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.

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Dedicated to
Mother and Father
Arindam Vashisht and Agastya Vashisht

About the Editor

Dr. Suresh Kumar received his Ph.D. degree in Physics and Materials Science from Jaypee University of Information Technology (JUIT) – Waknaghat, 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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"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 academician 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.

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Dr. Suresh Kumar

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.

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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

Contents

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E-waste Challenges, Impacts Over Health and Job Opportunities in India

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Abstract

The development of the global information technology and communication 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 electronic (E-waste), in turn, increasing the solid waste sector. The volume of E-waste increased by 21% in the five years upto 2019, when 53.6 million metric tonnes (Mt) of E-waste was generated. For perspective, last year's E-waste can be weighing as much as 350 cruise ships was put up until the end to build a 125 km-long line. This enhancement is projected to continue as the use of computers, mobile phones, and other electronics continues to expand, with their rapid obsolescence. It is also observed that only 17.4% of the E-waste produced is reaching formal management or recycling facilities. India is the "3rd largest E-waste producer in the world"; about 3.5 Mt of E-waste has generated annually, of which about 70% is generated in computer equipment, 12% from the telecommunications sector, 8% from medical equipment, and 7% from electrical equipment (Parks, 2019). Governments, public sector companies, and private sector companies generate about 75% of electronic waste, with the individual household contributing only 16%. This growing issue of E-waste invites more work on recycling and good management of electronic waste. On the other as E-waste is rising, its hazardous implications rising health issues. Thus, opening the doors for better management, researchers, and mechanized systems on its recycling, refurbishment, and reuse in India is to manage the growing millions of tones of E-waste as India is the third-largest producer. 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.

Keywords: ITC, electronic gadgets, solid waste, mechanization, job opportunities

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Introduction

Growth in the information technology and communication (ITC) sectors has led to a rapid increase in the use of electronic equipment. The rapid upgrades of electronic products are forcing users to discard old electronic products very fast, which, in turn, add E-waste to the solid waste stream. The growing E-waste problem demands greater emphasis on E-waste recycling and better E-waste management. Electronic waste or E-waste is generated when electronic and electrical equipment becomes unfit for its original use or exceeds the expiration date (WEEE, 2019). Examples of E-waste (when unfit for use) are computers, servers, mainframes, monitors, compact discs (CDs), printers, scanners, copiers, calculators, fax machines, battery cells, cellular phones, transceivers, TVs, iPods, medical devices, washing machines, refrigerators, and air conditioners. These electronic components are increasingly replaced with new models due to rapid technological advancement and the production of new electronic components. This has led to a rapid increase in E-waste production (Figure 1). People turn to newer models and the life of the products has also become shorter.

E-waste usually consists of metals, plastics, cathode ray tubes (CRTs), printed circuit boards, cables, etc. Valuable metals such as copper, silver, gold, and platinum can be recovered from E-waste if they are processed scientifically. The presence of toxic substances such as liquid crystals, lithium, mercury, nickel, polychlorinated biphenyls (PCBs), selenium, arsenic, barium, brominated flame retardants, cadmium, chrome, cobalt, copper, and lead makes it very dangerous if E-waste is treated destroyed and processed in a crude manner by primary techniques. E-waste is a huge threat to humans, animals, and the environment. The presence of heavy metals and highly toxic substances such as mercury, lead, beryllium, and cadmium pose a significant threat to the environment, even in very small amounts.

Figure 1 E-waste Generated After Obsoleting

(source: CONS200/ The story of Canada's digital dumping ground)

Consumers are the key to better management of E-waste. Initiatives like Extended Producer Responsibility (EPR); Design for the Environment (DFE); Reduce, Reuse, Recycle (3Rs), a technology platform to connect markets to facilitate

a circular economy, aims to encourage consumers to dispose of their E-waste correctly, increase reuse and recycling rates, and adopt sustainable consumer habits. In developed countries, high priority is given to E-waste management, while in developing countries it is difficult to fully adopt or replicate E-waste management of developed countries and many related problems including lack of investment and technically skilled human resources. In addition, there is a lack of infrastructure and appropriate laws specifically to deal with E-waste. Also, there is an inadequate description of the roles and responsibilities of the stakeholders and institutions involved in E-waste management etc. In 2016, the Ministry of Environment, Forest and Climate Change (MoEFCC) issued updated E-waste (management) rules, which came into the siege of E-waste in India.

Challenges in India About E-waste Management and Recycling

E-waste, as important a task as it sounds, is not easy. This is something that has started in India in past decades and for a vast country like India, it is understandable for India to face certain challenges for the purpose of e-recycling. Challenges that include,

a) Volume of E-waste Generated

The production of E-waste at about 1.7 lakh tons per year ranked India and stood fifth. But in the year 2019, India accounted for the third-highest E-waste producer after China and U.S.A.

b) Participation of child Employment

In India, around 4.5 lakh working children between the ages of 10 and 14 are believed to be involved in various E-waste activities and without adequate protection in various campuses and rehabilitated workplaces. Therefore, there is an urgent need to bring effective legislation to prevent the entry of children in the E-waste market – its collection, classification, and distribution.

c) Unemployment Law

There is no public information on the Pollution Control Committee (PCC) in the case of most of the State Pollution Control Boards (SPCBs) or Union Territory websites for the State. Approximately 15 out of the 35 PCBs/35 PCCs do not have E-waste related information on their websites, their point being a visible public connector. The basic E-waste Rules and guidelines are also needed to be uploaded. If there is no information on their website, especially the details of recycling personnel and E-waste collectors, residents, and waste producers who are losing their garbage and do not know how to fulfill their responsibility. Therefore, e-management is a failure ineffective implementation of the Waste Management Regulations.

d) Lack of Infrastructure

There is a big difference between the current renovation and the collection of sites and the amount of E-waste that is generated. There is no collection and retrieval of items available. Recycling facilities are also lacking.

e) Health Risks

E-waste contains more than 1,000 toxic substances, which pollute the soil and groundwater. Exposure can cause headaches, irritability, nausea, vomiting, and eye pain. Recyclers can suffer from kidney and emotional problems. Out of ignorance, they risked their lives and their environment (E-waste is releasing toxic, 2018).

f) Lack of Incentive Programs

No clear guidelines exist for the management of E-waste for the informal sector. And there is no incentive to entice those involved in the legal process of E-waste management. The conditions in the informal reform sector are much worse than in the formal sector. There are no plans to encourage producers to do something to manage E-waste.

g) Negative Awareness and Empathy

Limited access and notification regarding disposal after setting an expiration date. And only 2% of people think about the impact on the environment when discarding their old electrical and electronic equipment.

h) Importation of E-waste

Import of waste equipment arriving in India – In developed countries, 80% of E-waste is exported to developing countries like India, China, Ghana, and Nigeria for recycling.

i) Decentralisation Involved

The lack of cooperation between the various authorities responsible for the management and disposal of such waste includes non-municipal participation.

j) Security Results

Lifelong computers often contain sensitive personal information and bank account information, which, if not removed, leaves room for fraud.

k) High Cost of Setting up Re-uses Space

Furthermore, the study also noted that renewable technology projects (including steel and non-ferrous metal refining) are at a major economic disadvantage compared to basic process activities and are generally not economically viable. Legal recycling

companies in India are limited to pre-processing E-waste material among others, where the crushed waste is exported to mines outside India. The formal sectors in India will still need to be utilized to use state-of-the-art waste recycling technology due to garbage collection problems and in part because of the difficulty of making a profit with high investment in high-tech and expensive technology.

l) Lack of Research

The government should encourage research into hazardous waste management, environmental monitoring, and the development of hazardous waste management and standards.

The Minister of State for Electronics and IT, Shri Rajiv Chandrasekhar informed the Parliament (Lok Sabha) on Dec. 08, 2021, that more than 3.54 Mt of E-waste was collected and processed in the financial year 2020-21, up from the previous 2.24 lakh tonnes, was excessive. In the previous year (Fig. 2). Based on the annual reports submitted by 35 State Pollution Control Boards (SPCBs)/Pollution Control Committees (PCCs) to the Central Pollution Control Board (CPCB), 22,700.33 tonnes of E-waste was collected and processed in the financial year 2016-17, 69,413.619 tonnes in the financial year 2017-18, 1,64,662.993 tonnes in the financial year 2018-19, 2,24,041 tonnes in the financial year 2019-20 and 3,54,540.7 tonnes in the financial year 2020-21.

Figure 2 Over 3.54 Lakh Tonnes of E-waste Collected and Processed in FY21 in India

End of the E-waste Generation

Electronic waste generation can't be ended as such there is no method developed for this issue so far. It can however be recycled by adapting more convenient ways and its challenges and opportunities can go hand in hand like rights and duties. Most of the time, it is noticed that whenever a challenge for the country at large develops that becomes an area of opportunity provided proper solutions are laid down for such

challenge. There is no doubt that E-waste has increased in the past decades and these numbers will go on increasing in the coming times, which opens up a huge area of opportunities for the recyclers of E-waste. Electronic and equipments are designed in such a way that they would be used for 3-4 years only and then will have to be re-cycled and the statics themselves shows that India is the 3rd largest country that generates 3.2 Mt (India, 2019) and this would increase in the coming times (Park, 2019). Some suggested solutions to the existing problems related to E-waste are:

(i) *Trained managers*: Employees want that a reputable labor team supplier shall briefly explain the expectation of the job and shall then manage the workers. This would make the employees happy so that they do a good job and keep their job. This would help to a large extent in the problem of employee retention as well.

(ii) *Domestic legal framework*: To address the deficiencies in the import of E-waste and ensure that the framework addresses the issue of importing E-waste for recycling and reuse. There is also a definite need to address the safe disposal of household waste.

- Recycling shall be tied up with take-back products.
- Investments that shall attract the re-cycling sector.
- Linking of activities of the informal sector with formal sector activities.
- Promotion of technologies for recycling, like adequate ESM technology and incorporation of precautionary principles.

(iii) *Collection depots*: As in the example of British Columbia, the actual influx of used electronic items begins at authorized collection depots. Enter contracts in over 100 locations in B.C., receiving authorized items, where they are usually tiled and folded in type (computer, television, etc.), are sent to the assembly center. Most of the B.C. Collection centers also serve as bottles and beverages that can be brought back to the centers while generating more business than the e-scrap side of the work.

(iv) *Consolidation points*: Consolidation points are a common practice in the logistics world. They allow less than load (LTL) to be integrated into full load to provide efficient transportation efficiency. In the BC model, the next step behind the collection center is the assembly center. For a company interested in this type of business integration, port departments to facilitate loading and unloading of truck handling equipment and a secure storage area for bulk products are needed. For some authorities, integration opportunities are also available.

(v) *Basic recycling*: In recycling materials, a recycling 25,000-square-foot facility with more than 100 employees, incoming debris is removed from pallets and recycled by equipment operators in the workplace and the appropriate pallet bin is packed in including areas such as circuit boards, metal, plastic, and glass. For larger companies, the need to protect reputation and credit as well as corporate confidential information is considered.

(vi) *Secondary process*: Clean items are sent to other tasks for further processing. Some of these materials, such as copper, may generate revenue for recycling raw materials, while other materials, such as glass, that will be reused will

pay for better processing. Another way to continue the release of material is the use of cutting machines, which separate the electrical debris to facilitate the release of the material. The extraction is aided by a number of filtering technologies including magnets, vibrations, optical devices, and eddy currents.

E-waste recycling is an important issue and must be dealt with caution and on an urgent basis. The government of the country shall provide the recyclers with adequate technologies and solutions to the challenges faced by them in the process of recycling.

Impact of E-waste on Human Health

Workers aiming to recover valuable materials such as copper and gold are at risk of exposure to more than 1,000 harmful substances, including lead, mercury, nickel, brominated flame retardants, and polycyclic aromatic hydrocarbons (PAHs). For an expectant mother, exposure to toxic E-waste can affect the health and development of her unborn child for the rest of her life (Brun, 2013). Potential adverse health effects include negative birth outcomes, such as stillbirth and premature birth, as well as low birth weight and height. Exposure to lead from E-waste recycling activities significantly decreased neonatal behavioral neurological assessment scores, attention-deficit/hyperactivity disorder (ADHD), behavioral problems, changes in child disposition, sensory integration difficulties, is associated with and reduced cognitive and language score. Other adverse child health effects associated with E-waste include changes in lung function, respiratory and respiratory effects, DNA damage, impaired thyroid function, and an increased risk of certain chronic diseases later in life, such as cancer and heart disease.

"Marie-NolBrune Dries, the WHO's lead author on the report, said: "A child who ate just one chicken egg from Agbogbloshi, a waste site in Ghana, was consuming 220 times the European food safety authority, last year's E-waste – weighing as much as 350 cruise ships, kept till the end to make a line 125 km long. This growth is projected to continue as the use of computers, mobile phones and other electronics continues to expand along with their rapid obsolescence. Only 17.4% of the E-waste produced in 2019 reached formal management or recycling facilities, according to the most recent GESP estimates, with the rest illegally dumped in low – or middle-income countries, where it is recycled by informal workers. Appropriate collection and recycling of E-waste are important to protect the environment and reduce climate emissions.

In 2019, daily limit of chlorinated dioxins – "Improper E-waste management is the reason. It is a growing issue that many countries do not yet recognize as a health problem (Grant, 2013). If they do not act now, its effects will have devastating health impacts on children and will put a heavy burden on the health sector in the years to come".

Figure 3 Worker's Dismantling E-waste

A Rapidly Escalating Problem

The amount of E-waste is increasing globally. According to the global e-waste statistics partnership (GESP), they grew by 21% in the five years to 2019, when 53.6 million metric tons of E-waste was generated (Figure 3). For perspective GESP found that 17.4% of E-waste that was collected and recycled appropriately prevented the release of 15 million tons of carbon dioxide equivalents into the environment.

Children and Digital Dumpsites

It calls for effective and binding action by exporters, importers, and governments to ensure environmentally fair disposal of E-waste and the health and safety of workers, their families, and communities; monitoring E-waste exposure and health outcomes; to facilitate better reuse of materials and to encourage the manufacture of more durable electronic and electrical equipment. It also calls on the health community to take action to reduce adverse health effects from E-waste, by building the capacity of the health sector to diagnose, monitor, and prevent toxic exposure among children and women, more raising awareness of the potential co-benefits of more responsible recycling, working with affected communities and advocating for better data and health research on the health risks faced by informal E-waste workers.

"Children and adolescents have the right to grow and learn in a healthy environment, and exposure to electrical and electronic waste and its many toxic components unquestionably impacts that right," said Dr. Maria Neira, Director, Department of Environment, Climate Change and Health, at the WHO. The health sector can demand that health concerns be central to E-waste policies by providing leadership and advocacy, conducting research, influencing policy-makers, involving communities, and reaching out to other sectors (Joon, 2019).

A significant proportion of the E-waste produced each year is exported from high-income countries to low- and middle-income countries, where regulation may be lacking, or where regulation exists, may be poorly implemented. Here, E-waste is dismantled, recycled, and refurbished in an environment where infrastructure, training, and environmental and health safeguards may not exist or are poorly followed. This puts E-waste workers, their families, and communities at greater risk of adverse health effects from recycling E-waste (Monica, 2010).

E-waste presents a unique exposure scenario as people are exposed to complex mixtures of chemicals from multiple sources and through multiple exposure routes. William A. Suk, Ph.D., Branch Chief of the NIEHS Hazardous Substances Research Branch said "We know the toxicities and health implications of the individual components that make up E-waste, but we need to understand how these components potentially interact to affect human health".

E-waste is often exported to developing countries where workers use primitive recycling techniques such as acid leaching and cable burning to recover gold, silver, copper, and other valuable metals. Workers at so-called informal recycling centers are directly exposed to contaminants as they destroy discarded equipment. In addition, primitive recycling practices release polyaromatic hydrocarbons, dioxins, and other hazardous byproducts into the environment. This environmental pollution exposes neighboring communities to pollutants.

The review shows that exposure to E-waste is always harmful to human health; especially in children and pregnant women. WHO, in collaboration with NIEHS and other partners, recently launched an initiative to raise awareness and advance research on this emerging health threat as to how E-waste affects children's health?

Three Scary Effects of E-waste

1) E-waste Negatively Impacts the Soil

First, E-waste can have a detrimental effect on the soil of an area. As E-waste breaks down, it releases toxic heavy metals. Such heavy metals include lead, arsenic, and cadmium. When these toxins get into the soil, they affect the plants and trees growing from this soil. Thus, these toxins can enter the human food supply, causing birth defects. As well as many other health complications (Chennai soil, 2019).

2) E-waste Negatively Impacts the Water

E-waste that is improperly disposed of by residents or businesses also leads to toxins in groundwater. It is groundwater that is at the bottom of many surface streams, ponds, and lakes. Many animals depend on these channels of water for nutrition. Thus, these toxins can make these animals sick and cause imbalances in the

planetary ecosystem. E-waste can also affect humans who depend on this water. Toxins such as lead, barium, mercury, and lithium are also known to be carcinogenic (E-waste Contaminants, 2019).

3) E-waste Negatively Impacts the Air

When E-waste is disposed of in a landfill, it is usually burned by incinerators on site. This process can release hydrocarbons into the atmosphere, which pollute the air that many animals and humans rely on. In addition, these hydrocarbons can contribute to a greenhouse gas effect, which many scientists consider to be a major contributor to global warming. In some parts of the world, desperate people sift through landfills to salvage E-waste for money. Nevertheless, some of these people burn unwanted parts such as wires to remove the copper, which can also cause air pollution (Maria, 2019).

Even though the long-term effects of E-waste are still unknown, it certainly has some negative effects on soil, water, and air quality. All these are essential parts of a healthy planet. A green E-waste recycling center can provide a disposal drop-off location for residents and pick-up service for businesses. Such centers and many others that have advanced technology and specialized technicians can do a great job of proper recycling of E-waste. These exercises will help bring the planet back to a state of equilibrium.

E-waste Job Opportunities in India

In many Southeast Asian countries, garbage collection has increasingly become a private initiative. This has accelerated waste management. In India, it is still in the hands of corporations that are slow to implement the changes. But there is immense potential for development as far as engineering of the sites; organized methods of trapping and recycling methane are concerned.

Career Prospects

E-waste management is a niche area in the West. There are many organizations that have done well by specializing in this field. Professor Anjan Raychaudhuri, Center for Entrepreneurship Development, IIM Calcutta says, "Environmental management and engineering is a well-established stream in the West. It is far less developed in India and the main thrust comes from NGOs and individuals concerned about the environment. The government seems rather slow in legislation and taking concrete steps. The young are, however, conscious of this emerging career prospect and are thinking closely on these issues. We have had a student who successfully runs an organisation that reduces energy waste while various groups have made plans for setting up ventures in the recycling of urban waste".

Courses on Offer

While there are no formal courses available specifically on E-waste management, there are diploma courses in waste management that cater to this area of specialisation as well. At IIMC, many elective courses touch the field. Center for Environmental Studies has a very interesting syllabus on "Environmental Challenges in India' that covers all the aspects of dealing with waste. The public policy group also offers a course on urban management. There are also courses on entrepreneurship in NGOs, which cover initiatives in this area," says Raichaudhuri.

UNESCO has an academic program in this area, while many universities in the UK and US offer specialisations. Those with technical degrees like BE/B.Tech or ME and M.Tech can also pursue a course on environmental engineering or environmental management. Others can consider a BSc in Environmental Science or a Doctorate of Philosophy in Eco-Sustainability and Hazardous Waste Management. An added advantage would be a course on entrepreneurship if one is interested in going in for their own venture/NGO. A fresher wanting to join the industry can expect a minimum salary of Rs 15,000 and above. Those working on their own can also hope to earn something between Rs 20,000 and Rs 35,000 per month, while those with technical degrees can look at anything between Rs 30,000 and Rs 50,000.

In making the E-waste management industry, it can tackle environmental issues while generating employment and revenue. Therefore, everyone who falls in the GenY category can think beyond the white-collar job; and do their bit to make the environment better. They can do this not only by participating or deliberating at conferences and speech competitions but by taking initiatives to challenge carbon footprints. After all, managing a career and pursuing your passion can be the right combination.

Half Million Jobs in India by 2025

The E-waste sector will generate 4.5 lakh direct jobs by 2025 and 1.8 lakh jobs in the allied sectors of transportation and manufacturing, according to the International Finance Corporation (IFC), a member of the World Bank Group. IFC, which has been working in the E-waste sector since 2012, under a program launched by it in 2017, has collected over 4,000 metric tonnes of E-waste from citizens and corporations and recycled responsibly under the program is gone (Figure 4).

Environment Ministry official Sonu Singh while praising IFC at the conference on 'E-waste Management in India: The Way Forward' said that the government is happy to see IFC's commitment in developing the sector in a responsible manner (Singh, 2017).

Figure 4 Need of E-waste Management

- The E-waste sector has significant potential to contribute to the country's economy and generate employment. The power and electronics industry is collaborating with the government and has taken a lot of initiatives to handle E-waste responsibly.
- If the responsibility is shared between the government, producers, and consumers of E-waste, efficient management of E-waste can be successfully achieved in India. "We are delighted to see IFC's commitment to helping this sector grow in a responsible manner," said Singh, Joint Director, Hazardous Substances Management Division, Ministry of Environment.

Electronic waste or E-waste is thrown to electrical or electronic equipment. Used electronics destined for reuse, resale, disposal, recycling, or disposal are also considered E-waste.

Conclusion

From the study of the above chapter, we can find that E-waste has three scary effects:

1) Affects the soil because of its harmful effect on the soil of an area. When E-waste breaks down, it releases toxic heavy metals.
2) Affects water when E-waste is not properly disposed of by residents or businesses, allowing toxins to enter groundwater.
3) Affects the air, when E-waste is disposed of in a landfill, it is usually incinerated by incinerators on site.

Soil, water, and air are the basic needs of survival of life. It should be addressed properly on the one hand and on the other hand, E-waste recycling should be handled scientifically and systematically so that the process generates employment

opportunities for the development of the nation. It is very likely that the electronic waste sector in India will generate 4.5 lakh direct jobs and another 1.8 lakh jobs by 2025 in allied sectors of transport and manufacturing.

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