

E-waste **IN INDIA**

Management, Challenges & Opportunities

Volume II

Editor

Dr. Suresh Kumar



AUTHORS P R E S S



Worldwide Circulation through Authorspress Global Network

First Published in 2022

by

Authorspress

Q-2A Hauz Khas Enclave, New Delhi-110 016 (India)

Phone: (0) 9818049852

E-mail: authorspressgroup@gmail.com

Website: www.authorspressbooks.com

E-waste in India: Management, Challenges & Opportunities

(Volume-II)

ISBN 978-93-5529-322-0

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Printed in India at Thomson Press (India) Limited




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Dedicated to
Mother and Father
Arindam Vashisht and Agastya Vashisht






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About the Editor



Dr. Suresh Kumar received his Ph.D. degree in Physics and Materials Science from Jaypee University of Information Technology (JUIT) – Wahnaghat, Solan, H.P., India in 2014. Dr. Kumar has completed M.Phil. (Physics) from VMU, Salem, T.N. in 2008, M.Ed. from Jammu University, J&K in 2007, M.Sc. (Physics) from Dr. Bhim Rao Ambedkar University, Agra, U.P., India in 2002, and B.Ed from the University of Kashmir, J&K in 2000. He is currently working as an Associate Professor in the Department of Physics, MMEC, Maharishi Markandeshwar (Deemed To Be University), Mullana, Ambala, Haryana, India. He is the author of more than 50 research articles that are published in International/National SCI/Scopus/Peer-reviewed journals and conference series. Dr. Kumar has published one Indian patent “A method for chemical solution processing of nanostructured nickel sulfide thin films and method of deposition the same” and has completed one research project. He has guided many students at the Master level and four students are doing Doctoral research work under his supervision. Dr. Kumar has 19 years of teaching experience at the undergraduate and postgraduate levels. He has dedicated himself to the cause of education and research, thus promoting and facilitating the students to use innovative techniques and tools in the process of learning, living, and protecting the environment. Dr. Kumar has research expertise in Materials Science and his current research interests include nanomaterials, II-VI group semiconductors, dilute magnetic semiconductors, photo catalysis, thin-film solar cells, wireless charging transmission, and E-waste. He has published two books entitled “E-waste: Management and Procurement of Environment”, ISBN 978-93-90588-87-9 (2021), and E-waste in India: Management, Challenges and Opportunities”, (Volume-I) ISBN 978-93-91314-55-2 (2021), Authorspress, New Delhi, India. Dr. Kumar is a Life Member of the Material Research Society of India (MRSI), Indian Society for Technical Education (ISTE), and Senior Member of the American Society for Research (ASR). He is an editorial member and regular reviewer of many reputed journals such as IOP, Elsevier, Springer, AIP, and De-Gruyter. Recently, Dr. Kumar is awarded by Rakshita Welfare Society, Bhopal, M.P., on Teacher’s Day (Sept. 05, 2021) with a Certificate of Recognition (Award for TEACHERS with INNOVATIVE Techniques during the Pandemic). Dr. Kumar has also published one poetry book “Teri Yaad Ka Dariya” ISBN 978-93-5529-269-8 (2021) sponsored by “Haryana Sahitya Akademi” under “Pushtak Protsahan Yojana 2020”. In addition, Dr. Kumar is actively associated with many social agencies that work for the welfare of society.






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Acknowledgements

“ॐ नमो नीलकण्ठाय नमः”
“Om Namo Neelkanthay Namah”

करचरण कृतं वाक्कायजं कर्मजं वा । श्रणनयनजं वा मानसं वापराधं ।
विहितमविहितं वा सर्वमेतत्क्षमस्व । जय जय करुणाब्धे श्रीमहादेव शम्भो ॥

श्रीमद् आद्य शंकराचार्य

‘Oh Lord of mercy, please forgive all my sins performed consciously or unconsciously. I request you to pardon the sinful actions committed by my hands and feet, or produced by my words spoken or deeds done. Please pardon the sinful acts committed by my senses like ears and eyes or sinful thoughts that entered my mind. Please forgive me for all sins committed while performing my duties as well as the action not explicitly prescribed. Please forgive me for all my sins. Victory to you, Mahadev, Shambho, you are the ocean of compassion’

Shrimad Adi Shankaracharya

Hearty indebtedness and obeisance to Almighty, “BHAGAWAN SHIV” who illuminate each moment of my life with happiness and bless me with enough courage and strength to complete every arduous task.

My gratitude to every luminary who has made this tough task of book publication a satisfying piece of intellectual endeavor. It is a matter of pleasure and pride to express sincere thanks to all the scholars who have contributed their valuable book chapters for this volume in a short period. I express my gratitude to reverent academicians Prof. Sanjay Kumar Sharma, Director, ICT, Gautam Buddha University, Noida, Uttar Pradesh for his valuable conversation during the compilation of the chapters. I am thankful to Dr. Jatindra Kumar Pradhan, Assistant Professor, Department of Zoology, Kalahandi University, Bhawanipatna, Kalahandi, Odisha for inspiring me to select the theme and sub-themes of this book.

I extend my love and regard to my wife, Dr. Anuradha, who took all familial onuses and spared me to toil at odd hours to finish the task timely.

I am thankful to Mr. Sudarshan Kcherry, Managing Director, Authorspress, New Delhi, and his entire team for cooperation and providing shape to my endeavor within the stipulated period.

Dr. Suresh Kumar






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Preface

Electronic waste *i.e.*, E-waste, refers to the electronic products that are not in use, are unneeded, or are nearing the end of their useful lives, is one of the rapidly growing waste streams across the globe at present. E-waste produced annually is worth over \$62.5 billion more than the GDP of most countries. According to the UN's Global E-waste Monitor 2020, the annual global production of E-waste is approximately 53.6 million metric tons (Mt) in 2019 which will exceed 74 Mt till 2030. While at present only 9.3 Mt (17.4%) of the total generated E-waste was collected and recycled globally. It means that many precious metals (gold, platinum, silver, copper, etc.) and other high-value recoverable critical materials (cobalt, palladium, indium, germanium, etc.) are worth the US \$57 billion, are dumped or burned in the E-waste every year. According to the report, Asia generated the greatest volume of E-waste in 2019 — some 24.9 Mt, followed by the Americas (13.1 Mt) and Europe (12 Mt), while Africa and Oceania generated 2.9 Mt and 0.7 Mt respectively. Besides in India, the rapidly growing population and increased disposal of electrical and electronic products have instigated serious concerns to the environment and human health. India generated 3rd highest volume of E-waste (3.2 Mt) in 2019, behind China (10.1 Mt) & the USA (6.9 Mt). However, India's per capita (2.4 kg) E-waste generation is 1/3rd the global average (7.3 kg per capita) while it is 3-times the global average in the USA. Moreover, India a country with low recycling capacity (8 lakh tonnes annually) is an indication of big loss in terms of its inability to mine precious and critical materials from the E-waste. In addition, non-collected E-waste is also serious health and environmental hazard as it contains several toxic substances. With the purpose of discretely collecting, effectually treating, and efficiently dispose-of the E-waste, and diverting it from conventional landfills and open burning, it is requisite to integrate the informal sector with the formal sector. Hence, proper E-waste management is a great challenge to all developing countries including India. It is becoming gigantic public health & environmental issue and is exponentially increasing by the day. India like other countries has framed rules and regulations, policies, and guidelines to manage the E-waste for the producers, consumers, and recyclers.

This book (Volume-II) is an anthology of scholarly articles that depicts numerous issues, challenges, prospects, and opportunities related to E-waste



management and practices within India. Volume-I of “E-waste in India: Management, Challenges and Opportunities” is already published in 2021, with ISBN 978-93-91314-55-2, which is based on different sub-themes like current affairs of E-waste in India and its future strategies, E-waste: modern-day scenario and its management, environmentally affable and economical bioleaching method for metal recovery from E-waste, an overview of E-waste status in Indian scenario, issues and opportunities associated with E-waste in India, toxicity and health hazards of E-waste, impact of spent lithium-ion batteries recycling on economy and environment, clean fuel production by the recycling of E-waste plastic, E-waste legislation and legal services in India, policies and best practices for E-waste management in India, current scenario of E-waste in India: problems and solution, E-waste: a challenge for digital India, government initiatives for E-waste management in India, issues, implications, and opportunities of E-waste in India. Volume II is providing an overview of E-waste management, issues, challenges, regulations, opportunities, initiatives, etc., in the current scenario including Indian perspectives. It explores the trends & strategies in the research & practices to mitigate the environmental problems via effective recycling tactics and the emerging potential of the circular economy. It highlights many major topics associated with E-waste such as environmental treatment, toxicity & health hazards, management, challenges and opportunities, extended producer responsibility, legislations, current best practices, advanced recycling processes, and other associated issues. This book contains valuable contributions in the form of book chapters authored by renowned and emerging researchers across the country.

Chapter 1 includes the work ‘Green Electronics for A Clean and Sustainable Future’ presented by Dr. Komal Jakhar. The rapid technological advancements and competitive market strategies encouraged electronics manufacturers to upgrade their devices to newer, faster, more energy-efficient, and fancier models. Consumeristic culture, well-planned advertisement strategies, and upgraded living standards further intensify the situation by unprecedented demand for electronic gadgets. This fastest growing waste stream of electric and electronic materials is radically dangerous for the well-being of our planet earth as it causes severe environmental pollution, climate change, depletion of natural resources, ecological imbalances, and health hazards. Green electronic technologies emerge as a cleaner and sustainable alternative to address the issue of E-waste generation and treatment. Green electronics are prepared by using non-toxic, biodegradable, recyclable, sustainable, and energy-efficient materials with an ultimate aim of benign integration between nature with technology. This chapter discusses a variety of safer and bio-metabolizable organic electronic materials of natural or nature-inspired origin for green electronic applications as substrates or insulating materials, dielectrics, semiconductors, conductors, etc.

Chapter 2 comprises a study on ‘Heavy Metals in E-waste: Its Toxicity and Health Effects’ compiled by Dr. Bijoy Sankar Boruah. It explored that increase in



population increases the demand for electrical and electrical devices. For the manufacturing of these devices, lots of metals and heavy metals are applied, however many of them are very toxic. After the end of life, these devices generate E-waste which releases heavy metals into the environment. Due to the un-biodegradable nature of heavy metals, they accumulate in an ecosystem and contaminate the food chain which causes severe health problems. Entering the cellular organism they break the molecular chain for which protein, DNA, lipid lose their normal activities. Depending upon the toxicity WHO, EPA, and ISI set the different permissible limits for heavy metals. In this chapter, various E-waste sources of heavy metals and their effect on the ecosystem are discussed.

Chapter 3 contains the 'Environmental Threat of E-waste in Indian Perspective' elaborated by Dr. Sheerin Masroor, Dr. Anil Kumar Singh and Dr. Sanjeev Rathore. In the last few decades, the electronic industry has been the world's largest and fastest-growing manufacturing industry. Almost all countries around the world are trying to reuse the waste produced so that it will not affect living things and the environment. But it has been also seen that some E-waste has their own shelf life which further cannot be taken in reuse and have to dump them forever. So, it is a requirement for that E-waste to dispose of them with extreme precautions. Abandoned E-waste mainly releases highly toxic metals, which can be easily absorbed by the soil and enter the environment chain and will further affect human and living beings' health. This chapter described the probable environmental and human health threats

Chapter 4 represents 'E-waste Challenges, Impacts Over Health and Job Opportunities in India' written by Prof. Bharat Raj Singh, Dr. Dharmendra Singh and Dr. Anoop Kumar Singh. The development of the global ICT sector has led to a rapid increase in the use of electronic gadgets and devices. The main reason for discarding old electronic devices and gadgets is their rapid upgrades and this is forcing consumers to replace them at a faster rate, resulting in piling up of E-waste, in turn, increasing the solid waste sector. This growing issue of E-waste invites more work on recycling and management. On the other as E-waste is rising and its hazardous implications also rising many health issues. Thus, opening the doors for better management, and mechanized systems on its recycling, refurbishment, and reuse to manage the growing E-waste flood. This chapter covers the type of challenges, implications on health issues as well as on fertile soil, and a new area for research towards mechanization and job opportunities about managing E-waste in India.

Chapter 5 covers the 'Initiatives by Government to Manage the E-waste' described by Dr. Ravi Kumar. ICT and systematic networking have infiltrated practically every facet of contemporary life. It improves people's lives throughout the globe, even in the most distant corners of developing nations. As a consequence, several nations today have large amounts of E-waste. Managing E-waste in



developing nations is difficult due to a deficiency of waste management infrastructure, lack of particular regulation, lack of a framework for abandoned product take-back, and lack of extended producer responsibility. E-waste production in India has surged by 2.5 times in the six years running up to 2019 and reached 3.23 Mt in 2020. Indian legislation on E-waste has been in place since 2011, making it the first South Asian country to have such legislation and introduced producer responsibility organizations, and the environmental protection agency brought in buy-back, deposit refund, and exchange programs. But despite all of this, the majority of official sector or pollution control board certified E-waste handlers face basic challenges such as high costs of handling and procurement, weak margins, and underutilization of available capacity.

Chapter 6 covers the ‘Managing India’s Solar Panel Waste: Prospects, Progress, Policies and Environmental Impact’ as explained by Swapnil J. Rajoba and Rajendra D. Kale. Energy plays a crucial role in the development, economic growth, atomization, and modernization of a country. Current conventional energy sources are depleting in nature and are responsible for emitting harmful gases. To protect the environment and fulfill the energy demand of the society additional energy sources are desirable. Currently, the Indian government experiencing severe challenges in providing a clean and sustainable energy supply to the ever-growing industries and domestic population. Compared with fossil fuel, a renewable energy source offers several benefits. Among these renewable energy sources, solar energy has gained more attention. Based on the photovoltaic principle, solar panels convert solar radiation directly into electrical energy. This chapter presents the current status of solar panels in the Indian market, classification of waste, challenges in the waste management and various recycling steps including mechanical, chemical, and thermal processes, different policies and regulations implemented by the Indian government. Such extensive study provides access to a wide range of fields like science, finance, commerce, business, and engineering.

Chapter 7 overview the ‘E-waste Management: A Big Challenge for India’ review by Dr. Madhu Kumari Gupta. A massive increase in E-waste or digital rubbish in India has created an alarming situation to take action for its management. As the reach of common people for technology have been achieved resulted in the accumulation of E-waste on a large scale. For a country like India where a large population is still not acquainted with the harmful substances used in various electronic devices and instruments discard it as landfills along with domestic waste in the locality. With the use of updated technology and less legislation in our country, the manufacturer doesn’t take responsibility for their management and safe disposal of E-waste. As a result, they use cheaper chemicals or substances which harm the environment and the lives of the people. They are engaged in money-making and dumping pollutants into our resources. Hence, in this chapter, the author draws attention to the challenges faced by the ecosystem and public when exposed to E-



waste. Besides these remedies are also discussed for minimizing the effects of E-waste.

Chapter 8 represents 'E-waste Bioremediation: A Green Revolution' described by Dr. Bhuvaneswari Manivel and Dr. M.R. Suchithra. Each year globally gigantic volume of E-waste was generated and over 1000 different chemicals are identified in the E-waste stream. Currently, E-waste generation has rapidly generated problems and its recycling is more complicated. Microbial remediation of E-waste is an emerging technology that plays a vital role by the participation of microbes to improve the process in a greener way to detoxify hazardous environmental pollutants. Management of the thermo-stable part of E-waste was bio-remediated by a microbial consortium. However, the biological methods and role of strategies were eco-friendly, economically feasible, and more advantageous; because a variety of species are analysed from distinct sites and are more efficient in E-waste control. In such a way, the chapter aims to express the current trend of the microbial consortium, striving to make this world safer. Nowadays, it is a fiery research area because microbes are eco-friendly and encouraging tools to solve environmental threats by transforming pollutants in an enzymatic way.

Chapter 9 describes 'E-waste: An Opportunity of Circular Economy in India' presented by Dr. R. Remya. Circular economy (CE) utilises the materials as far as might be feasible, diminishing the wastage at every life-cycle, and redesigns its greater worth through reusing, fixing, remanufacturing, and recovering at each service time. Electronic and electrical equipment production has relied upon gigantic material utilisation alongside uncommon earth components. The extraction of these assets is higher than the pace of its development in nature. E-waste has been regarded as the rich wellspring of auxiliary raw materials, particularly waste assortment that stays a key challenge. It requires the shift to a more circular methodology for the manufacturer, which prompts the reconciliation of circularity rule in the plan, assembling, utilisation, and ends with the life management of the items. It centers on the extended utilisation of the product, quality affirmation for the repair, adjusts progressed reusing innovation to yield optional materials from E-waste, and redesigned nature of item life span.

Chapter 10 includes the 'Environmental and Health Issues Related to E-waste Management in India' as presented by Dr. Padmakar A. Savale. E-waste, which contains hazardous components, is still handled in an environmentally unfriendly manner mainly in developing countries. The hazardous content of these materials poses a threat to human health as well as to the environment. This is a huge challenge for the countries to handle E-waste responsibly and protect the environment. In India electronic waste is produced in a huge quantity due to the modernisation of lifestyle. In addition to the technical, social, and organisational aspects of the E-waste management system, it is crucial to consider the economic aspects, if the systems have to be made financially viable and sustainable along with



being socially acceptable. This chapter highlights the issues related to E-waste disposal methods and management of E-waste. In this chapter, an approach is made towards assessing the present situation of E-waste management in India, considering the present regulations and guidelines.

Chapter 11 explores “Some Initiatives by the Indian Government for E-waste Management” an overview by Mr. Anchal Saxena. Presently, E-waste becomes a global problem and every coming year generates a huge amount of E-waste. As per records, India’s E-waste rank is 177 out of 180 countries on the Environmental Performance Index. One should aware of the initiatives which are being taken by the government in this regard and whether these initiatives are being successful in the resolution of the issues. Ministry of Electronics and Information Technology (Meity) has launched the project “Awareness Program on Environmental Hazards of Electronic Waste”. Meity has played a vital role in the propagation of knowledge on E-waste regulations. The government of India has made a provision for a separate rule like “E-Waste (Management and Handling) Rules, 2011”, training and up-skilling of workers handling and dismantling hazardous materials under the National Skill Development Mission, a point-based reward system of E-waste recycling credit (ERC) to encourage formal organizations to channel their E-waste, etc. Despite many efforts, rules, and plans are enough in the current situation for the management of the speedily increasing E-waste and its lethal impact on human life. This chapter overview some of the initiatives taken by the Indian government towards the proper disposal of E-waste for the betterment of the country.

This book brings together researchers and faculties working in different fields of E-waste and excitedly provides up-to-date information on the prevailing issues of E-waste in India.

Dr. Suresh Kumar
Editor



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