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Preface

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Preface

As the editors of "Solid Waste Management for Resource-Efficient Systems: Circularity in Action," our journey has been both thrilling and intellectually demanding. In exploring the scientific realm of solid waste management, we carefully selected content that not only aligns with the book's overarching objectives but also reflects the dynamic complexities inherent in this field. From the outset, our mission was clear: to assemble a compendium of knowledge that exceeds disciplinary boundaries, catering to the diverse needs of students, professionals, and researchers vested in the domain of circularity and resource conservation. After careful consideration, we proudly present 21 thoughtfully curated chapters across five comprehensive parts, each offering unique insights, research findings, and practical case studies aimed at advancing the discourse on sustainable waste management practices across the world.

Part I, comprising four chapters (1–4), focuses on the composition and characterization of various types of municipal solid waste. Chapter 1 of this book embarks on a journey through the scientific landscape of Municipal Solid Waste (MSW) management, delving into its complex dynamics influenced by factors such as climate, population dynamics, economic conditions, and technological advancements. The chapter explores the composition and complexities of MSW based on its physical, chemical, and biological characteristics. It further discusses various methods of managing MSW, including biological processes, thermal treatment, reuse, recycling, energy recovery, and landfilling. Integrated waste management strategies cover systematic approaches to collection, transport, treatment, and disposal, considering the diverse properties influencing MSW composition. It also highlights the contrast between developed nations' effective waste management and the challenges developing countries face due to limited resources, urbanization, and infrastructure. Addressing this disparity requires a focus on research, innovation, and technological progress in integrated waste management practices. Chapter 2 on the MSW in Pacific Island Countries and Territories (PICT) presents challenges due to limited resources and infrastructure. Many islands rely on landfills or open dumps for waste disposal, leading to environmental degradation and health risks. Incineration and composting are utilized in some areas but face constraints like insufficient funding and expertise. To tackle these issues, PICTs are adopting Integrated Waste Management (IWM), incorporating composting and recycling. Enhancing public awareness and education on proper waste management, backed by legislation, is crucial. This chapter offers insights into current MSW practices, challenges, and recommendations for improvement, focusing on Fiji. Besides MSW, the increasing volume of electronic waste (e-waste) due to high demand for electrical products and inadequate waste management practices in developing nations is a pressing issue, and it is covered in Chapter 3. This chapter presents the current status of e-waste in these countries,

emphasizing global management approaches and regulatory frameworks. A significant challenge is the legal export of e-waste from developed to developing countries, exploiting cheaper labor and lax regulations. The chapter also highlights key factors for successful and affordable e-waste management techniques. It discusses the challenges developing countries face, strategies for e-waste management, and necessary policy interventions. Drawing insights from successful practices in other countries, it proposes measures like take-back policies and regulatory frameworks suitable for implementation in developing nations. Chapter 4 titled "Uniform E-Waste Classification - A Required Policy to Compare Country-Level E-Waste Statistics" highlights the need for a standardized classification policy for e-waste to compare country-level statistics accurately. Using India as an example, the study demonstrates the difference in estimating e-waste generation based on national and international classifications. It employs a sales stock lifespan model to estimate e-waste generation and explores the circular economy potential of secondary raw materials within e-waste. The chapter emphasizes the importance of a uniform e-waste classification policy, particularly in developing countries, for effective e-waste management.

Part II, comprising three chapters (5–7), discusses the environmental and health hazards due to improper management of solid wastes. Chapter 5, titled "Emerging Environmental Contaminants: Fate at Landfill Sites and in Leachate," discusses the several challenges of landfill leachate. While landfills are commonly used for solid waste management, many lack proper engineering and maintenance, leading to leachate contamination of groundwater and surface water. While conventional pollutants in landfills have long been studied and regulated, emerging contaminants (ECs) have recently gained attention for their environmental impact despite limited past examination and regulation. This chapter provides an overview of ECs, their classification, and their journey to landfills and leachate. Recent case studies highlight EC contamination and its environmental consequences. Finally, it discusses current and emerging strategies for managing EC contamination in landfill leachate. Besides ECs, plastic pollution has reached epidemic proportions, with microplastics (MPs), particles smaller than 5 mm, emerging as a major global environmental issue, which is the focus of Chapter 6. Urban aquatic systems, serving as primary receptors for land-based MPs, face significant pollution, with landfill sites one of the major contributors. Effective strategies are needed to mitigate this pollution. This chapter examines MP pollution in urban aquatic environments, emphasizing the role of wastewater treatment plants and estuarine fronts as potential control points. Waterborne MPs undergo various processes that complicate pollution assessment and control. The review underscores heightened MP pollution in Asia, prompting exploration of its causes and proposed management strategies for pollution control in the region. Chapter 7 discusses how MSW management has emerged as a significant environmental concern during the COVID-19 pandemic, with a surge in biomedical and plastic waste due to increased usage of personal protective equipment and single-use plastic items. The pandemic has disrupted traditional waste management practices, posing challenges for waste collection, transportation, and treatment. Municipalities and waste management companies face difficulties managing diverse waste types, risking the spread of infectious diseases and environmental pollution. This chapter examines the pandemic's impact on solid waste generation, disposal, and recycling worldwide, highlighting novel management strategies and proposing preventive measures for future pandemics.

Part III, comprising five chapters (8–12), focuses on the management strategies and approaches for biodegradable and nonbiodegradable solid waste. Chapter 8, titled "A review of rapid composting techniques and optimization of parameters for the management of organic waste" addresses the global issue of organic waste generation and the increasing demand for effective management solutions. It provides a comprehensive overview of rapid composting techniques, including windrow, vermicomposting, and in-vessel composting, while emphasizing optimizing parameters such as temperature, moisture content, and carbon-to-nitrogen ratio. The chapter highlights the challenges and opportunities in sustainable and efficient organic waste management. Chapter 9, titled "Decarbonization in waste management sector," emphasizes the importance of addressing climate change through decarbonization in waste management. It discusses the environmental footprint of waste activities, including emissions from landfilling, transportation, and open burning. The chapter further highlights the need to reduce greenhouse gas emissions, particularly methane and nitrous oxide, and explores technological innovations, policy frameworks like the Paris Agreement and Sustainable Development Goals, and community engagement. By adopting a holistic approach, the waste sector can contribute to a more sustainable and circular economy while combating climate change. This aspect is further covered in Chapter 10 with examples from China. China's rapid urbanization continues to generate unprecedented volumes of MSW, driving the government to explore optimized waste management strategies within a circular economy framework. Initiatives such as "carbon peak and neutrality" and "zero-waste cities" underscore this effort. Effective MSW classification is crucial for waste minimization and valorization, yet non-electronic waste is predominantly incinerated, contributing to air pollution. Current air pollution control devices struggle to meet stringent emission standards, posing challenges to pollution reduction and carbon neutrality goals. Proper MSW classification supports the circular economy and aids in carbon emission reduction. This chapter further examines China's MSW classification, incineration policy, ultra-low emission technology, and international waste recycling practices to inform improved MSW management and pollution control strategies. The review study on plastic waste management in India in Chapter 11 emphasizes the urgent need to tackle the country's annual production of 3.3 million tons of plastic waste. It discusses legislative measures, such as bans on single-use plastics and extended producer responsibility initiatives, to mitigate the environmental and health impacts of plastic pollution. The chapter explores the classification, impacts, and recycling of plastic waste, highlighting challenges and opportunities. Innovative solutions like plastic use in road construction and conversion into oil are also discussed, showing their potential to address plastic waste management challenges sustainably. It has been recognized that integrating the informal sector into solid waste management is vital for resource recovery, especially in developing economies. Chapter 12 highlights that waste pickers, although they play a crucial player in this process, face challenges like occupational hazards and lack of recognition. Efforts to integrate them involve mapping contributions, organizing cooperatives, and mobilizing communities. Initiatives in cities like Belo Horizonte, Brazil, and Pune, India show how recognizing and empowering waste pickers transforms waste management. Social mobilization and community involvement change public perception and foster inclusive participation,

leading to a more equitable waste management system.

Part IV, comprising four chapters (13–16), highlights dumpsite remediation and landfill management with environmental implications and management strategies. Landfills, though historically favored, have been associated with several environmental and health hazards and often end in catastrophic events such as landfill fires. They remain prevalent globally, particularly in developing nations, due to their cost-effectiveness. However, many developing countries are now improving waste management practices. In contrast, developed nations have successfully implemented recycling, composting, and energy recovery alongside engineered landfills. Chapter 13 compares landfill practices between developed and developing countries, highlighting key differences. Addressing global environmental and health hazards associated with open landfills and their remediation challenges is crucial, particularly in developing and developed economies where improper or inadequate waste disposal poses significant environmental and health risks and reduced recycling rates. In this connection, Chapter 14 focuses on a tailored framework for managing legacy waste (aged waste) in India, emphasizing sustainable practices and landfill mining initiatives under the Clean India Mission 2.0. In addition, Chapter 15 explores the European perspective on landfill mining, highlighting its potential as a solution for reclaiming landfill capacity and resources. Both chapters highlight the importance of strategic measures, standardized evaluation frameworks, and regulatory support for effective waste management and resource recovery through landfill remediation. The widespread landfill pollution highlights the urgent need for environmentally sound and cost-effective leachate treatment technologies. Chapter 16 suggests that natural treatment systems (NTSs), notably constructed wetlands (CWs), have demonstrated efficacy in removing both conventional pollutants and ECs from landfill leachates, making them vital in addressing India's sustainability challenges in leachate management."

Part V, comprising five chapters (17–21), presents the management of special waste streams. This part of the book deals with the special waste streams such as hazardous waste, wastewater, and their treatment technologies. For example, Chapter 17 reports that ship recycling yields substantial waste, including hazardous and nonhazardous materials. While ships comprise 90% steel, 0.5%–1% nonferrous metals, and 4%–5% equipment and fixtures, waste constitutes 0.05%–1% of the ship's weight. However, considering a 40,000-ton ship, this equates to a significant 400 tons of waste per vessel. With India alone processing over 200 ships annually, the scale of waste management challenges is evident. These wastes range from asbestos, heavy metals, and persistent organic pollutants to garbage, plastics, and oily slags. Effective waste management strategies are essential in ship recycling yards to address environmental and health risks. This chapter highlights the issues, circular economy potential, and effective management of waste from ship recycling. The chapter further highlights the gaps in waste management and how to bridge them. Chapter 18, entitled "Methods for Treatment of Asbestos Containing Wastes for their Safe Disposal and Gainful Utilization," addresses the global challenge of managing asbestos-containing waste (ACW) in a financially and environmentally sustainable manner. It critically reviews environmentally sound disposal alternatives and recycling options for ACWs from various sources. The chapter discusses decontamination techniques such as thermal treatment, microwave irradiation, acid cracking, and supercritical steam treatment. It compares them based on factors like

recyclability potential, secondary pollution, workforce risk, cost-effectiveness, and energy requirements. It also presents a decision-making framework for selecting appropriate ACW treatment technologies. The rise in biomedical waste due to modern medical practices is the focus of Chapter 19. Inadequate waste management leads to environmental buildup, posing health risks. Pre-pandemic, managing biomedical waste was challenging globally. COVID-19 worsened the situation with increased production of PPE and medical gear. Proper handling of pandemic-generated waste was crucial due to its infectious nature. Effective and eco-friendly biomedical waste management is imperative. This review examines biomedical waste generation, associated risks, and sustainable management methods. It also assesses COVID-19's impact, challenges, and prospects. Continuing from the previous chapter, Chapter 20 explores how industrial waste can be repurposed as catalysts for wastewater treatment, aligning with the principles of circular economy. By repurposing waste from various industries such as paper mills, agro-industries, mining, and metal industries, this approach not only addresses environmental concerns but also contributes to sustainable resource utilization. Finally, Chapter 21 discusses treatment options for oil refinery wastes, such as biorefinery processes, advanced oxidation methods, and biological treatments, to reduce associated risks. It emphasizes the necessity of sustainable practices to address the increasing energy demand from oil industries. The study outlines effective techniques for managing oil refinery sludge, aligning with Sustainable Development Goal 7.

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