

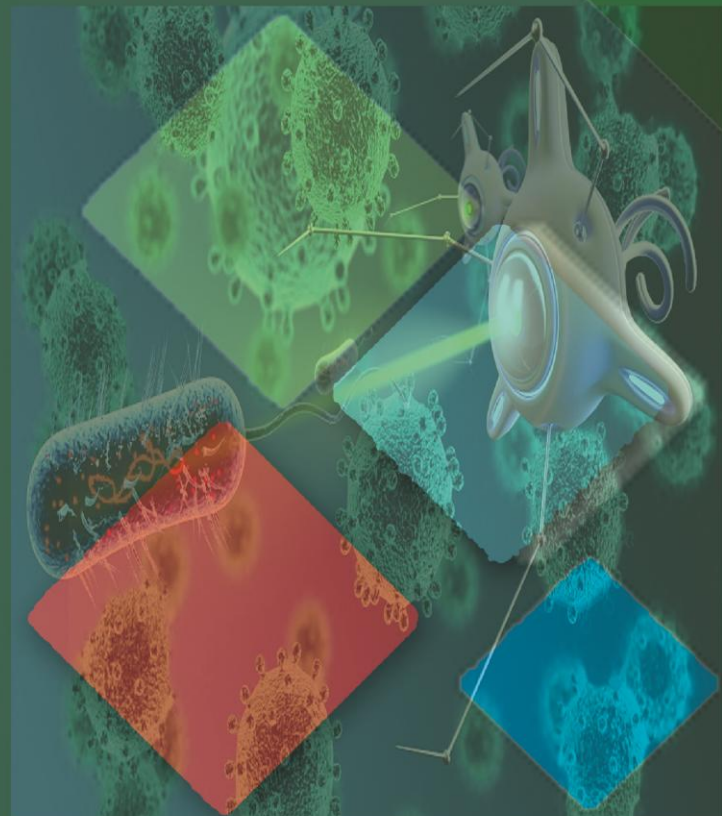
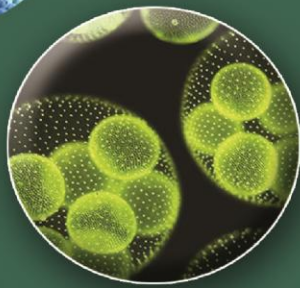
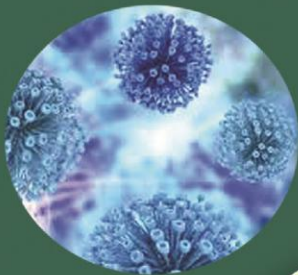
ISBN-978-93-94174-13-9

Status, Trends and Advances in Bioremediation

Editors

Dr. Natchimuthu Karmegam

Dr. Mani Prakash



Excellent Publishers

Status, Trends and Advances in Bioremediation

Editors

Dr. Natchimuthu Karmegam

Assistant Professor, PG and Research Department of Botany,
Government Arts College (Autonomous), Salem-7, Tamil Nadu,
India

Dr. Mani Prakash

Associate Professor and Head of the Department of Microbiology,
Kanchi Shri Krishna College of Arts and Science, Tamil Nadu,
India

ISBN: 978-93-94174-13-9

<https://doi.org/10.20546/978-93-94174-13-9>



Excellent Publishers



Excellent Publishers

Kancheepuram, India

www.excellentpublishers.com

email id: excellentpublishers2013@gmail.com

Copyright © 2022 Excellent Publishers. All rights reserved.

Publisher: Excellent Publishers

Editors: Dr. Natchimuthu Karmegam and Dr. Mani Prakash

ISBN: 978-93-94174-13-9

DOI: <https://doi.org/10.20546/978-93-94174-13-9>

Note: No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the publisher.

Table of Contents

Contents		Page No.
Chapter-1 Microbes as Potential Bioremediation Agents <i>G. Vijayanandini</i>		1-21
1.1	Introduction	2
1.2	Some Biodegradable Pollutants	2
1.3	Role of Microbes in Bioremediation	4
1.4	Microbial Processes	4
1.5	Approaches Used in Microbial Bioremediation	6
1.6	Microorganisms Used in Bioremediation	12
1.7	Factors Affecting Microbial Degradation	17
1.8	Advantages of Microbial Bioremediation	18
1.9	Disadvantages of Microbial Bioremediation	19
1.10	Conclusion and Perspectives	19
	References	20
Chapter-2 Advances and Challenges in Phytoremediation <i>P. Sumithira</i>		22-48
2.1	Introduction	23
2.2	Phytoremediation Methods	23
2.3	Mechanism of Phytoremediation	25
2.4	Proper Plant Selection	25
2.5	Plant Selection for Phytoremediation by Following Recognized Methods	26
2.6	Plants Used in Phytoremediation	27
2.7	Plants Used for Phytoremediation	28
2.8	Phytoextraction	29
2.9	Phytodegradation	29
2.10	Phytostabilization	31
2.11	Phytostimulation	31
2.12	Phytovolatilization	32
2.13	Phytotransformation	32
2.14	Rhizofiltration	32
2.15	Treatment of Wastewater Using Phytoremediation Method	33
2.16	Role of Marine Hydrophytes in Phytoremediation	33
2.17	Role of Aquatic Macrophytes in Bioremediation	34
2.18	Hydrical Contaminants and Heavy Metals	35
2.19	Environmental Biotechnology and Bioengineering	35
2.20	Vegetable Resistance to Metals	36

2.21	Phytochelatins	37
2.22	Distinct Mechanisms of Metal Resistance in Plants	38
2.23	Aquatic Macrophytes	38
2.24	Free Floating Aquatic Macrophytes	38
2.28	Advantages	45
2.29	Cost Effective	45
2.30	Disadvantages	45
2.31	Drawbacks of phytoremediation	46
	References	47
	Chapter-3 Pollutant Removal through Phytoremediation: A Viable Strategy <i>P. Sumithira</i>	49-68
3.1	Introduction	50
3.2	Treatment of Industrial Liquid Waste by Phycoremediation	51
3.3	Applications of Algae Industrial Waste Removal	51
3.4	Nitrogen and Phosphorous Removal	52
3.5	Role of Algae - Heavy Metal Removal	52
3.6	Algal Flow Way Systems	53
3.7	Nanotechnology in Wastewater Treatment	53
3.8	Synthesis of Nanoparticles	54
3.9	Green Synthesis or Biological Synthesis	54
3.10	Algae Used for Nanoparticle Synthesis	55
3.11	Synthesis of Metal Nanoparticles from Algae	55
3.12	Silver Nanoparticles	56
3.13	Gold Nanoparticles	56
3.14	Other Metallic Nanoparticles	56
3.15	Synthesis of Metalloxiide Nanoparticles by Algae	56
3.16	Zinc Oxide Nanoparticles	57
3.17	Iron Oxide Nanoparticles	57
3.18	Nanoparticles Supported Adsorbent Models for Wastewater Remediation (Nanoadsorbents)	57
3.19	Role of Algae in Dye Industry: Phycoremediation	59
3.20	Factors Affecting the Abatement of Synthetic Dyes by Algae	60
3.21	Effect of pH	60
3.22	Effect of Temperature	61
3.23	Effect of Contact Time	61
3.24	Effect of Initial Concentration of Dyes	61
3.25	Effect of Agitation Speed	62
3.26	Effect of Biomass Dosage	62
3.27	Mechanism of Dye Abatement by Algae	62
3.28	Functional Group Involvement during Dye Abatement by Algae	63

3.29	Utilization of Heavy Metals by Using Plants and Algae	64
3.30	Impact of Industrial Pollutants on Primary Producers	64
3.31	Evaluation of Heavy Metals Utilization by the Primary Producer <i>Chlorella</i>	64
3.32	Heavy Metals Employed in this Study	64
3.33	Experimental Set up	64
3.34	Estimation of Pigment Content of the <i>Chlorella</i>	65
3.35	Evaluation of the Impact of Heavy Metals in the Vegetative Cells of <i>Chlorella</i>	65
3.36	Testing for Metals	65
3.37	Impact of Heavy Metals on Fenugreek Leaves	66
3.38	Experimental setup	66
	References	67
	Chapter-4 Nanobioremediation - An Emerging Technology for Pollution Control <i>Maheswari Pandiaraj, Vijayalakshmi Gurusamy, Shanmugiah Mahendran and Kannan Marikani</i>	69-98
4.1	Introduction	70
4.2	The Science of Bioremediation with Nanomaterial (NMs)	71
4.3	Principles of Nanobioremediation Technologies	73
4.4	Nanoparticles	76
4.5	Unique properties of nanoparticles	77
4.6	Nanoparticles for remediation of contaminated sites	77
4.7	Biogenic production of various nanoparticles	79
4.8	Strategies for Synthesis of Nanoparticles Using Microbes	79
4.9	Nanoparticles produced by bacteria	81
4.10	Nanoparticles produced by yeast and fungi	82
4.11	Nanomaterials and Nanoparticles Used in Bioremediation	82
4.12	Biological Response during the Combined Application of Nanomaterials and Bioremediation	83
4.13	International Markets and Regulations of Nanotechnologies Applied in Bioremediation	87
4.14	Recent research trends and advances reported in bioremediation	87
4.15	Conclusion	89
	Acknowledgement	89
	References	89
	Chapter-5 Phytoremediation of Persistent and Emerging Contaminants <i>V. V. Kaviya, K. Harini, Joyce Salomi, Suganthi Muthusamy, Jayanthi Malaiyandi and Thenmozhi Mani</i>	99-111

5.1	Introduction	100
5.2	Contaminants	100
5.3	Characteristics of heavy metal contamination in soils	101
5.4	Mechanism of Phytoremediation	101
5.6	Phytovoltalization	103
5.7	Phytostabilization	104
5.8	Phytostimulation	104
5.9	Phytodegradation	105
5.10	Potential Native Flora of Contaminated Soil	106
5.11	Recent Trends and Approaches in Phytoremediation	106
5.12	Advantage and Limitation	107
5.13	Conclusion	109
	References	110
	Chapter-6 Heavy Metal Bioremediation Using Microbes <i>Karthikeyan Vidhya, Gopalakrishnan Abirami, Malayandi Jayanthi, Krishna Kumar Ashok Kumar and Muthusamy Suganthi</i>	112-125
6.1	Introduction	113
6.2	Sources and origin of heavy metals	114
6.3	Classification & toxicity of heavy metals	115
6.4	Exposure and impacts on environment	116
6.5	Role of microbes in bioremediation	119
6.6	Conclusion	121
	References	122
	Chapter-7 Environmental Pollutants - A Global Perspective <i>R. Janet Rani</i>	126-144
7.1	Introduction	127
7.2	Types of Ecosystem	127
7.3	The components of the environment are mainly divided into two categories.	127
7.4	Importance of Environment	128
7.5	Other Physical and Cultural Environment	128
7.6	Pollution	128
7.7	Industrial Melanism	128
7.8	Industrial Melanism in Marine Dwellers	129
7.9	Types of Pollution	129
7.10	Types of Air Pollutants	130
7.11	Causes of Air Pollution	130
7.12	Effects of Air Pollution	132
7.13	Air Pollution Control	133
7.14	Water pollution	134

7.15	Pollution of the Ganges	137
7.16	Soil pollution	138
7.17	The O-Horizon	139
7.18	The A-Horizon or Topsoil	139
7.19	The E-Horizon	140
7.20	The B-Horizon or Subsoil	140
7.21	The C-Horizon or Saprolite	140
7.22	The R-Horizon	140
7.23	Soil Moisture	140
7.24	Types of Soil Moisture	141
7.25	Chemically Combined Water	141
7.26	Capillary Water	141
7.27	Atmospheric Humidity	141
7.28	Other effects of soil pollution include	141
7.29	Radioactive waste Pollution	142
7.30	Types of Radioactive Wastes	143
7.31	Noise pollution	143
	References	144
	Chapter-8 Vermi-Management of Plant Biomass Wastes with Green Manure for Enriched Vermicompost Production <i>R. Sabarish, M. Biruntha, N. Karmegam and M. Prakash</i>	145-162
8.1	Introduction	146
8.1.1	Vermitechnology	146
8.1.2	Vermicompost for plant growth and productivity	147
8.1.3	Need for the study	147
8.2	Materials and Methods	148
8.2.1	Collection of materials and earthworms	148
8.2.2	Vermicomposting	148
8.2.3	Physico-chemical analysis of vermibed substrates	149
8.2.4	Enumeration of total bacterial population	149
8.2.5	Phytotoxicity test with seed germination assay	149
8.3	Results and Discussion	150
8.4	Conclusion	157
	References	157
	Chapter-9 Effective Hybrid Treatment Techniques for the Remediation of Emerging Pollutants in Pharmaceutical Wastewater <i>J. R. Anoop Raj, R. Yedhu Krishnan, M. Biruntha and R. Subbaiya</i>	163-169
9.1	Introduction	164
9.1.1	Biological Treatment Approach through Integrated Bioprocessing	164

9.1.2	Engineered Microbial Approach	165
9.1.3	Open Pond Culture Systems	165
9.1.4	Phytoremediation	165
9.1.5	Types of Phytoremediation	167
9.2	Conclusions	168
	References	168
	Chapter-10 Bioremediation of Allelopathic Effect of Plants by Vermicompost Application – A Review <i>R. Sabarish and M. Prakash</i>	170-178
10.1	Introduction	171
10.2	Allelopathy among plants	171
10.3	Allelopathic effect of <i>Lantana camara</i> L.	172
10.4	Effect of vermicompost on plant growth	174
10.5	Conclusions	176
	References	176
	Chapter-11 Natural Resource Management for Greener Environment <i>S. Parvathy, P. Ramalingam Karthik and R. P. Subramanian</i>	179-193
11.1	Introduction	180
11.2	Natural resource	180
11.3	Renewable resources	180
11.4	Nonrenewable Resources	180
11.5	Why Do We Need To Manage Our Natural Resources?	181
11.6	What is Management of Natural Resources?	181
11.7	What are the Three R's of Waste Management?	181
11.8	Reduce	181
11.8.1	Following are the ways to reduce	181
11.9	Reuse	181
11.9.1	Following are the ways to reuse	181
11.10	Recycle	182
11.11	Need to Manage Natural Resources	182
11.12	The Challenges of using Natural Resources	182
11.13	Ecosystem	183
11.14	Resource Management	183
11.15	Various Segments of Resource Management	184
11.16	Forest Resource Management	184
11.16.1	The main objectives of new national forest policy are	184
11.16.2	Conservation of Forests Can Be Done Possible by Adopting the Following Techniques	184
11.17	Water Resources Management (Khadse et al., 2012)	185
11.17.1	For Proper Water Management	186

11.18	Mineral Resource Management (Jhariya et al., 2022)	186
11.18.1	Measures to Conserve the Mineral Resources	186
11.19	Land Resource Management	187
11.19.1	Some Important Soil Conservation Mechanisms	187
11.20	Energy Resource Management	188
11.20.1	Some important causes of energy crisis are as follows	188
11.20.2	Some energy conservation methodologies are outlined below	188
11.21	Wildlife Management	188
11.21.1	Some important factors are	188
11.21.2	Methods of Conservation of Wildlife	189
11.22	Agriculture Resource Management	189
11.23	For an increase in productivity without pollution, the following points should be considered	190
11.24	For the safe storage of agricultural products, the following points should be considered	190
11.25	Ownership Regimes	190
11.25.1	State Property	191
11.25.2	Private Property	191
11.25.3	Common Property	191
11.25.4	Non-property (open access)	191
11.25.5	Hybrid	192
11.26	Conclusions	192
	References	192

Preface

The present days, environmental situation posed by anthropogenic activities require right technology for achieving sustainability in respect of remediating various kinds of environmentally unsafe contaminants. There is a need for more research in this area because it seems to be a sustainable approach for managing environmental pollution. As part of the environmental impact on the fate and behavior of environmental contaminants, efforts must be made to promote a synergistic interaction between them, as well as selecting and applying the most appropriate bioremediation techniques and other relevant technologies that can sustain the effective and successful operation and monitoring of these processes. The method of bioremediation involves using living organisms to eliminate contaminants, pollutants, and toxins from soil, water, and other environments. According to cost, site dimensions, contaminants types, and concentrations, bioremediation can be conducted both *in situ* and *ex situ*. In comparison to other methods of cleanup, bioremediation has numerous advantages. Natural processes are used exclusively so that ecosystems are not damaged. In order to clean up contaminants in soil and groundwater, bioremediation is often conducted underground using amendments and microbes. Attractively, biostimulation, bioaugmentation, and intrinsic bioremediation efforts have been addressed world-wide for mitigating the issues. At this juncture, there is an urgent requirement to provide different aspects of bioremediation to eliminate different kinds of pollutants in the environment, source elimination and attractive biological methods. Hence, the present context of current information pertaining to bioremediation measures have been compiled to provide upto date knowledge on bioremediation processes. We hope the chapters of this book definitely would provide a platform for sharing research innovations, solutions to environmental issues and advanced knowledge on bioremediation techniques.

Dr. N. Karmegam
Government Arts and Science College (Autonomous),
Salem -7

Dr. M. Prakash
Kanchi Shri Krishna College of Arts and Science,
Kanchipuram

About the Editors



Dr. N. Karmegam is an Assistant Professor of Botany, Government Arts College (Autonomous), Salem-7, Tamil Nadu, India. He obtained his PG and Ph.D., degrees from The Gandhigram Rural Institute (Deemed University), Gandhigram. He is having more than twenty years of teaching and research experience. His research interest includes medicinal and aromatic plants, phytochemistry, biomass valorization, waste management, vermitechnology and environmental remediation. His guidance has led to the award of 15 M. Phil., and 9 Ph.D., degrees. He is a recipient of Young Scientist and Best Researcher awards and he has published over 90 scientific articles in reputed Scopus indexed journals with a cumulative impact factor >400 and contributed 15 book chapters.

As a Guest Editor, he has compiled the four special issues/ books:

- (1) *Vermitechnology I* (2009), GSB, Japan.
- (2) *Vermitechnology II* (2010), GSB, Japan.
- (3) *Vermitechnology III* (2012), GSB, Japan.
- (4) *Status, Trends, and Advances in Earthworm Research and Vermitechnology* (2010), Hindawi Publications, UK.

Presently, he is serving as a Guest Editor for the Special Issues:

- (1) Aerobic and Anaerobic Digestion of Agro-Industrial and Livestock Wastes: A Green and Sustainable Way toward the Future (2021) - Journal: *Agronomy* (MDPI, Ongoing).
- (2) Environmentally safe management strategies for biowaste and emerging pollutants (2022) - Journal: *Environmental Research* (Elsevier, Ongoing).

Dr. N. Karmegam is currently serving as Editor for two international journals and Review Editor for six different disciplines of *Frontiers Journals* (*Microbiology, Energy Research, Water, Chemical Engineering, Soil Science and Waste Management*).



Dr. M. Prakash, Ph.D., is working as an Associate Professor and Head of the Department of Microbiology, Kanchi Shri Krishna College of Arts and Sciences, Kancheepuram, Tamil Nadu, India. He is having more than 20 years of teaching experience. He has organized National and International Conferences funded by DBT and TNSCST. He is designated as a Recognized Supervisor for M. Phil., and Ph.D., by a reputable University of Madras, Chennai, India. Under his guidance 22 M. Phil., and Eight Ph.D., research scholars have been awarded. Dr. M. Prakash has extensive scientific experience, has presented more than 40 research works in various National and International Conferences/Seminars. To his credit, Dr. Prakash has published more than 50 research and review articles in reputed journals with a high impact factor and published eight books and book chapters. He is serving as an Editor-in-Chief in two International journals of repute. He has been serving as a Reviewer for several peer reviewed international journals.