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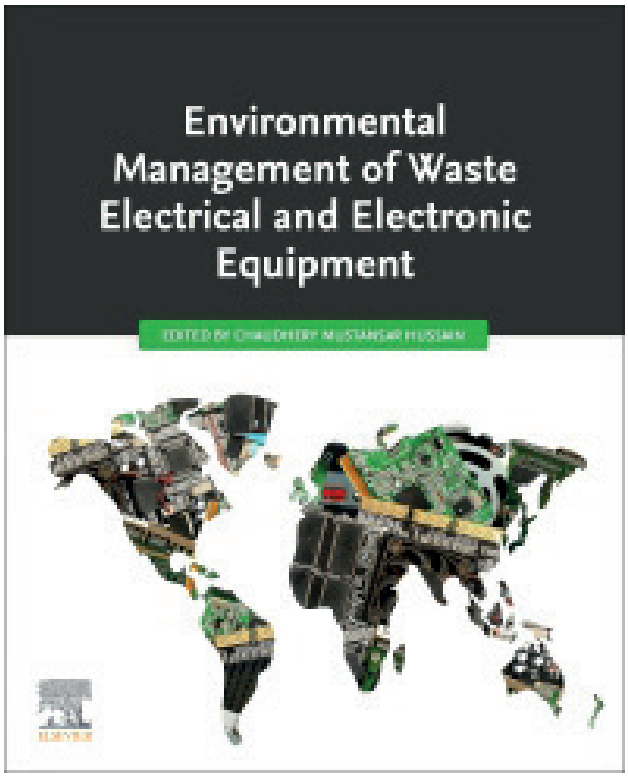

ENVIRONMENTAL MANAGEMENT OF WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT

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The information and communication revolution alongside technological development has been a blessing and a curse to our environment; these developments have led to multiple problems which include the problem of the huge amount of hazardous waste and other waste generated from electrical and electronic products. This problem requires coordinated efforts to address it for achieving sustainable development. Providing in-depth analysis and step-by-step descriptions of environmental strategies and procedures for managing sustainability in electrical and electronic waste, is a step closer to addressing the challenges in electrical and electronic waste.

Environmental Management of Waste Electrical and Electronic Equipment, the book, is divided into four parts to discuss in-depth the Environmental Management of Waste Electrical and Electronic Equipment. First, it introduces the environmental problems of e-waste. It addresses the discharge of electrical and electronic waste or e-waste into ecosystems, occupational exposure to hazardous components of electrical and electronic waste, and loss of recoverable resources. It then moves to cover the treatment methods that could be used to recycle e-waste to recover valuable metals, these methods are said to pose less risk to human health and the environment. More emphasises is placed on the methods of treatment that are microbe-assisted for heavy metals recovery. The third part of the book focuses on providing the reader with detailed information on the environmental management strategy that is applicable for Waste Electrical and Electronic Equipment (WEEE) with a focus on the roles of socioeconomic intervention. Finally, the last part of the book takes the reader through the current sustainability paradigm followed around the globe, the current legislative laws that keep in check the illegal recycling and disposal activities of e-wastes and the state of global research on the sustainable management of WEEE.

An introductory chapter is devoted to explaining the concept of E-waste or electronic waste and discussing the major sources of e-wastes with their classification. The challenge of the growing amount of e-wastes and their management worldwide is presented with more attention in the situations of the United States, Japan, China, and India. Special emphasis is given to the discussion of the generation and management systems of China and India. The chapter also includes the international treaty, known as the Basel Convention on the Control of Transboundary Movement. Some suggestions on how to reduce e-waste accumulation are given and possible solutions using green energy in a way better to avoid major effects on e-waste are discussed. The use of clean energy for sustainable development could reduce the impact of energy production on e-waste, particularly organic solar cells will reduce the amount of e-waste to some extent. Inorganic silicon-based solar cells leave silicon substrates as e-waste, which is neither degradable nor can be reused. Silicon wafers and substrates heavily pollute the soil and if burned will have a deleterious effect on the atmosphere.

While, chapter 2 presents the extent, state and trend of global research on Waste Electrical and Electronic Equipment (also known as e-waste) in relation to the Environment (WEEEE). And seeks to find answers to questions like, what is the current state of WEEEE?; how does WEEEE management impact the environment?; what are the main agents promoting research on WEEEE?; which are the most relevant research lines in this area?; what are the main research gaps? The chapter shows that research work on WEEEE displays a growing trend that has accelerated in the last 5 years, and the progress of this line of research shows growth rates higher than those of general environmental research.

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The focus of chapter 3 is on e-waste generation in the Indian and global context, and their impact on the environment, human, and animal health. An overview of strategies practised for e-waste management and recycling for sustainable development, including some of the policy-level initiatives taken by India regarding e-wastes.

Chapter 4 begins with a discussion on the environmental, occupational and health hazards posed by the poor disposal of e-waste and further gave detailed information on the health impacts of some hazardous substances present in the WEEE. The chapter also identifies the treatment methods like landfill and incineration that have been practised over the years and their possible risks to human health and the environment. Landfill and incineration according to the chapter is the most practised treatment method despite causing high health risks. The chapter also briefly presents metallurgical processes, and treatment methods employed for the segregation of metallic and non-metallic fractions from WEEE after dismantling. Hydrometallurgy, pyrometallurgy, electrometallurgical, and biometallurgical processes, are metallurgical processes for extracting metals from WEEE. However, the chapter further expresses that none of the recovery methods is considered an eco-technique due to associated limitations with each of them. Biometallurgy involving the use of microbes is expected to be green and eco-friendly, however, it is in its early stages of research.

Biohydrometallurgical methods and the processes involved in the bioleaching of WEEE and the efficiency and eco-friendliness of biohydrometallurgy were addressed in chapter 5 by explaining the role of microorganisms in the metal dissolution and accumulation, also reporting the findings of researchers that exploited different types of organisms for the dissolution and leaching abilities under different environmental condition. In this chapter, the different metal-microbe processes that occur during the biometallurgy of e-waste are presented including bioleaching and its three methods of application, biooxidation-reduction, followed by biosorption, bioaccumulation, and bioprecipitation. The roles of each of these processes with the particular metals they are targeted towards are further discussed.

Chapter 6 identifies the core component of WEEE as a printed circuit board (PCB) comprising around 28% metallic and 72% non-metallic fractions. The writers give an overview of the hybrid bioleaching process for extraction of critical metals particularly from PCBs as the major e-waste in the treatment process. Chapter 9 further shares some microbial species in the hybrid approach and their critical metal recovery rate. The chapter also discusses the limitation of the hybrid bioleaching process including the toxicity of WEEE to the microorganisms and the huge time requirement for the process. By performing the SWOT analysis of the technique, the chapter also explores the possible application of the hybrid bioleaching technique on an industrial scale with the aim of making profits.

Chapter 7 shares the trend of e-waste generation from 2010 up to 2018, then it shares the studies regarding chemical and physical recycling methods including pyrolysis that could be particularly used for the recovery of PCB under high temperatures. The chapter also shares information on the physical method of e-waste recycling which is carried out by a mechanical process.

Chapter 8 introduces concrete and the rising environmental concern in the use of concrete. The CO_2 emission from the cement industry contributes to global warming and threatens the environment. Chapter 8 also explains the recent effort in the concrete industry to use e-wastes like cathode ray tubes (CRTs), liquid crystal displays (LCDs), plastic, and printed circuit boards (PCRs) to replace the natural aggregates and wires as reinforcement fibres in concrete. The impact of this replacement on the environment is further discussed in this chapter.

Chapter 9 gives detailed and robust information on WEEE metal composition. It also discusses the classification, toxicity, and impact of Waste PCBs. The chapter further gives insight into the bio-based technologies for recovering metallic resources from waste PCBs, in particular, bioleaching technology. The mechanisms of bioleaching and the types of microbes for bioleaching are further discussed. It presents the factors for the bioleaching including pH, oxidation ratio, pulp density, temperature and the toxicity of the waste, and their effect on the process.

Chapter 10 starts by discussing the principles of metal bioleaching together with the microbiology involved in the process. The bioprocess engineering for metal bioleaching in e-waste treatment is also presented where the type of bioreactors, their designs and their limitation in WEEE bioleaching is also presented in the chapter.

The socioeconomic aspects of WEE management particularly the importance and benefit of the optimal socioeconomic and legislative environment for WEEE recycling are discussed in chapter 11. The chapter analyses the institutional and socioeconomic ambience in the Republic of Serbia. The other section of chapter 11 analyses the socioeconomic intervention in the form of state incentives where social justification is tested by comparing the level of incentives and generated socioeconomic benefits in the area of waste refrigerators. Financial stimulation policy, a form of socioeconomic intervention, plays a role in the implementation of circular economy principles in the area of WEEE. Apart from the financial stimulation policy, while addressing the rising problem of e-waste recycling, other kinds of socioeconomic intervention in this field are analysed.

Chapter 12 reviews at length the sources of these WEEE, the current paradigm followed around the globe, the current legislative laws that keep in check the illegal recycling and disposing activities of e-wastes, and the changes that are needed to be carried out in these legislative laws that may lead to an efficient e-waste management system. The work also sheds light on the innovative approaches and systems that are already in action in different parts of the world and is also suggesting theoretical strategies and procedures that may lead to an ideal case where 99% of the total e-waste generated is efficiently neutralized, disposed of, or recycled.

Finally, the last chapter shows the state of global research on the sustainable management of WEEE and seeks to find answers to the following questions:

- Which fields regarding sustainability are being analysed?
- Who are the main agents promoting this research?
- What are the most relevant research lines in this field?
- What are the main research gaps?

To achieve this, the international research conducted in the period from 2000 to 2019 is reviewed through a bibliometric and systematic analysis.

Overall, this book is ideal for experts, researchers, and scientists who are searching for new and modern development in WEEE. It captures an inclusive impression of the environmental management of WEEE and provides the reader with a logical and expressive representation

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