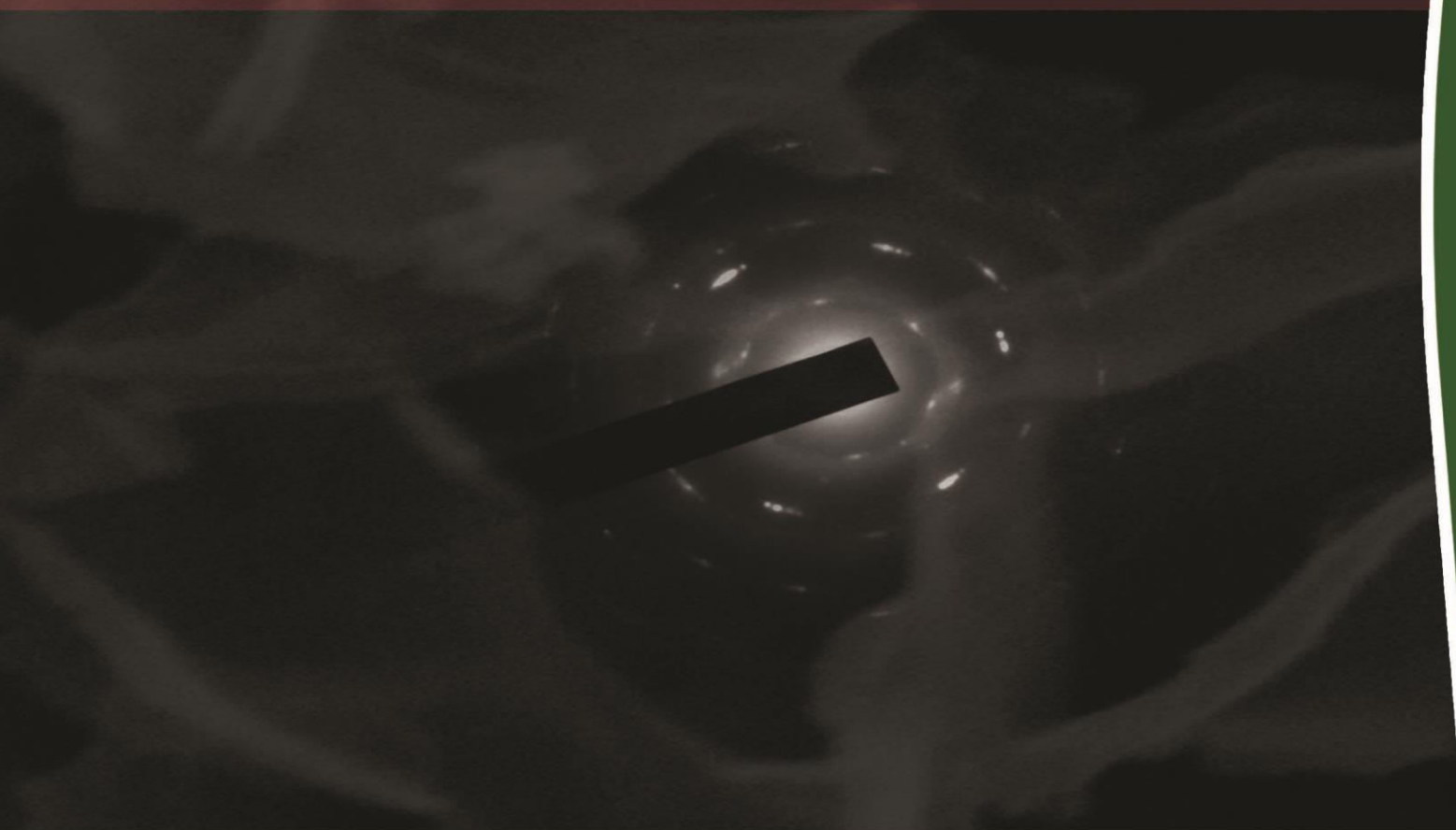


**ISBN: 978-93-94174-20-7**

# **Development of Biogenic Nanomaterials and their Benign Applications**

**Editors**

**Dr. R. Balachandar  
Dr. K. Ashok Kumar**



**Excellent Publishers**



# Development of Biogenic Nanomaterials and their Benign Applications

Editors

**Dr. R. Balachandar**

Professor, Department of Biotechnology,  
Prathyusha Engineering College, Chennai, Tamil Nadu, India

**Dr. K. Ashok Kumar**

Associate Professor and Department of Biotechnology, School of  
Life Sciences, Vels Institute of Science Technology and Advanced  
Studies (VISTAS), Pallavaram, Chennai, Tamil Nadu, India

**ISBN: 978-93-94174-20-7**

<https://doi.org/10.20546/978-93-94174-20-7>



**Excellent Publishers**



## **Excellent Publishers**

Kancheepuram, India

[www.excellentpublishers.com](http://www.excellentpublishers.com)

email id: [excellentpublishers2013@gmail.com](mailto:excellentpublishers2013@gmail.com)

Copyright © 2023 Excellent Publishers. All rights reserved.

***Publisher:*** Excellent Publishers

***Editors:*** Dr. R. Balachandar and Dr. K. Ashok Kumar

**ISBN:** 978-93-94174-20-7

**DOI:** <https://doi.org/10.20546/978-93-94174-20-7>

**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.
<b>Chapter-1</b> <b>Biosynthesis of Nanomaterial and Characterization</b> <i>K. Gowtham, Ravindran Durgadevi,</i> <i>Krishna Kumar Ashok Kumar and M. Jayanthi</i>		<b>1-15</b>
1.1	Introduction	1
1.2	Selection of Biological Organism	2
1.2.1	Bacteria	2
1.2.2	Fungi	3
1.2.3	Plants	3
1.2.4	Algae	3
1.2.5	Enzymes	3
1.3	Preparation of Biological Material	3
1.3.1	Cultivation	4
1.3.2	Harvesting	4
1.3.3	Cell Disruption (if required)	4
1.3.4	Biomolecule Extraction	4
1.3.5	Purification	4
1.3.6	Concentration	4
1.3.7	Storage	4
1.4	Biomolecule Extraction	5
1.4.1	Homogenization	5
1.4.2	Centrifugation	5
1.4.3	Filtration	5
1.4.4	Precipitation	5
1.4.5	Extraction solvents	6
1.4.6	Enzymatic treatment	6
1.5	Nanoparticle Synthesis	6
1.5.1	Selection of Organism or Biomolecule	6
1.5.2	Reaction Mixture Preparation	6
1.5.3	Reduction and Nucleation	7
1.5.4	Growth and Stabilization	7
1.5.5	Reaction Optimization	7
1.5.6	Purification and Separation	7
1.5.7	Characterization	7
1.6	Purification and Separation	8
1.6.1	Centrifugation	9
1.6.2	Filtration	9
1.6.3	Dialysis	9

1.6.4	Precipitation	10
1.6.5	Electrophoresis	10
1.6.6	Size Exclusion of Chromatography	11
1.6.7	Ultrafiltration	11
1.7	Characterization	11
1.7.1	Electron Microscopy	12
1.7.2	X-ray Diffraction (XRD)	13
1.7.3	Fourier Transform Infrared Spectroscopy (FTIR)	13
1.7.4	UV-Vis Spectroscopy	13
1.7.5	Dynamic Light Scattering (DLS)	13
1.7.6	Zeta Potential Analysis	13
1.7.7	Thermogravimetric Analysis (TGA)	14
	References	14
	<p style="text-align: center;"><b>Chapter-2</b>  <b>Biosynthesized Nanomaterials – Anticancer</b>  <i>V. Keerthivasan, Muthusamy Suganthi,</i>  <i>Gopalakrishnan Abirami and Malaiyandi Jayanthi</i></p>	<b>16-25</b>
2.1	Introduction	16
2.2	Biosynthesis of Nanomaterial	18
2.3	Nanoparticles As Anticancer Agent	18
2.3.1	Organic Nanoparticles	18
2.3.1.1	Liposome Nanoparticles	18
2.3.1.2	Dendrimers	20
2.3.2	Inorganic Nanoparticles	21
2.3.2.1	Gold Nanoparticles [AuNPS]	21
2.3.2.2	Silver Nanoparticles [AgNPs]	22
2.3.3	Hybrid Nanoparticles	22
2.3.3.1	Lipid-Polymer Hybrid Nanoparticles	22
	References	23
	<p style="text-align: center;"><b>Chapter-3</b>  <b>Application of Nanotechnology in the Agriculture Sector and Food Supply Chain Management</b>  <i>V. K. Rekha, P. K. Sindhu,</i>  <i>Krishna Kumar Ashok Kumar and D. Suresh</i></p>	<b>26-34</b>
3.1	Introduction	26
3.1.1	Methods of Synthesising Nanomaterials	28
3.1.2	Classification	28
3.2	Classification Based on Chemical Composition	28
3.2.1	Organic Nanomaterials	28
3.2.2	Inorganic Nanomaterials	28
3.2.3	Hybrid Nanomaterials	29
3.3	Agricultural Applications of Nanomaterials	29

3.4	Nanofertilizers	30
3.4.1	Advantages of nano fertilizers	30
3.5	Nano pesticide	30
3.5.1	Advantages of nano pesticide	30
3.6	Nanosensors	31
3.6.1	Advantages of Nano sensor	31
3.7	Benefits of Nano-technology in Agriculture	31
3.8	Challenges in use of nanotechnology in agriculture	32
3.9	Conclusion	32
	References	32
	<p style="text-align: center;"><b>Chapter-4</b>  <b>Nanomaterials Derived from Higher Plants</b>  <i>P. Deepthi, Muthusamy Suganthi and Palanisamy Senthilkumar</i></p>	<b>35-44</b>
4.1	Introduction	36
4.2	Different types of Plant-Derived nanoparticles	36
4.3	Characterization of nanoparticles	37
4.4	Electron microscopy	38
4.5	Dynamic light scattering	39
4.6	Structural and chemical characterization	39
4.7	Nanoparticle from microalgae	39
4.8	Nanoparticles derived from plants and its applications in biomedicine	40
4.9	Conclusion	41
	References	42
	<p style="text-align: center;"><b>Chapter-5</b>  <b>Pharmacological Applications of Biosynthesized Nanomaterial</b>  <i>R. Anith Kumar, Muthusamy Suganthi and Palanisamy Senthilkumar</i></p>	<b>45-66</b>
5.1	Introduction	46
5.2	Biosynthesis Techniques	47
5.3	Types of Biosynthesized Nanomaterials	48
5.3.1	Metal Nanoparticles	48
5.3.2	Metal Oxide Nanoparticles	48
5.3.3	Biological Nanoparticles	48
5.4	Characterization Methods	49
5.5	Therapeutic Applications	50
5.5.1	Infectious diseases	50
5.5.2	Anticancer Activity	52
5.5.3	Anti-Inflammatory and Antidiabetic Activity	53
5.6	Theranostics - therapeutic and diagnosis	59
5.7	Conclusion and Future Directions	60
	References	61

	<b>Chapter-6</b> <b>Role of Biogenic Nanomaterials in Environmental Bioremediation</b> <i>Muthusamy Suganthi, T. Keerthika, S. Lekha Bhagawathi, Palanisamy Senthilkumar and Malaiyandi Jayanthi</i>	<b>67-78</b>
6.1	Introduction	68
6.2	Role of nanotechnology in microbial mediated remediation	68
6.3	Nanotechnology in waste water bioremediation	70
6.4	Toxic impact of heavy metals in waste water	71
6.5	Gold based nanomaterials in waste water treatment	72
6.6	Iron based nanomaterial in waste water treatment	72
6.7	Silver based nanomaterial in waste water treatment	72
6.8	Copper based nanomaterial in waste water treatment	73
6.9	Titanium based nanomaterial in heavy metal elimination	73
6.10	Cerium based nanomaterial in heavy metal elimination	73
6.11	Applications of nanomaterials in waste water treatment	74
6.12	Nano bioremediation of oil spills	75
6.13	Conclusion	76
	References	76
	<b>Chapter-7</b> <b>Applications of Nanomaterial in Recombinant DNA Technology</b> <i>Muthusamy Suganthi, M. Priyadharshini, N. Yokesh, Palanisamy Senthilkumar and Gopalakrishnan Abirami</i>	<b>79-90</b>
7.1	Introduction	80
7.2	DNA-Based nanoparticles	81
7.2.1	Structure and function of DNA	81
7.2.2	Nano-structure construction using DNA	81
7.2.3	Surface attachment or integration of DNA	82
7.2.4	Organization of metal nanoparticles based on DNA	83
7.2.5	Biosensors Based on DNA	83
7.3	Nanotechnology-based genome editing and its application in plant biotechnology	84
7.3.1	Nanoparticle Design Principles for Plant Genome Editing	84
7.3.2	Scaled-Up Nanoparticle Plant Gene Editing	85
7.3.3	Nano-biotechnology-based plant biomolecule delivery approaches	85
7.3.4	CRISPR/Cas9 Nanoparticle Delivery for Genome Editing	85
7.3.5	Approaches towards CRISPR/Cas9 Nano-Delivery	85
7.4	Plant genetic engineering via nanoparticle-mediated gene transformation	86
7.4.1	Applying Nanoparticle-Mediated Techniques for Gene	86

	Transformation in Plant Biotechnology	
7.4.1.1	Magnetofection	86
7.4.1.2	Peptide nanoparticle	86
7.4.1.3	Nanoparticle absorption and degradation	86
7.4.1.4	Nanoparticle phytotoxicity	87
7.5	Application of Nanomaterial in Tissue Engineering	87
7.5.1	Bone tissue engineering	87
7.5.2	Neural tissue engineering	88
7.5.3	Skeletal and cardiac muscle engineering	88
7.6	Conclusion	89
	References	89
	<p style="text-align: center;"><b>Chapter-8</b>  <b>Synthesis of Nanoparticles by Bacteria</b>  <i>A. Ramya, D. Divya Tejaswini,</i>  <i>Krishna Kumar Ashok Kumar and Gopalakrishnan Abirami</i></p>	<b>91-106</b>
8.1	Introduction	92
8.2	Morphology of Nanoparticles	93
8.3	Properties of Nanoparticles	93
8.4	Nanoparticles and Its Types	94
8.5	Synthesis of Nanoparticles By Microbial Strains	94
8.6	The Nanoscale Molecules Are Produced By Two Methods	95
8.6.1	Top-Down Method	95
8.6.1.1	Evaporation/Condensation	95
8.6.1.2	Laser Pyrolysis	96
8.6.1.3	Ionic/Electronic Radiation	96
8.6.2	Bottom-Up Method	96
8.7	Chemical Techniques	96
8.8	Sol-Gel Techniques	96
8.9	Super Critical Fluid with a Chemical Reaction	97
8.10	Nanoparticle Synthesis By Bacteria	97
8.11	Extracellular Synthesis	97
8.12	Intracellular Synthesis	97
8.13	Metallic Nanoparticles	98
8.14	Gold Nanoparticles	98
8.15	Silver Nanoparticles	99
8.16	Other Metallic Nanoparticles	99
8.17	Magnetic Nanoparticles	100
8.18	Non Magnetic Oxide Nanoparticles	100
8.19	Sulfide Nanoparticles	100
8.20	Physical Factors Affecting Synthesis of Nanoparticles	103
8.21	Characterization	103
8.22	Applications	104



8.23	Nano-biomedicine	104
8.24	Incomprehensible as antimicrobial	104
8.25	Biosensors	104
8.26	Environmental remediation	104
8.27	For cancer therapy	105
8.28	Optimization and Methodical Protocols	105
8.29	Conclusion	105
	References	105
	<p style="text-align: center;"><b>Chapter-9</b>  <b>Nanotechnology for Pollution Control and Remediation</b>  <i>P. Bhavadharani, S. Sree Laxmi,</i>  <i>M. Jeyanthi and Gopalakrishnan Abirami</i></p>	<b>107-114</b>
9.1	Introduction	107
9.2	Air Pollution	108
9.3	Air Remediation Using Small Sized Nanotechnology Photocatalysts	108
9.4	Indoor Air Pollution	109
9.5	Outdoor Air Pollution	109
9.6	Nanotechnology for Adsorption of Toxic Gases	109
9.7	Adsorption of Dioxins	110
9.8	Soil Pollution	110
9.9	Contaminated Soil by Calcium by Calcium Polysulfide and Green Tea Nanoscale Zero Valent Iron	111
9.10	Water Pollution	111
9.11	Adsorption	111
9.12	Nanocomposite Membranes	112
9.13	Nanofibrous Membrane	112
9.14	Nanotechnology Based Biosensors	112
9.15	Cantilever Sensor	112
9.16	Other Advances in Nanotechnology Sensors	113
9.17	Electronic Detection of Lectins using Carbohydrate Functionalized Nanostructures Graphene Versus Carbon Nanotubes	113
	References	113
	<p style="text-align: center;"><b>Chapter-10</b>  <b>Synthesis and Characterization of Biogenic Nanomaterials and their Biomedical Application</b>  <i>R. Priyadharshini, Muthusamy Suganthi, Ravindran Durgadevi</i>  <i>and Gopalakrishnan Abirami</i></p>	<b>115-122</b>
10.1	Introduction	115
10.2	Categorization of Nanomaterials	117
10.3	Organic-based NPs	117

10.4	Carbon-Based NPs	117
10.5	Inorganic-based NPs	117
10.6	Pathway of Biosynthesis	117
10.7	Bactericidal Properties of Biogenic Nanomaterial	118
10.8	Biogenic Nanoparticle Synthesis	118
10.9	Application of Biogenic Nanoparticle	119
10.10	Characterization of Biogenic Nanoparticle	120
10.11	Conclusion	120
	References	121
	<p style="text-align: center;"><b>Chapter-11</b>  <b>Nanomaterials in Action: Revolutionizing Airborne Particulate  Pollution Control for a Sustainable Future</b>  <i>A. Ramya, B. T. Mayurika,  Malaiyandi Jayanthi and Durgadevi Ravindran</i></p>	<b>123-133</b>
11.1	Introduction	124
11.2	Types of Nanomaterials	124
11.2.1	Metal and Metal Oxide based Nanomaterials	125
11.2.2	Carbon-Based Nanoparticles	125
11.2.2.1	Fullerene	125
11.2.2.2	Carbon Nanotubes	126
11.2.2.3	Single Walled Carbon Nanotubes	126
11.2.2.4	Multi Walled Carbon Nanotubes	126
11.2.2.5	Graphene-Based Materials	126
11.2.2.6	Nano Catalysts	127
11.2.2.7	Nano Filters	127
11.2.2.8	Nano Sensors	127
11.3	Mechanisms of Nanoparticles in Pollution Control	127
11.3.1	Adsorption	127
11.3.2	Adsorption of Dioxins	128
11.3.3	NO <sub>x</sub> Adsorption	128
11.3.4	CO <sub>2</sub> Capture	128
11.3.5	Isopropyl Alcohol Adsorption	128
11.3.6	Catalytic Degradation of Pollutants	129
11.4	Nano-Enhanced Filtration Systems	129
11.5	Case Studies and Experiments	129
11.6	Challenges and Limitations in Practical Implementation	130
11.7	Successful Applications of Nanomaterials in Real-World Pollutant Control Scenarios	130
11.8	Conclusion	131
	References	131

	<b>Chapter-12</b> <b>Green Nanoparticles in organic dye degradation and Agriculture</b> <b>- A Systematic Review</b> <i>Indrani Chandra*, Rajat Mistry and Sushobhan Sen</i>	<b>134-148</b>
12.1	Introduction	134
12.2	Green synthesis nanoparticles	136
12.2.1	Specifications of different nanoparticles	137
12.3	Application	137
12.4.	Bioactivity	138
12.5	Photocatalytic activity	139
12.6	Agriculture	140
12.7	Growth Promoting Nano Fertilizer	141
12.8	Stress Tolerance	141
12.9	Conclusion	142
	References	142
	<b>Chapter-13</b> <b>Synthesis and Characterization of Silver Nanoparticles by</b> <b>Chemical Method and its Catalytic Application for Study of</b> <b>Reduction of 4-Nitro phenol</b> <i>Dr. Sandeep V. Khansole</i>	<b>149-155</b>
13.1	Introduction	149
13.2	Experimental	150
13.2.1	Chemicals	150
13.2.2	Preparation of Colloidal AgNPs by the Chemical Method	150
13.3	Results and Discussion	151
13.3.1	Characterisation of AgNPs	151
13.3.1.1	UV Spectrophotometry	151
13.3.1.2	X Ray Diffraction Study	151
13.3.1.3	Catalytic Reduction of 4-Nitrophenol	152
13.4	Conclusion	153
	References	153
	<b>Chapter-14</b> <b>Development of Functionalized Aromatic Polyamides for</b> <b>Environmental Applications and Clean Energy Devices</b> <i>Shivaji D. Ghodke</i>	<b>156-169</b>
14.1	Introduction	156
14.2	Molecular Design and Monomer Synthesis	157
14.2.1	Monomer Design Strategy	157
14.2.2	Monomer Synthesis	158
14.2.3	Polymerization and Characterization of Polyamides	159
14.3.2	Characterization of Polyamides	161
14.3.2.1	FT-IR Spectroscopy	161

14.3.2.2	$^1\text{H}$ NMR and $^{13}\text{C}$ NMR	161
14.3.2.	3 Gel Permeation Chromatography (GPC)	161
14.3.2.4	X-Ray Diffraction (XRD)	162
14.3.2.5	Solubility Tests	162
14.4	Thermal Properties	163
14.4.1	Differential Scanning Calorimetry (DSC)	163
14.4.2	Thermogravimetric Analysis (TGA)	164
14.5	Future Outlook	166
14.6	Conclusion	167
	References	168
	<p style="text-align: center;"><b>Chapter-15</b>  <b>Nanomaterials and its Impact on Health and Biological Systems</b>  <i>Saagarika Srinivasan, M. Suganthi, T. Pratheep and</i>  <i>M. Thenmozhi</i></p>	<b>170-180</b>
15.1	Introduction	171
15.2	Nanomaterials as drug carriers	172
15.3	Acute and chronic diseases	174
15.4	Occupational hazard causing health impacts	176
15.5	Nanomaterials and environmental hazards	177
	References	178

## Preface

Nanotechnology is a multidisciplinary field that involves manipulating matter at the nanoscale, typically in the range of 1 to 100 nanometers. At this scale, the properties of materials can be significantly different from those at larger scales, leading to unique and often enhanced characteristics. Nanotechnology encompasses a wide range of scientific disciplines, including physics, chemistry, biology, materials science, and engineering. Here are key aspects of nanotechnology.

**Development of Biogenic Nanomaterials and their Benign Applications:** This book is an attempt to bring a perspective to the innovations that are constantly evolving in the field of Nanotechnology towards Life Sciences.

Nanomaterial's application in the diverse fields of Biochemistry, Microbiology, Biotechnology, Environmental Sciences and Phytochemistry has come a long way in the field.

Development of Biogenic Nanomaterials and their Benign applications is an effort to bring together the knowledge of various experienced and talented science minds striving silently towards Nanomaterials and their biological applications. This book has chapters contributed by masterminds in the different areas of Nanotechnology and Life Science.

The book has chapters on current and trending topics like the role of Nanotechnology and synthesized Nanoparticles in the fields of Agriculture, Environment Such as Bioremediation, Medicine and Eco-friendly synthesis of Nanoparticles.

Biogenic nanomaterials are nanoscale materials that are synthesized by biological entities such as bacteria, fungi, plants, and other microorganisms. These materials have gained significant attention due to their unique properties, eco-friendly synthesis processes, and potential applications in various fields. The development of biogenic nanomaterials and their benign applications involves several procedures. Microorganisms like bacteria, fungi, and algae can be used to synthesize nanomaterials. Plants can also be employed in the synthesis of nanomaterials. Plant extracts contain various phytochemicals that can act as reducing and stabilizing agents in the formation of nanoparticles. Thorough characterization of biogenic nanomaterials is crucial to understanding their size, shape, composition, and surface properties. Techniques such as transmission electron microscopy (TEM), scanning electron microscopy (SEM), X-ray diffraction (XRD), and Fourier-transform infrared spectroscopy (FTIR) are commonly used.

## **Benign Applications:**

**Medicine:** Biogenic nanomaterials have applications in drug delivery, imaging, and diagnostics. They can be tailored to enhance the therapeutic efficacy of drugs and reduce their side effects.

**Environmental Remediation:** Biogenic nanoparticles can be utilized for the removal of pollutants from air and water. They can act as efficient adsorbents for heavy metals and other contaminants.

**Food Industry:** Biogenic nanomaterials can be employed in food packaging, preservation, and sensing applications to enhance food safety and shelf life.

**Agriculture:** Nanoparticles synthesized from plant extracts or microorganisms can be used in agriculture for crop improvement, nutrient delivery, and pest control.

**Sustainability:** Considerations for the sustainability of the synthesis processes and the overall environmental impact of biogenic nanomaterials are essential. Researchers aim to develop green and sustainable methods for the production of these materials. The development of biogenic nanomaterials and their applications is a multidisciplinary field that combines biology, chemistry, materials science, and engineering. As research progresses, it is expected that more innovative and environmentally friendly applications will be discovered, contributing to sustainable technological advancements.

**Dr. R. Balachandar**

*Professor, Department of Biotechnology,  
Prathyusha Engineering College, Chennai,  
Tamil Nadu, India*

**Dr. Ashok Kumar K**

*Associate Professor and Department of Biotechnology,  
School of Life Sciences, Vels Institute of Science  
Technology and Advanced Studies (VISTAS),  
Pallavaram, Chennai, Tamil Nadu, India*

## About the Editors



**R. Balachandar**, Ph.D., is working as an Professor in the Department of Biotechnology, Prathyusha Engineering College, His research interests include Microbiology, Micrbial Biotechnolgy, Genetic Engineering Nanobiotechnology, Vermicompost Technology, Biofuel and Waste management. He has Received a “**Best Research Paper Award**” from “Arupadai Veedu Institute of Technology”, Chennai, India in the year of 2020.and he had received “**Best Teacher Award**” from Arulmigu Meenakshi Amman College of Engineering. He had filed two Indian patents and published more than 30 Research and Review articles in reputed journals with a cumulative impact factor of above 400 and published 13 Book chapters to his credit. He is serving as a Reviewer for several Indexed Journals. Presented papers and attended more than 20 National and International Conferences. He is also a life member of Society for Biotechnology and Indian Lichenological Society, Life Member in Indian Society for Technical Education (ISTE).



**K. Ashok Kumar, Ph.D.**, is working as an Associate Professor in the Department of Biotechnology, School of Life Sciences, Vels Institute of Science Technology and Advanced Studies (VISTAS), Pallavaram, Chennai, Tamil Nadu, India. His research interests include Biochemistry, Environmental Biotechnology and Phytochemistry. He possesses more than 18 years of Teaching Experience. He has qualified for SET a prestigious Exam conducted by Mother Teresa University, Tamil Nadu for the Qualification of Lectureship. He has received many awards from International and National Conferences for best paper presentations Organized by reputed Institutes. He has published more than 35 Research and Review articles in reputed, SCI and Scopus Indexed Journals and has Published 10 book chapters and one book to his credit. He has published more than 25 research findings in International and National Conferences organized by renowned Institutes. He is also a Life member of the Indian Nano-Biologists Association (INBA), a member of Einstein Research Academy (ERA), and the American Society of Microbiology.



# Development of Biogenic Nanomaterials and their Benign Applications

Edited by Dr. R. Balachandar and Dr. K. Ashok Kumar

**Dr. R. Balachandar**

Professor, Department of Biotechnology,  
Prathyusha Engineering College, Chennai, Tamil Nadu, India

**Dr. K. Asok Kumar**

Associate Professor and Department of Biotechnology,  
School of Life Sciences, Vels Institute of Science Technology and  
Advanced Studies (VISTAS), Pallavaram, Chennai, Tamil Nadu, India



Published by  
**Excellent Publishers**

No.: 38/48, Second Street, Ellappanagar, Kancheepuram, Tamilnadu, India  
[www.excellentpublishers.com](http://www.excellentpublishers.com) e.mail: [excellentpublishers2013@gmail.com](mailto:excellentpublishers2013@gmail.com)  
Mobile No.: +91-9842641794