers in the area of bioremediation of

industrial wastes and will go some way to make our planet safe and greener. At the end, we seek to learn more on the subject through the valuable comments, reviews, and suggestions from our readers, which can be directly sent to our e-mails: bharagavarnbbau11@gmail.com (Ram Naresh Bharagava) and gaurav10saxena@gmail.com (Gaurav Saxena).

May 2018

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