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Combating Plastic Pollution in Terrestrial Environment

Challenges and Strategies for a Sustainable Future

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Foreword

In recent decades, the world has witnessed an alarming increase in plastic pollution, particularly in terrestrial environments. The consequences of plastic pollution are far-reaching, affecting ecosystems, human health, and the global economy. This growing challenge requires urgent attention, innovative strategies, and a concerted global effort to mitigate its devastating effects.

The publication *Combating Plastic Pollution in Terrestrial Environment—Challenges and Strategies for a Sustainable Future* is a timely and significant contribution to this pressing issue. It combines the expertise and insights of scientists, researchers, and environmentalists from various regions, offering a comprehensive overview of the sources, impacts, and potential solutions to plastic pollution. The diverse range of topics covered in this book, from the hazards of microplastics in agriculture to sustainable waste management approaches, highlights the complexity of the problem and the multifaceted strategies needed to address it.

This publication's relevance extends beyond environmental concerns to directly supporting the achievement of the United Nations Sustainable Development Goals (SDGs), particularly SDG 12 (Responsible Consumption and Production), SDG 14 (Life Below Water), and SDG 15 (Life on Land). By addressing plastic waste management and promoting sustainable practices, this book contributes to minimizing plastic pollution's adverse effects on terrestrial and aquatic ecosystems. Furthermore, the innovative technologies and community-based initiatives presented here offer actionable pathways for policymakers, industries, and communities to embrace more sustainable practices and reduce plastic's harmful footprint on our planet.

Each chapter in this book underscores the current state of plastic pollution and points toward innovative technologies, community-driven initiatives, and policy measures that can drive sustainable change. This publication's interdisciplinary approach is commendable, as it bridges the gap between science, technology, and community engagement, making it a valuable resource for researchers, policymakers, and environmental advocates alike.

The contributions from nine countries including India provide a diverse perspective on how these countries are tackling the challenges of plastic pollution through

various innovative technologies, management strategies, energy and waste valorisation, biological solutions and chemical and physical characterisation of different types of plastics.

I am confident that this book will inspire a deeper understanding of the global plastic pollution crisis and encourage the scientific community and policymakers in the Non-Aligned Movement and other developing countries to take decisive steps toward a sustainable future. This publication paves the way for a cleaner, healthier, and more resilient world by addressing the challenges and exploring viable strategies for combating plastic pollution.

It is an honor to contribute this foreword to such an important and timely work. I commend the editors, S. Suriyanarayanan, Shivaraju H. P., and Kandiah Pakeerathan, as well as the contributors from across the globe, for their dedication and commitment to this critical cause. I am confident that this publication will serve as a cornerstone in the global effort to combat plastic pollution and inspire meaningful action toward safeguarding our planet for future generations.

September 2024

Prof. Dr. B. Suresh
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Preface

Plastic waste has become a critical global concern that is receiving the attention of scientists, decision-makers, and the general public. Over the past six decades, the world has produced approximately 8300 million tonnes of virgin plastics from which over 5800 million tonnes of wastes have been generated. All these wastes were managed through incineration, landfilling, release to the environment, and recycling. These waste materials have severely impacted the environment and global health. The accumulation of plastics in the environment has negatively impacted human health, agriculture, and ecosystems, which requires an immediate action.

Many studies have been conducted focusing on the plastic pollution in marine environment, whereas impacts on the terrestrial systems such as freshwater habitats, soil and groundwater have received less attention. The amount of plastics generated, consumed and released is more in the terrestrial environment rather than the marine ecosystem. Despite the increasing amount of research, there are still a number of important issues that need to be addressed. These include investigations into the sources of plastic pollution, the transport of these materials into various environments, the hazards it poses to ecosystems and human health, and possible ways to reduce emissions of plastic waste in the terrestrial settings. In terrestrial plastic pollution, the smaller plastics/microplastics are produced by a variety of sources, such as landfills, farming, and industry, and cause an extensive pollution of terrestrial habitats.

Plastics pollution significantly alter the physicochemical properties of soil, affecting bulk density, pore space, capillarity, soil moisture levels, evaporation, and evapotranspiration. These changes can disrupt the hydrological cycles, impair plant growth, and harm soil organisms, ultimately disturbing the food chains including the ecological services. Research studies demonstrated that plastics in the environment can also adsorb contaminants such as heavy metals, poisonous organic compounds and other emerging contaminants like antibiotics. These compounds pose a threat to the ecosystems especially the living things that inhabit them.

Inadequate waste management systems and the increasing use of plastics have led to significant plastic contamination in the terrestrial environment, particularly in developing nations.

The global plastic waste crisis is being exacerbated by ineffective policy measures aimed at limiting single-use plastics (SUPs). Poor enforcement of regulations and a lack of social consensus on reducing the plastic usage have led to negative consequences, with the impact often spilling over into neighbouring countries.

In this context, we understand how critical it is to address these changes carefully and comprehensively. As a result, we are delighted to present an edited book titled *Combating Plastic Pollution in Terrestrial Environment: Challenges and Strategies for a Sustainable Future* that emphasizes on different issues related to plastics in developing countries and their approaches in tackling this important problem. The book containing 25 chapters from 9 countries highlights various aspects of terrestrial plastic pollution and its management strategies, and the environmental and health hazards across the different regions. The key studies include the microbiological degradation of plastic materials, production of wood-plastics composites, risks of plastic wastes and the community-driven initiatives to tackle the plastic pollution, microplastics pollution in agricultural settings and freshwater ecosystem, use of technology for effective sorting methods, and use of waste plastics for sustainable practices provide a deep understanding of approaches to mitigate the plastic pollution in the terrestrial environment. To effectively reduce the plastic use, new and innovative business models are required. It is also recommended that a global plastic treaty, extended producer responsibility (EPR) schemes, import duties on plastic materials, reducing the trade barriers on substitutes, phasing out of fossil fuel subsidies and the exploration and adoption of bio-plastic as an alternative to traditional plastic and improved waste management infrastructure are to be implemented to address this global issue. We believe that the insightful research and best practices presented in this book would be a useful resource material for scientists and researchers interested in these emerging issues. We hope that this book successfully reaches its target audience.

Editors would like to express their gratitude to Dr. Amitava Bandopadhyay, Director General, NAM S&T Centre and their Staff Members for all of the technical and administrative assistance provided in the publication of this book. We are grateful to Prof. Dr. B. Suresh, Director of Technical Education at JSS Mahavidyapeetha, and Pro-Chancellor of the JSS Academy of Higher Education and Research (Deemed to be University), Mysuru for penning the "Foreword" of this book. We also thank Dr. Loyola D'Silva, Executive Editor at Springer Nature, Singapore and Springer Nature Staff Members for helping to make this project a success.

Mysuru, India — S. Suriyanarayanan, Ph.D.
Mysuru, India — Shivaraju H. P., Ph.D.
Jaffna, Sri Lanka — Kandiah Pakeerathan, Ph.D.

Introduction

Plastic pollution in terrestrial environment has rapidly escalated into a global crisis, capturing the attention of scientists, government officials, policymakers, etc., and affected the lives of the common people. The World Economic Forum has consistently identified environmental degradation, including plastic pollution, as one of the top challenges facing humanity. With over 380 million tons of plastic produced annually, the adverse effects of this waste are profoundly felt, particularly in developing nations where waste management systems are mostly inadequate.

The challenge of addressing plastic pollution in terrestrial environment is multi-faceted. Regulatory frameworks often lag behind the rapid pace of plastic production and consumption. Many existing policies are outdated, failing to cope with the evolving landscape of plastic use and waste management. Strengthening these frameworks and enhancing enforcement mechanisms are essential for curbing plastic waste generation and promoting sustainable alternatives.

Moreover, technological innovations in waste management and recycling present promising pathways to mitigate plastic pollution. Advanced materials and processes can enhance recycling efficiency and reduce the environmental footprint of plastic production and subsequent disposal. Community engagement and education also play pivotal roles in fostering behavioral changes that support sustainable consumption practices. By raising awareness about the impacts of plastic pollution, we can encourage individuals and communities to adopt more responsible habits, such as reducing single-use plastics and participating in local recycling initiatives.

Plastics, designed for durability and convenience, have unfortunately become ubiquitous in our ecosystems. From urban centers to remote rural areas, plastic waste is not only an eyesore but also a significant threat to biodiversity, wildlife, and human health. The fragmentation of larger plastic items into microplastics poses a severe risk, as these particles can infiltrate soil and water systems, impacting both terrestrial and aquatic life.

The extraction and disposal of plastics have accelerated with increasing population growth, urbanization, and changing consumption patterns, exacerbated by inadequate recycling infrastructures. The consequences of this pollution are alarming, leading to

significant ecological damage and raising public health concerns about the presence of microplastics in food and drinking water.

To address these urgent issues, the *Centre for Science and Technology of the Non-Aligned and Other Developing Countries (NAM S&T Centre), New Delhi*, is pleased to present this comprehensive publication aimed at disseminating relevant knowledge and innovative strategies for combating plastic pollution.

This book features contributions from scientists and researchers across 9 countries, viz., Egypt, India, Iraq, Malaysia, Mauritius, Myanmar, Pakistan, Sri Lanka, and Taiwan - highlighting the pressing challenges posed by plastic waste and showcasing effective management techniques.

Through its 25 chapters, the book provides an extensive overview of the sources and impacts of plastic pollution, exploring microplastics in freshwater systems, the hazards of micro-plastic contamination in agriculture, and the innovative reuse of plastic waste. The chapters delve into various strategies for combating plastic pollution, including microbial degradation, community initiatives, and advanced technological solutions, thereby offering a holistic view of the issue.

This publication not only serves as a resource for understanding the scope of plastic pollution but also aims to inspire action and collaboration among researchers, policymakers, environmental professionals, and students. The methods discussed in this book contribute significantly to achieving global Sustainable Development Goals (SDGs), particularly SDG-12 on "Responsible Consumption and Production".

I extend my heartfelt gratitude to all the contributors for their dedication and expertise, which have made this compilation possible. I specially thank the editorial team—Dr. S. Suriyanarayanan (India), Dr. Shivaraju H. P. (India), and Dr. Kandiah Pakeerathan (Sri Lanka) for their relentless efforts in reviewing and refining the chapters, ensuring that the information presented is both accurate and impactful.

I am immensely grateful to Prof. B. Suresh, Pro-Chancellor and Director (TED), JSS Academy of Higher Education (JSS AHER), Mysuru for kindly agreeing to our request to write the "Foreword" of this book in spite of his very busy schedule. We are thankful to Prof. Suresh and Dr. Surinder Singh, Former Vice Chancellor, JSS AHER for their encouragement and support towards S&T collaboration between JSS AHER and the NAM S&T Centre. We are also thankful to Prof. Vishal Gupta, Dean (Academics), JSS AHER for his help and support in many ways in our partnership with JSS AHER.

I am thankful to Dr. Loyola D'Silva, Executive Editor, Springer Nature, Singapore for his kind support and guidance towards bringing out this publication and Ms. Shalini Monica C. Selvam, Production Editor, Springer Nature, Trichy, India for managing all the technical and administrative responsibilities for the publication process.

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