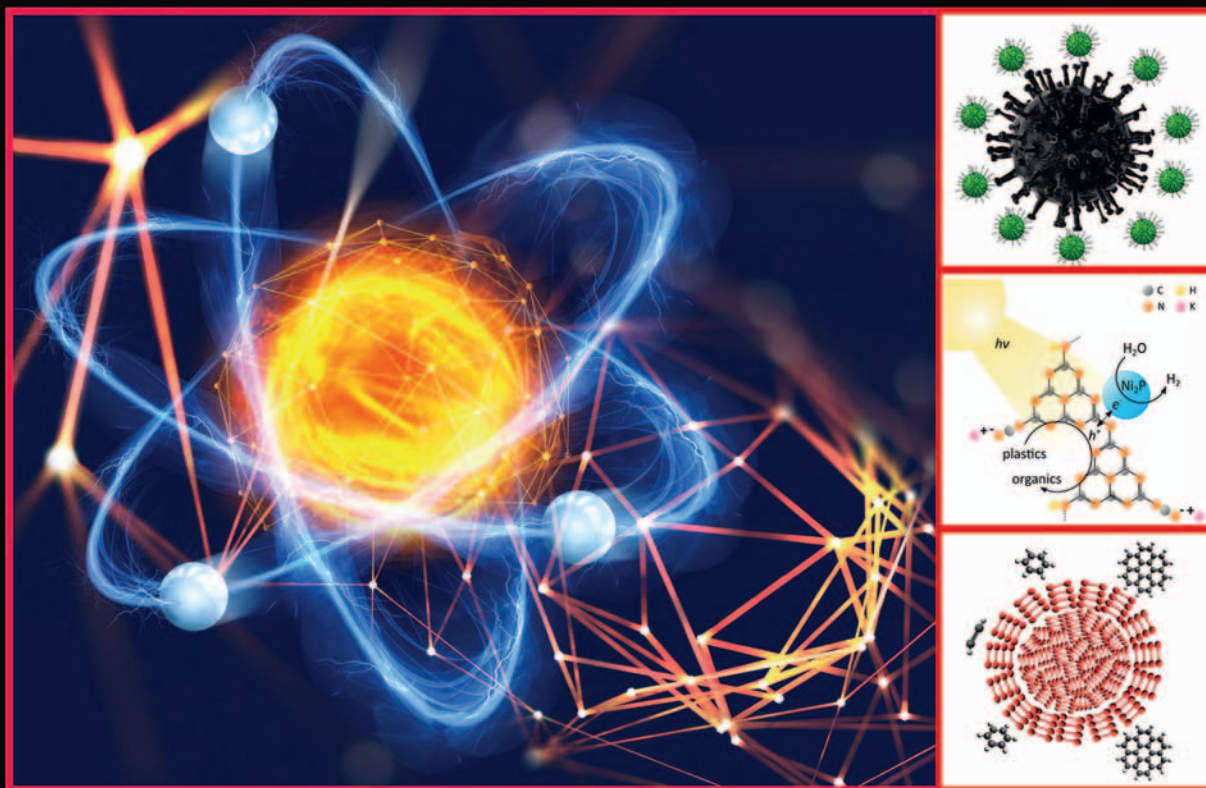


Progress in Biochemistry and Biotechnology

# ADVANCES IN NANO AND BIOCHEMISTRY

Environmental and Biomedical Applications



Edited by  
**Pranay Pradeep Morajkar**  
**Milind Mohan Naik**



Advances in  
**NANO AND  
BIOCHEMISTRY**  
ENVIRONMENTAL AND BIOMEDICAL APPLICATIONS

Advances in  
**NANO AND  
BIOCHEMISTRY**  
**Environmental and Biomedical  
Applications**

Edited by

**PRANAY MORAJKAR**

**MILIND NAIK**



**ACADEMIC PRESS**

An imprint of Elsevier

Academic Press is an imprint of Elsevier  
125 London Wall, London EC2Y 5AS, United Kingdom  
525 B Street, Suite 1650, San Diego, CA 92101, United States  
50 Hampshire Street, 5th Floor, Cambridge, MA 02139, United States  
The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, United Kingdom

Copyright © 2023 Elsevier Inc. All rights reserved.

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. Details on how to seek permission, further information about the Publisher's permissions policies and our arrangements with organizations such as the Copyright Clearance Center and the Copyright Licensing Agency, can be found at our website: [www.elsevier.com/permissions](http://www.elsevier.com/permissions).

This book and the individual contributions contained in it are protected under copyright by the Publisher (other than as may be noted herein).

### Notices

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

To the fullest extent of the law, neither nor the Publisher, nor the authors, contributors, or editors, assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

Library of Congress Cataloging-in-Publication Data  
A catalog record for this book is available from the Library of Congress

British Library Cataloguing-in-Publication Data  
A catalogue record for this book is available from the British Library

ISBN: 978-0-323-95253-8

For information on all Academic Press publications visit our website  
at <https://www.elsevier.com/books-and-journals>

*Publisher:* Stacy Masucci  
*Acquisition Editor:* Michelle Fisher  
*Editorial Project Manager:* Timothy J. Bennett  
*Senior Project Manager:* Umarani Natarajan  
*Publishing Services Manager:* Deepthi Unni  
*Designer:* Vicky Pearson Esser



*Cover image credit:* T. Uekert, H. Kasap, E. Reisner, Photoreforming of Nonrecyclable Plastic Waste over a Carbon Nitride/Nickel Phosphide Catalyst, *J Am Chem Soc.* 141 (2019) 15201–15210. <https://doi.org/10.1021/jacs.9b06872>.

Last digit is the print number: 9 8 7 6 5 4 3 2 1

## Dedication and acknowledgment

This book is dedicated to my parents Shri. Pradeep V. Morajkar and Smt. Pratibha P. Morajkar, for planting in me at a very young age, the seeds of responsibility and sensitivity toward environment and preservation of nature.

My sincere thanks to Prof. Julio B. Fernandes and Dr. Purnakala V. Samant (Goa University, India) for introducing me to the research in nanomaterials and nanotechnology. A million thanks to my PhD guides, Dr. Christa Fittschen (University of Lille1, France) and Prof. Eric Villenave (University of Bordeaux1, France) for motivating, inspiring, and training me to be a good chemistry researcher. I also wish to acknowledge and thank Shri P. S. Sreedharan Pillai (Chancellor), Prof. H. B. Menon (Vice-Chancellor), Prof. V. S. Nadkarni (Registrar), Prof. B. R. Srinivasan (Former Dean, School of Chemical Sciences), Prof. V. M. S. Verenkar (Dean, School of Chemical Sciences), and Prof. R. N. Shirsat (Vice-Dean, School of Chemical Sciences) of Goa University, for their constant support and encouragement. It is the culmination of all the above that paved the foundation of my teaching and research career at the University, which ultimately led to the establishment of my own research lab, “*Laboratory of Nano-structured Materials for Energy & Environmental Applications*” at the School of Chemical Sciences, Goa University, India.

Finally, a big thank you to all the authors of this book for their immense and timely contributions, without which this book would not have become a reality.

Dr. Pranay P. Morajkar

# Contents

<i>Contributors</i>	xv
<i>Preface</i>	xix

## SECTION I Environmental Studies

<b>1. Coupling of photocatalytic and bioremediation processes for enhanced mitigation of xenobiotic pollutants from wastewater</b>	<b>3</b>
Sarvesha S. Shetgaonkar, Amarja P. Naik, Milind M. Naik, and Pranay P. Morajkar	
1.1 Introduction	3
1.2 Xenobiotic remediation methods	6
1.3 Challenges and future outlook	28
1.4 Summary and conclusion	29
References	30
<b>2. Bioinspired nanomaterials for remediation of toxic metal ions from wastewater</b>	<b>39</b>
Dileep Maarisetty, Pradeep Kumar Sow, and Saroj Sundar Baral	
2.1 Introduction	39
2.2 Strategies for the bioinspired nanomaterials synthesis	41
2.3 Heavy metals removal technologies employing bioinspired nanoparticles	44
2.4 Conclusions and future prospect	49
Acknowledgments	50
References	50
Further reading	54
<b>3. Biocompatible nanomaterials for sensing and remediation of nitrites and fluorides from polluted water</b>	<b>57</b>
K. Rambabu, Abdul Hai, G. Bharath, A. Thanigaivelan, Cheng Chin Kui, Shadi W. Hasan, and Fawzi Banat	
3.1 Introduction	57
3.2 Nitrites and fluorides in water and wastewater	59
3.3 Preparation techniques of bionanomaterials	62
3.4 Bionanomaterials as ionic sensors	65
3.5 Nitrites and fluorides remediation by bionanomaterials	71
3.6 Challenges and future perspectives	75

3.7	Conclusions	77
	References	78
<b>4.</b>	<b>Role of gum nanostructured hydrogels in water purification, desalination, and atmospheric water harvesting applications: Advances, current challenges, and future prospective</b>	<b>85</b>
	Hemant Mittal, Ali Al Alili, and Saeed M. Alhassan	
4.1	Introduction	85
4.2	Fundamental principles of techniques and instrumentation procedures	86
4.3	Latest research and development in the field	94
4.4	Summary and conclusion	101
4.5	Challenges and future outlook	102
	References	102
<b>5.</b>	<b>Versatile nanomaterials for remediation of microplastics from the environment</b>	<b>107</b>
	Sumit B. Kamble and Ranjeet K. Bhore	
5.1	What are microplastics?	107
5.2	Effect of microplastics on human health	108
5.3	Traditional methods of microplastics separation	109
5.4	Advanced methods of microplastics separation	110
5.5	Nanomaterials	112
5.6	Remediation of microplastics using various nanomaterials	113
5.7	MPs adsorption strategies using nanomaterials	113
5.8	MPs degradation using nanomaterials	119
5.9	Limitations, challenges, and future outlook	121
	Acknowledgment	121
	References	122
<b>6.</b>	<b>Plastic degradation—contemporary enzymes versus nanozymes-based technologies</b>	<b>127</b>
	Subhranshu Samal, Pinaki Dey, Saroj Sundar Baral, and Vivek Rangarajan	
6.1	Introduction	127
6.2	Major natural enzymes for plastic degradation	129
6.3	Major polymers that form plastic and their degradation	132
6.4	Nanozymes	136
6.5	Computational advancement for enzyme identification	140
6.6	Conclusion and future perspectives	141
	Acknowledgment	143
	References	144

<b>7. Current trends in sensing and remediation of gaseous pollutants in the atmosphere</b>	<b>151</b>
Chaithanya D. Jain	
7.1 Introduction to the gas phase chemistry and pollutants of the atmosphere (tropospheric emphasis)	151
7.2 Current trends in measurement approaches of important gaseous pollutants of the atmosphere and the associated challenges	156
7.3 Current trends in concentration levels and mitigation approaches	168
7.4 Challenges and future outlook	170
Acknowledgments	171
References	171
<b>8. Emerging nonnoble metal nanocatalysts for complete mitigation of combustion generated CO, NO<sub>x</sub>, and unburnt hydrocarbons</b>	<b>179</b>
Pavan More	
8.1 Introduction	179
8.2 Different catalytic methods for the mitigation of pollutants emission	181
8.3 Latest research and development in mitigation of pollutants emission	184
8.4 Conclusion and future outlook	191
References	191
<b>9. Advanced methodologies for remediation of combustion-generated particulate matter (soot) from the environment</b>	<b>199</b>
Samantha Da Costa, Akshay V. Salkar, and Pranay P. Morajkar	
9.1 Introduction	199
9.2 Genesis of soot	200
9.3 Latest research and development in the remediation of combustion generated soot	212
9.4 Summary and conclusion	222
9.5 Challenges and future outlook	223
References	224
<b>10. Recent advances in quantification and remediation technologies for toxic PAH mitigation from the environment</b>	<b>233</b>
Bhausahaheb Dhokale, Zeinab M. Saeed, Wesam A. Ali, and Sharmarke Mohamed	
10.1 Introduction	233
10.2 PAH detection and quantification technologies	238
10.3 Techniques for the environmental remediation of PAHs	241
10.4 Summary and future outlook	251



Author contributions and acknowledgments	252
References	252

## **SECTION II Biomedical Studies**

<b>11. Application of nanoparticles as quorum quenching agent against bacterial human pathogens: a prospective therapeutic nanoweapon</b>	<b>261</b>
Komal Salkar and Lakshangy Charya	
11.1 General introduction	261
11.2 Nanoparticles: fundamentals and principles	265
11.3 Latest research on nanoparticles as quorum quenching agents	268
11.4 Mechanisms of quorum quenching by nanoparticles	276
11.5 Techniques and biosensors involved in quorum quenching research of nanoparticles	277
11.6 Summary and conclusion	278
11.7 Challenges and future prospects	279
Acknowledgments	279
References	279
<b>12. Biocompatible green-synthesized nanomaterials for therapeutic applications</b>	<b>285</b>
Maithili Majithia and Delicia A. Barretto	
12.1 Introduction	285
12.2 Fundamental principles of techniques and instrumentation/methods/procedures involved	294
12.3 Latest research and development in the field	342
12.4 Summary and conclusion	349
12.5 Challenges and future outlook	350
References	351
<b>13. Toxicological aspects of nanomaterials in biomedical research</b>	<b>369</b>
Avelyno H. D'Costa, Shamshad Shaikh, Gandhita Kundaikar, and Swizzle Furtado	
13.1 Introduction	369
13.2 Toxicity of nanomaterials in biomedicine	370
13.3 Genotoxic biomarkers	376
13.4 Safety against toxic effects	378

13.5	Summary and conclusions	381
13.6	Challenges and future outlook	382
	References	382
<b>14.</b>	<b>Quantum dots and hybrid structures as an innovative solution for bioimaging and diagnosis of viral infections</b>	<b>393</b>
	Aleksandra Schejn, Bilel Chouchene, and Raphaël Schneider	
14.1	Introduction	393
14.2	Synthesis methods, modification strategies, and properties of QDs	395
14.3	QDs photoluminescence—principles/mechanisms	397
14.4	Application of QDs in bioimaging and detection of viruses	401
14.5	Challenges and future prospects	413
14.6	Summary and conclusion	414
	References	415
<b>15.</b>	<b>Magnetic nanomaterials and their hybrids for magnetic hyperthermia</b>	<b>419</b>
	G. Bharath, Abdul Hai, K. Rambabu, Mohammad Abu Haija, and Fawzi Banat	
15.1	Introduction	419
15.2	Nanomagnetism	420
15.3	Magnetic alloy nanoparticles for MHT	421
15.4	Ferrite magnetic nanoparticles for magnetic hyperthermia	424
15.5	Superparamagnetic materials for magnetic hyperthermia	428
15.6	Summary and conclusion	433
15.7	Challenges and future outlook	434
	Acknowledgments	434
	References	434
<b>16.</b>	<b>Advanced functionalized nanomaterial—based electrochemical biosensors for disease diagnosis</b>	<b>437</b>
	Dr. Anjani P. Nagvenkar	
16.1	Introduction	437
16.2	Fundamental techniques of biosensing and nanomaterial-based diagnostic tools	438
16.3	Latest research and development in the biosensing field	453
16.4	Conclusion and future perspectives	459
	References	460

<b>17. Recent advances in MOFs-based nanocomposites for treatment of retinopathy or retina-related biomedical applications</b>	<b>467</b>
Amanpreet Kaur Jassal	
17.1 Introduction	467
17.2 Traditional methods of drug loading for ocular disease treatment	470
17.3 Categories of nanocarriers	472
17.4 Drug delivery routes for nanocarriers	472
17.5 MOFs and their nanocomposites as carriers for biomedical applications	475
17.6 Challenges, complications of ocular drug delivery, and future prospects	480
17.7 Summary and conclusions	481
References	482
<b>18. Recent advances in supramolecular organic nanostructures for drug delivery applications</b>	<b>487</b>
Kerba S. More, Harshad A. Mirgane, Vilas K. Gawade, Dinesh N. Nadimetla, Pooja V. Shreechippa, and Sheshanath V. Bhosale	
18.1 Introduction	487
18.2 Synthetic pathways for small organic molecules as drug delivery agents	488
18.3 Recent development in the field of drug delivery system	490
18.4 Summary and conclusion	507
18.5 Challenges and future outlook	507
References	507
<b>19. Recent advances in biopolymers for drug delivery applications</b>	<b>513</b>
Dr. Sandeep Chauhan and Dr. Kiran Kumar	
19.1 Introduction	513
19.2 Need for biocompatible materials for drug delivery	515
19.3 Various biopolymers used for drug delivery applications	517
19.4 Recent advances in biopolymers as drug delivery devices	523
19.5 Designing of biopolymers as suitable drug delivery devices	529
19.6 Mechanisms of drug delivery using biopolymers	531
19.7 Challenges, future scopes, and perspectives in using biopolymers as DDDs	535
19.8 Summary and conclusion	535
References	536

<b>20. Regenerated silk sericin from <i>Antheraea mylitta</i> and <i>Bombyx mori</i>, the potential biomaterial</b>	<b>545</b>
G.H. Darshan and Vootla Shyamkumar	
20.1 Introduction	545
20.2 Experimental	547
20.3 Results and discussion	549
20.4 Summary and conclusions	556
20.5 Challenges and future look	556
References	557
Further reading	559
<b>21. Structural DNA nanotechnology and its biomedical applications</b>	<b>561</b>
Meenal Kowshik	
21.1 Introduction	561
21.2 DNA nanostructures: various approaches for synthesis of DNA-based nanostructures	561
21.3 Applications of DNA nanostructures	568
21.4 Summary and conclusion	583
21.5 Challenges and future outlooks	583
References	583
<i>Index</i>	587

This page intentionally left blank

# Contributors

**Ali Al Alili, PhD**

Department of Mechanical Engineering, Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates

**Saeed M. Alhassan, PhD**

Department of Chemical Engineering, Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates

**Wesam A. Ali, MSc**

Department of Chemistry, Green Chemistry & Materials Modelling Laboratory, Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi, United Arab Emirates

**Fawzi Banat, PhD**

Department of Chemical Engineering, Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates; Center for Membranes and Advanced Water Technology (CMAT), Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates

**Saroj Sundar Baral, PhD**

Department of Chemical Engineering, BITS Pilani K K Birla Goa campus, Sancoale, Goa, India

**Delicia A. Barretto, PhD**

School of Chemical Sciences, Goa University, Taleigao, Goa, India

**G. Bharath, PhD**

Department of Chemical Engineering, Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates

**Ranjeet K. Bhore, MSc**

Salt and Marine Chemicals Division, CSIR-Central Salt and Marine Chemicals Research Institute, Bhavnagar, Gujarat, India

**Sheshanath V. Bhosale, PhD**

School of Chemical Sciences, Goa University, Taleigao, Goa, India

**Lakshangy Charya, PhD**

School of Biological Sciences and Biotechnology, Goa University, Taleigao Plateau, Goa, India

**Dr. Sandeep Chauhan, PhD**

Department of Chemistry, Himachal Pradesh University, Shimla, Himachal Pradesh, India

**Bilel Chouchene, PhD**

Université de Lorraine, Laboratoire Réactions et Génie des Procédés (LRGP), UMR 7274, CNRS, Nancy Cedex, France

**Avelyno H. D'Costa, PhD**

School of Biological Sciences and Biotechnology, Goa University, Taleigao, Goa, India

**Samantha Da Costa, MSc**

School of Chemical Sciences, Goa University, Taleigao, Goa, India

**G.H. Darshan, PhD**

Department of Materials Engineering, Indian Institute of Science, Bangalore, Karnataka, India

**Pinaki Dey, PhD**

Microbial Processes and Technology Division, CSIR–National Institute for Interdisciplinary Science and Technology (NIIST), Thiruvananthapuram, Kerala, India

**Bhauasaheb Dhokale, PhD**

Department of Chemistry, Green Chemistry & Materials Modelling Laboratory, Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi, United Arab Emirates; Department of Chemistry, University of Wyoming, Laramie, Wyoming 82071, United States of America

**Swizzle Furtado, MSc**

Department of Zoology, Carmel College for Women, Nuvem, Goa, India

**Vilas K. Gawade, MSc**

School of Chemical Sciences, Goa University, Taleigao, Goa, India

**Abdul Hai, ME**

Department of Chemical Engineering, Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates

**Abdul Hai, MSc**

Department of Chemical Engineering, Khalifa University, Abu Dhabi, United Arab Emirates

**Mohammad Abu Haija, PhD**

Department of Chemistry, Khalifa University, Abu Dhabi, United Arab Emirates

**Shadi W. Hasan, PhD**

Department of Chemical Engineering, Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates; Center for Membranes and Advanced Water Technology (CMAT), Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates

**Chaithanya D. Jain, MSc, PhD**

National Atmospheric Research Laboratory, Department of Space, Government of India, Gadanki, Andhra Pradesh, India

**Amanpreet Kaur Jassal, PhD**

Department of Chemistry, Indian Institute of Technology Delhi, New Delhi, Delhi, India

**Sumit B. Kamble, PhD**

Salt and Marine Chemicals Division, CSIR–Central Salt and Marine Chemicals Research Institute, Bhavnagar, Gujarat, India

**Meenal Kowshik, PhD**

Biological Sciences, BITS Pilani K K Birla Goa Campus, Zuarinagar, Goa, India

**Cheng Chin Kui, PhD**

Department of Chemical Engineering, Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates

**Dr. Kiran Kumar, PhD**

Department of Chemistry, Himachal Pradesh University, Shimla, Himachal Pradesh, India

**Gandhita Kundaikar, MSc**

School of Biological Sciences and Biotechnology, Goa University, Taleigao, Goa, India

**Dileep Maarisetty, PhD**

Department of Chemical Engineering, BITS Pilani, Sancoale, Goa, India

**Maithili Majithia, PhD**

School of Biological Sciences and Biotechnology, School of Arts and Sciences, Ahmedabad University, Ahmedabad, Gujarat, India

**Harshad A. Mirgane, MSc**

School of Chemical Sciences, Goa University, Taleigao, Goa, India

**Hemant Mittal, PhD**

Department of Mechanical Engineering, Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates

**Sharmarke Mohamed, PhD**

Department of Chemistry, Green Chemistry & Materials Modelling Laboratory, Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi, United Arab Emirates; Advanced Materials Chemistry Center (AMCC), Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi (UAE)

**Pranay P. Morajkar, PhD**

School of Chemical Sciences, Goa University, Taleigao, Goa, India

**Kerba S. More, MSc**

School of Chemical Sciences, Goa University, Taleigao, Goa, India

**Pavan More, PhD**

Department of Chemistry, Institute of Chemical Technology, Mumbai, Maharashtra, India

**Dinesh N. Nadimetla, MSc**

School of Chemical Sciences, Goa University, Taleigao, Goa, India

**Dr. Anjani P. Nagvenkar, PhD**

Assistant Professor, School of Chemical Sciences, Goa University, Taleigao, Goa, India

**Amarja P. Naik, PhD**

School of Chemical Sciences, Goa University, Taleigao, Goa, India

**Milind M. Naik, PhD**

School of Biological Sciences and Biotechnology, Goa University, Taleigao, Goa, India

**K. Rambabu, PhD**

Department of Chemical Engineering, Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates; Center for Membranes and Advanced Water Technology (CMAT), Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates

**Vivek Rangarajan, PhD**

Department of Chemical Engineering, BITS Pilani K K Birla Goa campus, Sancoale, Goa, India

**Zeinab M. Saeed, MSc**

Department of Chemistry, Green Chemistry & Materials Modelling Laboratory, Khalifa University of Science and Technology, P.O. Box 127788, Abu Dhabi, United Arab Emirates



**Komal Salkar, MSc**

School of Biological Sciences and Biotechnology, Goa University, Taleigao Plateau, Goa, India

**Akshay V. Salkar, MSc**

School of Chemical Sciences, Goa University, Taleigao, Goa, India

**Subhranshu Samal**

Department of Chemical Engineering, BITS Pilani K K Birla Goa campus, Sancoale, Goa, India

**Aleksandra Schejn, PhD**

Université de Lorraine, Laboratoire Réactions et Génie des Procédés (LRGP), UMR 7274, CNRS, Nancy Cedex, France

**Raphaël Schneider, Prof.**

Université de Lorraine, Laboratoire Réactions et Génie des Procédés (LRGP), UMR 7274, CNRS, Nancy Cedex, France

**Shamshad Shaikh, PhD**

School of Biological Sciences and Biotechnology, Goa University, Taleigao, Goa, India

**Sarvesha S. Shetgaonkar, MSc**

School of Chemical Sciences, Goa University, Taleigao, Goa, India

**Pooja V. Shreechippa, MSc**

School of Chemical Sciences, Goa University, Taleigao, Goa, India

**Vootla Shyamkumar, PhD**

Department of Biotechnology and Microbiology, Karnatak University, Dharwad, Karnataka, India

**Pradeep Kumar Sow, PhD**

Department of Chemical Engineering, BITS Pilani, Sancoale, Goa, India

**A. Thanigaivelan, PhD**

Department of Chemical Engineering, Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates; Center for Membranes and Advanced Water Technology (CMAT), Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates

## Preface

Environmental pollution is by far the greatest threat that the humanity faces today, which slowly but steadily is challenging the very existence of life on earth. The unregulated and untreated release of toxic and persistent pollutants such as Xenobiotics (dyes, pesticides, antibiotics, chlorinated biphenyl's), heavy metal pollutants (Pb, Zn, Hg, Ni, Cd, Cu, Cr, As), anionic pollutants (Fluorides and Nitrites), and polycyclic aromatic hydrocarbons, have been the major cause of water and soil pollution globally. The ever-increasing demand for energy through fossil fuel combustion has resulted in emissions of gaseous pollutants such as  $\text{NO}_x$ ,  $\text{SO}_x$ , hydrocarbons, CO,  $\text{CO}_2$ , and solid-phase pollutant such as soot which not only diminishes air quality but also has a severe impact on global warming and climate change. The emergence of microplastics in water bodies and their detection in human blood has set shockwaves throughout the globe. It is due to the bioaccumulation of such persistent pollutants that the global and regional environments are threatened, which either directly or indirectly results in emergence of newer and newer classes of diseases. The ever-increasing antibiotic resistance of bacterial infections and the emergence of new classes of viruses such as SARS-CoV-2 resulted in the COVID-19 pandemic, which brought the entire world to its knees, enduring loss of countless lives.

It is therefore, we felt the need to highlight these issues in the environmental and biomedical field through this book, emphasizing on the use of nano and biochemistry together as a tool to address the above challenges. This book not only provides the fundamental knowledge on the above topics but also familiarizes the student and the research community about the recent developments in the emerging technologies for mitigation of environmental pollutants and their role in biomedical applications. Some of these nanotechnologies include designing of nanostructured materials with enhanced efficacies for adsorptive separation, photocatalytic degradation, bioremediation using nanozymes, Coupling of Photocatalytic and Bioremediation Processes (ICPB), biopolymers, bionanomaterials, and hydrogels for detection and mitigation of water pollutants. A special section is dedicated to the detection and quantification of atmospheric gaseous and solid-phase pollutants and their reduction and/or mitigation using novel biofuels, bio-nano additives, advanced engine strategies such as low temperature combustion, nanocatalyst-based catalytic converters, and diesel particulate filter technologies.

The application of nanotechnology in nanomedicines and targeted drug delivery systems has provided significant breakthroughs in treating and eradicating some of the most complex diseases discussed above and hence have become the prime focus of research in

biomedical sector. Nanoparticles have shown to inhibit biofilm formation in multidrug resistant bacteria through quorum quenching, an important feature of a pathogen in microbial colonization. Quantum dot-based nanostructures have showcased potential applications in bioimaging and diagnosis of viral infections. Biopolymers, metal organic frameworks, supramolecular organic nanostructures, and DNA-like nanostructured assemblies are proving to be emerging tools in biomolecular sensing, imaging, and in intelligent and targeted drug delivery systems. This book also highlights the toxicological aspects of nanomaterials by summarizing their toxicities as well as approaches to ameliorate the toxic side effects.

It is therefore we believe that this book will definitely help researchers, teachers, and students across disciplines especially those involved in disciplines of Chemistry, Physics, Environmental Chemistry, Chemical-Microbiology, Bio-Physical Chemistry, and Bio-Medical field. We hope that this book serves as a guiding platform to young and aspiring graduate/postgraduate students to pursue research careers in emerging and sustainable technologies for environmental and biomedical research.

Dr. Pranay P. Morajkar and Dr. Milind M. Naik