

E-WASTE

Impact, Disposal and Recycling

Editor

Dr. Suresh Kumar



AUTHORS P R E S S

Worldwide Circulation through Authorspress Global Network
First Published in 2024

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: Impact, Disposal and Recycling

ISBN 978-93-6095-258-7

Copyright © 2024 Dr. Suresh Kumar (Associate Professor), Department of Physics, MM Engineering College, Maharishi Markandeshwar (Deemed to be University), Mullana, 133 207, Ambala, Haryana, India. E-mail: sureshlakhanpal@gmail.com; Mobile: +91-9466739929

Concerned authors are solely responsible for their views, opinions, policies, copyright infringement, legal action, penalty or loss of any kind regarding their articles. Neither the publisher nor the editor will be responsible for any penalty or loss of any kind if claimed in future. Contributing authors have no right to demand any royalty amount for their articles.

Printed in India at Thomson Press (India) Limited

Preface

The world's fastest-growing waste stream at the moment is electronic waste, which is produced by electronic items that have reached the end of their useful lives. E-waste produced annually is worth over \$62.5 billion more than the GDP of most countries. E-waste is growing by an average of 2 million metric tons (Mt) per year and approximately 347 Mt of unrecycled E-waste is accumulated on the earth at present. According to the UN's Global E-waste Monitor 2022, the annual global production of E-waste was 57.4 Mt in 2021 while only 17.4% (9.98 Mt) of the total E-waste was collected and recycled globally. It means that many precious metals (gold, copper, silver, platinum, etc.) and other high-value recoverable critical materials (cobalt, palladium, indium, germanium, tin, etc.) worth US \$57 billion, dumped or burned as trash every year. However, some efforts are initiated by many nations seriously to recover precious materials from the junk of E-waste. In 2020, the E-waste recycling market was valued at \$49,880 million and is projected to almost triple to \$143,870 million by 2028. In addition, non-collected E-waste is also a serious health and environmental hazard as it contains several toxic substances. With the purpose of discretely collecting, effectually treating, and efficiently disposing 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 a gigantic public health and environmental issue and is exponentially increasing by the day. Several countries have framed rules and regulations, policies, and guidelines to manage the E-waste for the producers, consumers, and recyclers. This book will be an anthology of scholarly articles devoted to different issues, challenges, prospects, and opportunities related to E-waste management and practices in the context to India. Besides in India, the huge 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), after the top two countries China (10.1 Mt) and the USA (6.9 Mt). However, India's per capita (2.4 kg per capita) 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. Nevertheless, India a country with a 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 and

simultaneously release hazardous constituents that impose severe threats to the environment and mankind.

The main objective of this scholarly anthology “E-WASTE: Impact, Disposal & Recycling” is to instigate genuine research works for evocative insight into the considerable content of E-waste and to facilitate the dissemination of knowledge among academicians, researchers, and entrepreneurs. This anthology of scholarly articles includes considerable content on E-waste like current scenarios, management, policies & best practices, issues, implications & opportunities, toxicity & health hazards, severe environmental threats, challenges & prospects, advancements in recycling, extended producer responsibility, opportunity in the circular economy, money out of waste, care for clean to green, Indian perspectives, initiatives of government; environment & health impact; methods of extractions, etc., and other associated issues. This book contains valuable research contributions in the form of book chapters authored by renowned and emerging researchers across the country.

Chapter 1 explores the work ‘E-waste: Environment & Health Impact’ compiled by Ms. Neeru Devi, Ms. Sunita Khatkar and Dr. Satish Kumar. Nowadays, massive amounts of electrical and electronic devices are produced worldwide and it is growing as a major concern for the environment after their use. E-waste is regarded as hazardous containing toxic elements of barium, lithium, polybrominated flame retardants, lead, mercury, and cadmium. Our ecosystem and public health are at risk due to the hazardous elements. Its poisonous emissions combined with uncontaminated soil and the atmosphere had negative effects either directly or indirectly on the entire environment. The current chapter analyzes the effects of E-waste disposal on the environment and human well-being. A clean environment is brought about by creating eco-design equipment, gathering E-waste, and safely disposing of it.

Chapter 2 comprises a study on ‘Government Initiatives for E-waste Management in India’ compiled by Dr. Preety Aneja. This chapter investigates the various initiatives undertaken by the Indian Government to address the burning issue of E-waste and highlights the key milestones in the journey towards sustainable management. A study on the pivotal role of the E-Waste (Management) Rules, 2011, 2016, 2018, and 2022, including their amendments in July 2023 and latest in March 2024 is presented. The government’s establishment of E-waste management centers across the country to facilitate the collection, segregation, and recycling of it is presented. To create awareness and invoke behavioral change among individuals, businesses, etc., several campaigns and awareness programs launched by the Government are also discussed.

Chapter 3 contains the ‘Impacts of E-waste, Its Recycling for Economic Development’ elaborated by Dr. Heena Gupta. With the rapidly growing technological industries, electronic devices and gadgets; the manufacturing of E-

waste has also been increasing day by day. Various unsound activities like dumping of discarded products on land or in water bodies, and combustion of non-biodegradable plastic coatings of electronic gadgets are considered harmful to the ecosystem including living beings and climate as they release toxic particles. During manufacturing, reprocessing and disposal of electronic products, various hazardous materials are released into the air leading to air pollution. The leaching of poisonous industrial effluent into underground aquifers damages the water quality and makes them unfit for drinking as well as for any other agricultural purposes. The present analysis of manufacturing, usage, processing and reprocessing of e-devices suggests that numerous hazardous materials are being released into the air which can have irreversible damage to mankind and the environment.

Chapter 4 explores the 'Management, Challenges and Role of Recycling for E-waste' written by Dr. Aparna M. Pawar, Dr. Suhas N. Patil, and Dr. Ghanashyam B. Bhagat. E-waste has occurred as a demanding global concern due to the escalating proliferation of electronic devices and their rapid obsolescence. The impact of E-waste on the environment and human health is characterized by the existence of hazardous or toxic materials, posing a significant threat to ecosystems. This chapter provides a concise overview of multifaceted aspects of E-waste, encompassing its environmental and human health impact, methods of disposal and the imperative role of recycling in mitigating adverse consequences. The essential role of consumer awareness in fostering responsible E-waste management education campaigns and the integration of recyclability in product design are highlighted as essential components in promoting sustainable practices at both individual and industrial levels.

Chapter 5 covers the 'E-waste Recycling and Methods of Metal Extraction' as explained by Ms. Sunita Khatkar, Ms. Neeru Devi and Dr. Santosh Kumar Dubey. Dumping and disposing of waste into water bodies is one of the main causes of water pollution. E-waste is one of the wide streams that is estimated to be expanding the fastest in the world among all other waste types. Because E-waste comprises hazardous constituents when it corrodes from any physical or chemical source or is exposed to intense UV radiation, these materials may leak into the surrounding soil, water bodies, and atmosphere, endangering public health. Recycling of E-waste has many advantages beyond safeguarding the environment and public health. However, a numeral of existing tasks is stopping the electronic recycling industry from climbing up. In this chapter, the authors explore how E-waste recycling is done and why we should concentrate on scaling it up. How, we can extract precious metals, renovating E-waste pollution threats into metal resources thereby increasing the income and budget of the country?

Chapter 6 overviews the 'Biochemical Hazards Associated with E-waste Generated Organic Pollutants' review by Dr. Komal Jakhar. The lifespan of the majority of electronic gadgets is constantly decreasing as a result of swift innovations

and upgradation in equipment features and capabilities. The unsystematic disposal and recycling of electric and electronic waste led to the generation of several hazardous chemicals, causing adverse environmental consequences. A comprehensive evaluation of the prevalence and negative impact of toxins derived from E-waste is urgently required to restore environmental integrity and facilitate global, economic, and societal progress. The highly persistent organic contaminants released from E-waste are characterized by their resistance to degradation, extended environmental persistence, and intercontinental migration. They extensively pollute the air, water, and soil resources and exert long-term and severe biochemical effects on plants, insects, birds, animals, and humans through biotoxicity, bio-persistence, and bio-amplifications. This chapter highlights the toxicity hazards of the dirty dozen on living beings and suggests plausible preventive measures for judicial e-waste management to mitigate their generation and exposure.

Chapter 7 represents 'E-waste: Care for Clean to Green' described by Ms. Komal Bharti, Dr. Vijay Kumar and Dr. Surender Kumar. The pollution in our living environment is getting worse, not just because of the quantity of resources being used more carelessly, indiscriminately, and excessively. Daily garbage is not collected, categorized, or disposed of properly or handled under regulations. The majority of electronic garbage is collected through facilities for spontaneous collection or collectors and is gathered to craft villages for recycling. These recycling facilities are small, most of them harm the environment and the health of their employees and are dirty, filthy, and lacking in contemporary technology. Consequently, investment policies, loan and technology incentives, and other measures are required for formal dismantling and recycling facilities with full recovery and recycling capabilities. The creation of an international framework for the treatment of hazardous waste, which includes the management and tracking of waste transportation operations to determine the origin and destination of hazardous waste sources, is currently the primary issue that has to be resolved.

Chapter 8 describes 'E-waste Management through EPR: A Comprehensive Review' presented by Dr. Chhavi Kiran and Ms. Zeenat Madan. Technological advancements across the globe have opened multiple gateways in different industries. But it has also led to the growth of heaps of E-waste across the globe. The major concern related to E-waste is its management. Different strategies like incineration, recycling, landfilling, and exporting are being adopted for management of the E-waste. However, all these strategies have implications for the environment and the health of stakeholders involved in the process. Consequently, the Governments of different countries have been making efforts to address the concerns. One of the solutions proposed for it is in the light of Extended Producer Responsibility (EPR). The EPR concept aims to ensure that a discarded E-waste product is dealt well with after it completes its life cycle. The current chapter assesses the different possible EPR approaches and their systems which can be implemented well in different nations.

Chapter 9 includes the ‘E-waste: Eco-Health Impacts, Challenges, and Recycling Innovations’ as presented by Dr. M. Malarvizhi, Ms. R. Ramya, Mr. R. Savith Krishnan and Dr. G. Suganthi. This chapter examines the most recent advances in science and technology related to electronic garbage. This study explores the harmful effects of E-waste on ecosystems and human health, emphasizing the need for sustainable practices to mitigate environmental and human impact. The chapter discusses novel disposal strategies and gives insight into environmentally friendly options that solve the issues provided by traditional disposal processes. This chapter is an invaluable resource for scholars, policymakers, and industry professionals, providing insights into the most recent advancements in global E-waste management and mitigation. This study focuses on typical E-waste disposal methods like landfilling and incineration, highlighting environmental and societal issues such as soil and water contamination, air pollution, and resource inefficiencies.

Chapter 10 explores ‘Navigating Depths: Challenges & Strategies in Seawater E-waste Management’ an overview by Ms. Kavitha Datchanamoorthy, Dr. B. Padmavathi, and Mr. Thivagar M. This chapter examines the challenges associated with seawater E-waste management and explores potential strategies to mitigate its adverse impacts on marine ecosystems. Firstly, the chapter delves into the environmental hazards posed by improper disposal of E-waste in seawater, including contamination of marine habitats, ingestion by marine organisms, and the release of hazardous chemicals into the aquatic environment. Next, the chapter represents various strategies for addressing seawater E-waste management challenges. In conclusion, effective management of seawater E-waste presents complex challenges that require coordinated action at the global, regional, and local levels. By implementing a combination of regulatory, educational, technological, and community-based initiatives, it is possible to mitigate the environmental impacts of E-waste on marine ecosystems and move towards a more sustainable approach to electronic consumption and disposal.

Chapter 11 covers the ‘Unlocking Wealth: Comprehensive Guide to Gold Recovery from E-waste’ represented by Dr. Swapnil J. Rajoba, Dr. Sachin B. Kulkarni, Dr. Vijay S. Mohite and Dr. Rajendra D. Kale. The extraction of gold from E-waste presents a multifaceted endeavor encompassing environmental, technological, and economic dimensions. This chapter provides a comprehensive overview of the methods, challenges, and implications associated with the recovery of gold from E-waste. Gold recovery from E-waste primarily relies on chemical processes designed to dissolve the precious metal from electronic components while leaving other materials intact. Technological innovations play a pivotal role in advancing E-waste recycling practices, enhancing efficiency, and sustainability. Despite its potential benefits, the recovery of gold from E-waste faces several challenges and considerations. Regulatory compliance, particularly regarding the handling and disposal of hazardous chemicals, imposes stringent requirements on E-waste recycling facilities.

Chapter 12 Overview of the ‘Advanced Techniques in E-waste Recycling: Manual to High-Tech Solutions’ review by Mr. Gautam Shekhar Kamat, Dr. Vishal Hareshgiri Goswami and Mr. Sanket Amrutlal Mistry. The escalating volume of E-waste worldwide necessitates innovative and efficient processing techniques to manage and recycle these materials sustainably. This chapter provides a comprehensive analysis of the evolution and advancements in E-waste processing techniques, focusing on the transition from manual dismantling to sophisticated, high-tech recycling solutions. It begins with an overview of traditional manual dismantling practices, highlighting their benefits in terms of employment and the ability to salvage working parts for reuse, alongside the significant health and safety challenges faced by workers in low-regulation environments. The chapter delves into the specifics of mechanical separation techniques, including the use of magnets, eddy currents, and Trommel screens, to efficiently sort metal and plastic fractions for recycling, thereby reducing environmental impact through meticulous containment and treatment of hazardous emissions.

Chapter 13 contains the ‘E-Waste in Indian Perspectives’ elaborated by Dr. Nupur Gupta and Dr. Mandeep Kaur Sandhu. E-waste presents a rapidly escalating environmental and health challenge in India. Driven by the swift adoption of technology and increasing consumerism, India stands as one of the world’s leading producers of E-waste. The informal sector dominates the management of this waste, employing rudimentary and hazardous methods that pose severe threats to human health and ecological systems. This chapter examines the volume of E-waste generated in India, the dominant contributors, and the prevalent disposal practices. This chapter offers an in-depth look at how India manages electronic waste. It examines the challenges posed by the widespread use of technology and explores how cultural attitudes influence E-waste disposal. Furthermore, the chapter highlights innovative initiatives and community-driven approaches aimed at addressing the E-waste challenge in India.

Chapter 14 contains the ‘Toxicity Concerns of E-waste of Lithium-ion Batteries’ elaborated by Dr. Komal Jakhar. Advancements in solid-state batteries are spurred by rising demand for portable electronics. Because of its superior energy density, lightweight construction, and extended lifespan over alternative technologies, lithium-ion batteries (LIB) are the favored option in electronic devices. Because of the rapid advancement in electronic gadgets and capability upgrades, most electronic devices have a declining lifespan. The global emergence of digital societies worsened the issue due to fast urbanization, modernization, and astute business practices. The present study explores toxicity concerns of LIB technology and their recycling methods. The use of eco-friendly recycling methodologies facilitates proper utilization, safety, and sustainability in LIB applications.

Chapter 15, an additional chapter, covers the ‘Measure of Spent Nuclear Fuel in Dry Sealed Casks by Muon Tomography’ represented by Dr. Sonali Bhatnagar. E-waste, a rapidly growing waste in our country with many heavy metals introduced

into the atmosphere, is less fatal as compared to the nuclear radioactive waste generated by nuclear power plants. This article summarizes different methods to detect the radioactive waste from these nuclear plants and their disposal. The different nuclear waste materials are described along with Monte-Carlo-based simulations of the detection methods. The parameters are studied and the simulation results based on Geant4 have been presented. The muon scattering, energy loss and radiation length have been calculated. The present and future status of decommissioning of nuclear power plants around the globe is also discussed.

This book brings together academicians and researchers who specialize in various aspects of E-waste and enthusiastically presents up-to-date information on various issues related to E-waste that are currently plaguing the world.

Dr. Suresh Kumar
Editor

Contents

<i>About the Editor</i>	7
<i>Acknowledgements</i>	9
<i>Preface</i>	11
1. E-waste: Environment & Health Impact Neeru Devi, Sunita Khatkar, Satish Kumar	21
2. Government Initiatives for E-waste Management in India Preety Aneja	33
3. Impacts of E-waste, Its Recycling for Economic Development Heena Gupta	50
4. Management, Challenges and Role of Recycling for E-waste Aparna M. Pawar, Suhas N. Patil, Ghanashyam B. Bhagat	64
5. E-waste Recycling and Methods of Metal Extraction Sunita Khatkar, Neeru Devi, Santosh Kumar Dubey	76
6. Biochemical Hazards Associated with E-waste Generated Organic Pollutants Komal Jakhar	90
7. E-waste: Care for Clean to Green Komal Bharti, Vijay Kumar, Surender Kumar	104
8. E-waste Management through EPR: A Comprehensive Review Chhavi Kiran, Zeenat Madan	113
9. E-waste: Eco-Health Impacts, Challenges, and Recycling Innovations M. Malarvizhi, R. Ramya, R. Savith Krishnan, G. Suganthi	125
10. Navigating Depths: Challenges & Strategies in Seawater E-waste Management Kavitha Datchanamoorthy, B. Padmavathi, Thivaghar M	152
11. Unlocking Wealth: Comprehensive Guide to Gold Recovery from E-waste Swapnil J. Rajoba, Sachin B. Kulkarni, Vijay S. Mohite, Rajendra D. Kale	163

12. Advanced Techniques in E-waste Recycling: Manual to High-Tech Solutions	177
Gautam Shekhar Kamat, Vishal Hareshgiri Goswami, Sanket Amrutlal Mistry	
13. E-Waste in Indian Perspectives	194
Nupur Gupta, Mandeep Kaur Sandhu	
14. Toxicity Concerns of E-waste of Lithium-ion Batteries	220
Komal Jakhar	
15. Measure of Spent Nuclear Fuel in Dry Sealed Casks by Muon Tomography	233
Sonali Bhatnagar	
<i>Contributors</i>	241

Contributors



Ms. Neeru Devi completed her M.Sc. in Chemistry from Baba Mast Nath University, Rohtak, Haryana, in 2016. She is currently a Ph.D. student under the guidance of Dr. Satish Kumar at Kurukshetra University, Kurukshetra. Her research focuses on the physicochemical properties of modified polymers.



Ms. Sunita Khatkar completed her M.Sc. in Chemistry from Baba Mast Nath University, Rohtak, Haryana, in 2017. She is currently a Ph.D. student under the guidance of Dr. Santosh Kumar Dubey at Kurukshetra University, Kurukshetra. Her research focuses on the synthesis and biological activity of metal complexes.



Dr. Satish Kumar completed his school education from Jawahar Navodaya Vidyalaya, Rewari, Haryana. Post graduation and doctorate from the Department of Chemistry, Kurukshetra University Kurukshetra, Haryana, India. He has 17 years of teaching experience for UG and Int. PG courses. His research work is on thermal degradation kinetics of modified cellulose, synthesis, and physicochemical investigations of modified cellulose, Chitin, chitosan, polyacrylate latex, and other polymer derivatives. He published more than 15 national and international research papers including articles and 2 chapters in books. He has completed 2 minor research projects sponsored by KUK, Kurukshetra.



Dr. Preety Aneja is serving as an Assistant Professor in the Department of Physics, DAV College, Jalandhar. She completed her Ph.D. in Physical Sciences from the Indian Institute of Science Education and Research (IISER), Mohali in the year 2015. She has 9 years of experience in teaching and research. Her main research interests are Theoretical Physics, Statistical Physics and Thermodynamics, Condensed Matter Physics, Bio-

Physics, etc. She has 10 publications in National and International journals.



Dr. Heena Gupta is serving as an Assistant Professor in the Department of Applied Science, G.L. Bajaj Institute of Technology and Management, Greater Noida. She has done her education at Maharshi Dayanand University, Rohtak, Haryana. She has 10 years of experience in teaching and research. She was awarded with a Gold Medal for her excellent work throughout the PhD. She has 15 national and international journal publications in SCI/Scopus and 2 book chapters. She has handled 2 projects with funds from DST.



Dr. Aparna Madhukar Pawar is Assistant Professor in the Department of Electronics, Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati. Dist. Pune (India). She obtains Bachelor degree in Electronics from Shivaji University, Kolhapur. Master and Ph.D. in Electronics from Solapur University, Solapur. Her area of research is the Wireless Sensor Network and IoT design, Embedded Systems, and Instrumentation designing. More than 26 national and international journal research paper publications, more than 30 national conferences, 10 international conferences publications, 4 book publications and 02 patents to her credit with more than 230 citations. She is working as Editorial Board of the i-manager's Journal on Embedded Systems (JES) and a reviewer for the International Journal of Engineering and Research & Technology.



Dr. Suhas Namadev Patil is Assistant Professor in the Department of Electronics, Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati. Dist. Pune (India). He obtains Bachelor degree in Electronics from Shivaji University, Kolhapur. Master and Ph.D. in Electronics from Solapur University, Solapur. His area of research is Embedded Systems, Instrumentation designing, and Sensor development. He works as a UGC project fellow. More than 31 national and international journal research paper publications, more than 40 national conferences, 14 international conference publications, 4 book publications and 02 patents to his credit with more than 170 citations. He is working as a reviewer for the Journal of Emerging Technologies and Innovative Research, an Editorial Member of the Edwin Group of Journals, Reviewer of International Journal of Engineering and Research & Technology, an Editorial Board of i-manager's Journal on Embedded Systems (JES), reviewer Journal on Circuits and Systems (JCIR).



Dr. Ghanashyam Bhimarao Bhagat is Assistant Professor and Head Department of Electronic Science, Shri Sadguru Gangageer Maharaj Science, Gautam Arts and Sanjivani Commerce College, Kopergaon, Dist. Ahmednagar, Maharashtra, India. 423601. His area of research is Embedded

System, Instrumentation designing, and Wireless Sensor Networks. He has published 07 research papers in National and International journals.



Dr. Santosh Kumar Dubey completed his basic schooling from NE Railway School Gorakhpur. After completing B.Sc. Chemistry from DDU Gorakhpur University he joined APS University Rewa for M.Sc. He has completed a Ph.D. Chemistry in 2008 from the Institute of Science, Banaras Hindu University, Varanasi. He was awarded Dr. D.S. Kothari Post-Doctoral fellowship from UGC and worked at the University of Delhi from 2008-2010. He joined in 2010 as an Assistant Professor of Chemistry in the Institute of Integrated & Honors Studies, Kurukshetra University. He is a life member of CRSI and the Indian Science Congress and published several research papers and book chapters on his credit.



Dr. Komal Jakhar completed her M.Sc. Chemistry from M. D. University, Rohtak, Haryana in 2004. She has completed her Ph.D. in chemistry from M. D. University in 2010. She is presently working as an Associate Professor in the Department of Chemistry M.D. University, Rohtak, Haryana. She is an organic chemist and published many research papers in national and international journals. She is a life member of the Indian Science Congress Association and The Indian Thermodynamic Society.



Ms. Komal Bharti is serving as a research scholar in the Department of Chemistry under the guidance of Dr. Surender Kumar at the Institute of Integrated & Honors Studies, Kurukshetra University, Kurukshetra. She specializes in Organic chemistry and completed her M.Sc. from M.L.N. College, Yamuna Nagar (KUK), in 2017. Her research focuses on the synthesis of novel 1,2,3-Triazoles bearing nucleosides.



Dr. Vijay Kumar is working as an Assistant Professor in the Department of Physics, Institute of Integrated & Honors Studies (IIHS), Kurukshetra University. He has 12 years of teaching and Research experience. He has published 40 research papers in International and National journals and 07 book chapters. His areas of research include ion beam-induced modifications in polymers, Lead-Free Ceramics, Energy Storage and Energy Harvesting Devices.



Dr. Surender Kumar works as an Assistant Professor in the Department of Chemistry, Institute of Integrated & Honors Studies (IIHS), Kurukshetra University, Kurukshetra. His field of specialization is heterocyclic and nucleoside chemistry. He has 20 years of research experience and published more than 20 research articles in various reputed international journals. He has also

completed two research projects including one major project sponsored by SERB, Department of Science & Technology, New Delhi of worth 21.4 lakhs.



Dr. Chhavi Kiran is serving as an Assistant Professor in the Department of Commerce, Sanatan Dharma College, Ambala Cantt., Haryana. She is a Gold Medalist in M.Com (Hons.) from UBS, Panjab University, Chandigarh. Dr. Kiran completed her doctoral thesis on the topic 'Behavioural Analysis of Consumers towards Electronic Waste Management in Tricity'. She has delivered more than 30 sessions on the topic of 'Electronic Waste Management', 'Online Collaborative Google Tools', 'E-Content Development' & '21st Century Life Skills'. She has attended more than 65 National and International FDPs, workshops and Seminars. She has 25 papers and chapters published to her credit.



Ms. Zeenat Madan is currently working as an Assistant Professor in the Department of Zoology at Sanatan Dharma College, Ambala Cantt. She has 17 years of teaching experience. She is M.Sc (Gold Medalist), M.Phil and CSIR-NET qualified. She has done her Masters from Punjab Agricultural University, Ludhiana. She has published many research papers in National and International Journals and has presented several papers at many conferences. She has done tremendous work in the field of Environment Conservation and Waste Management for which she has been awarded by many recognized bodies.



Dr. M. Malarvizhi is serving as an Assistant Professor in the Department of Physics, K S Rangasamy College of Technology, Tiruchengode, Namakkal, Tamil Nadu India. She has 16 years of experience in teaching and research. She is specialized in energy storage materials from biomass for supercapacitors. She has three national and 7 international journal publications; 1 book chapter; 2 patents to her credit.



Ms. R. Ramya received a B.E. degree in Electronics and Communication Engineering from K.S.R College of Engineering, Tiruchengode in 2010 and a Master of Engineering degree in Applied Electronics, K.S. Rangasamy College of Technology, Tiruchengode in 2012. She is currently working as an Assistant Professor at K.S. Rangasamy College of Technology, Tiruchengode and doing Ph.D. research work in the faculty of

information and communication engineering under the guidance of Dr. P. Kumar. Her research areas include image processing, Machine learning, deep learning and IoT. She is a life member of ISTE. She has 12 National and International conference publications and 5 Journals.



Mr. R. Savithkrishnan is pursuing a third-year B.E. in Mechatronics Engineering at K.S. Rangasamy College of Technology, Tiruchengode, Namakkal, Tamil Nadu, India. He has 2 year of experience in Graphical Design. He specializes in the Internet of Things (IoT) and Machine Learning (ML).



Dr. G. Suganthi is serving as an Associate Professor in the Department of Physics, Government College of Engineering, Dharmapuri, Tamil Nadu India. She has 14 years of experience in teaching and research. She is specialized in molecular spectroscopy. She has three national and 4 international journal publications to her credit.



Ms. D. Kavitha (Kavitha Datchanamoorthy) received a B.E (Computer Science and Engineering) degree from Periyar Maniammai College of Technology for Women, Bharathidasan University in 2000 and M.Tech (Information Technology) from Sathyabama University in 2009. She has 12 years of teaching experience on both undergraduate and postgraduate levels and 4 years of industry experience. She is pursuing a Ph.D from

Anna University in the field of NLP. Currently, she is working at Easwari Engineering College, Ramapuram, Chennai as an Assistant Professor in the Department of Computer Science and Engineering. Her technical research interests include Natural Language Processing, data mining, data analytics and security. She also would like to learn and practice academic-related teaching methodologies, ICT and Assessment tools and evaluation metrics in higher education.



Dr. B. Padmavathi received a B.E (Computer Science and Engineering) degree from Madras University in 2004, an M.E (Computer Science and Engineering) from Anna University in 2009 and a Ph.D degree from Sathyabama Institute of Science and Technology under the Faculty of Computer Science and Engineering. She has 19 years of teaching experience on both graduate and post-graduate levels. She is currently working as an Assistant Professor in Easwari Engineering College, Ramapuram, Chennai in the Department of Computer Science and Engineering. Her technical research interests include

Artificial Intelligence, Machine Learning, Big data and Data Analytics, and Network Security.



Mr. Thivaghar M (Thivaghar Manoharan) Currently pursuing a B.E (Computer Science and Engineering) at Easwari Engineering College (2022-2026). He is an Enthusiastic Software Engineering Student with a strong foundation in programming and problem-solving. Dedicated to continuous learning and staying current with industry trends. Eager to apply theoretical knowledge in practical, real-world scenarios

and contribute to innovative software solutions. Proven ability to collaborate in team environments, adapt quickly to new technologies, and deliver high-quality code. He is dedicated and also has a strong interest in learning and practicing Full Stack Development.



Dr. Swapnil Jinendra Rajoba received his Bachelor's and Master's degrees in Physics from Shivaji University, Kolhapur and the University of Pune, Pune, Maharashtra (India) respectively. He obtained his Ph.D. degree in Physics from the Shivaji University, Kolhapur, India. After working as a Senior Research Fellow, on the Board of Research and Nuclear Science (BRNS), funded project. He is a life member of IAPT. He is

serving as an Assistant Professor in the Smt. Kasturbai Walchand College of Arts and Science, Sangli, Maharashtra (India). His research interest includes the development of electrode materials for lithium-ion batteries and supercapacitors. He has 11 International and 3 National journal publications to his credit.



Dr. Sachin B. Kulkarni (Dr. Sachin Babasaheb Kulkarni) received his Bachelor and Master degrees in Physics from Shivaji University, Kolhapur, Maharashtra (India). He obtained his Ph.D. degree in Physics from the Shivaji University, Kolhapur, India. He worked as Junior Research Fellow and Senior Research Fellow on UGC funded major research project at Rajaram College, Kolhapur. He was post-doctoral fellow at Yonsei University, Seoul, South Korea for two years. Currently,

he is working as Assistant Professor in Physics and Director of Centre for Innovative and Applied Research (CIAR) at Tuljaram Chaturchand College, Baramati, Maharashtra (India). He is the recipient of Early Career Research Award (ECRA) scheme with major research project funded by Science Engineering and Research Board (SERB) New Delhi, India. He is listed in World Scientist and University Rankings by AD Scientific Index since year 2021 up till now. His research interest includes the development of nano-structured electrode materials for Supercapacitors, Batteries and Energy storage/production. He has more than 20 international journal publications and 04 patents to his credit with more than 1495 citations. He has been working as reviewer for Elsevier journals too.



Dr. Vijay S. Mohite (Dr. Vijay Sampat Mohite) received his Bachelor and Master degrees in Physics from Shivaji University, Kolhapur, Maharashtra (India). He obtained his Ph.D. Degree in Physics from the Shivaji University, Kolhapur, India. Currently, he is working as Assistant Professor in Physics at Tuljaram Chaturchand College, Baramati; Maharashtra (India). His research interest includes Photocatalysis, Solar Cell, Gas Sensor, Metal Oxide, Material Science, Energy Science &

Nanoscience. He has more than 25 international journal publications and 01 Indian patent to his credit with more than 824 citations. He has been working as reviewer for Elsevier journals too.



Dr. Rajendra D. Kale is born in India in 1968. He completed his under graduation in Electronics and postgraduation in Applied Physics. He completed his Doctoral research degree in Materials Science and Engineering from the Indian Institute of Technology, Mumbai in 2000. He was a postdoc fellow in MIE University, Japan, TIFR, Mumbai and POSTECH, South Korea. He published many research papers in International and

National journals and conferences. He is a life member of IAPT. He is serving as an Associate Professor in the T. C. College, Baramati (Autonomous), Dist Pune, Maharashtra (India) and has more than 30 years of experience in teaching and research.



Dr. Vishal Hareshgiri Goswami is presently working as an Assistant Professor at the Department of Physics, Chikitsak Samuha's Sir Sita Ram And Lady Shanta Bai Patkar College Of Arts And Science And V. P. Varde College Of Commerce And Economics, S.V Road, Goregaon (W), Mumbai since 2013. He has been teaching physics to UG and PG students for the last 9 years. He has completed his MSc (Physics) from

Bharatiya Vidya Bhavans, JP Rd, Old D N Nagar, Munshi Nagar, Andheri West, Mumbai, Maharashtra. He has completed his Ph.D. in Physics from Mumbai University, Maharashtra. He works as a recognized research guide for Ph.D. and M.Sc. by research as well as by paper in Mumbai University. He has worked as a member of the Website Committee, ISR, MIS, Students Grievance Redressal Cell, NAAC-III Documentation Committee, NAAC-III Scrutiny Committee, DBT Committee, LIC, and Gymkhana Committee. He has also worked as a Convener for Avishkar Innovation Center, and startups, E-Cell and Skill Hub, Co-ordinator of CAP – IT program, Co-convener of ICT Audit of the college, and ICT co-ordinator for the College. He has been appointed as a Jury for science exhibitions and student activities in various colleges. He has published 14 research papers in reputed National/International high-impact journals, presented 25 research papers in International & National Conferences and also published 7 chapters in a Book. He is

an editor of three books. He has published two MSc Physics textbooks. He has organized various Seminars/ Conferences/ Workshops/ Guest lectures for teachers as well as students. He is a Life member of the Plasma Science Society of India. He is also a member of the Division of Plasma Physics, the Association of Asia Pacific Physical Societies (AAPPS-DPP). He has taken GMRAF Annual Membership for the year 2020-2021. He received the “Research excellence award” Gold plated Award Memento and Gold plated GMRAF Award Medal from Global Multidisciplinary Research & Academic Foundation (GMRAF), Chennai, Tamil Nadu, India in the National Seminar cum Awards ceremony in March 2021. He is also the Winner of the Prof. M. S. Sodha Quiz Competition Award with a cash prize of Rs. 10,000 in an international conference on Plasma Science, Technology & Application 2016, held at Amity University Lucknow campus, in January 2016. He also has received Best Research Paper Publication and Best Research Paper Presentation Awards. He has completed one RUSA Sponsored Minor Research Project. He has completed various project work with industry, Syscon Automation on, a “vibration testing simulator” for M/S Good Earth by using RS-232, RS-485 communication, vb (communication with plc) to record vibration & oscillation data, “paper cup manufacturing machine” for M/S Hyden Packaging Pvt. Ltd., “conveyor/reciprocator spray gan” for M/S Pankaj Enterprise.



Mr. Gautam Shekhar Kamat was born in 1989 in Mumbai, India. He holds both a bachelor’s and master’s degree from Mumbai University. Throughout his academic career, Mr. Kamat has contributed to the field through publications, including one research paper and one book chapter. He is currently pursuing Ph.D. under the mentorship of Dr. Vishal H. Goswami at S.S. & L.S. Patkar College of Arts & Science and

V.P. Varde College of Commerce & Economics in Goregaon, Mumbai.



Mr. Sanket Amrutlal Mistry is a seasoned educator, accomplished researcher, and dedicated scholar, with a steadfast commitment to advancing the field of physics, particularly in solid-state electronics. With a Master’s degree from the prestigious University of Mumbai’s Department of Physics, he has laid a solid foundation for his academic pursuits. Complementing this achievement is his Bachelor’s degree from Bhavan’s College (Andheri), where he specialized in applied electronics within the realm of physics. His academic prowess is further evidenced by his exemplary achievements, including successfully clearing both the UGC NET Exam in Electronics Science and the CSIR NET Exam in Physical Science. These credentials not only showcase his expertise but also reflect his unwavering dedication to his field. Over a distinguished career spanning 15 years, since 2008, Sanket has

made significant contributions to the education sector in Mumbai. At S. S. and L. S. Patkar of Arts and Science and V. P. Varde College of Commerce and Economics, he has served as the Coordinator of the Science Section in the Junior College. Here, he meticulously plans academic activities, conducts departmental meetings, and fosters a conducive learning environment. His dedication extends to his role as Department Head of Applied Electronics, where he designs curriculum, guides students, and ensures academic excellence. Beyond administrative duties, he excels as an Assistant Professor in Physics and B.Sc. IT, actively engaging in curriculum development and examination processes. Since August 2023, Sanket has been enriching the academic community at Bhartiya Vidya Bhavan's Hazarimal Somani College of Arts and Science, Shri Manubhai Maneklal Sheth Junior College of Arts And Science and Jayaramdas Patel College of Commerce and Management Studies, Chowpatty as an Assistant Professor in the Degree College, specializing in Physics. Here, he delivers engaging lectures and conducts practical sessions for students across all years of the B.Sc. program, ensuring a comprehensive learning experience. Prior to his tenure at Bhavan's College, he honed his teaching skills at Valia Chhaganlal Laljibhai College Of Commerce And Lilavantiben Chhaganlal Valia College Of Arts, where he served as a Visiting Lecturer for the B.Sc. IT Degree College, imparting knowledge in Electronics and Communication Technology and contributing to the academic assessment process. His scholarly pursuits extend beyond the classroom, as evidenced by his research endeavors. He has presented papers at prestigious international conferences, such as the International Conference on Challenges in Environmental Management (CEM - 2019), demonstrating his commitment to advancing scientific knowledge and finding practical applications for his expertise. In summary, Sanket Amrutlal Mistry's multifaceted expertise, passion for physics, and dedication to fostering academic excellence position him as a valued asset in the academic community. His tireless efforts inspire students and contribute to the advancement of scientific knowledge.



Dr. Nupur Gupta, the first author of this manuscript is serving as an Assistant professor, at the Department of Physics, Guru Nanak Dev University College, Pathankot & has teaching experience of 4 years. She has completed her Ph.D. from the Department of Physics, Guru Nanak Dev University, Amritsar in the field of glass science. Her core research is focused on the study of "Short-Range order in tellurite glass, anti-glass, and crystalline materials". She has 8 international journal publications, and 1 book chapter to her credit. She has efficiently been able to secure grants from various agencies such as the Punjab State Council for Science and Technology (PSCST), DST, GoI, and Indian Council for Social Science Research (ICSSR) to organize regional & national level symposiums/seminars.



Dr. Mandeep Kaur Sandhu is currently serving as Assistant Professor, at the Department of Computer Science, Guru Nanak Dev University College, Pathankot & has teaching experience of 16 years. She has completed her Ph.D. from the Department of Computer Science and Engineering, Chandigarh University, Mohali in the field of Image processing. She is a distinguished expert in the fields of image encryption and cybersecurity. With a robust publication record

exceeding 25 articles in prestigious national and international journals, and 1 National Patent to her credit.



Dr. Sonali Bhatnagar is a Senior Assistant Professor of Physics at Dayalbagh Educational Institute, Agra with her Ph.D. from Punjab University, Chandigarh. Her current area of expertise is in high-energy physics and has set up a muon telescope. Apart from this, a mini array for studying secondary cosmic rays with temperature and pressure at Agra has been set up as Dayalbagh Educational Air Shower Array (DEASA) in collaboration with T.I.F.R., Mumbai. She was awarded the Young Scientist Award

FOR WOMEN IN SCIENCE at the FMT 2020 Conference, by the Department of Physics, School of Applied Sciences, Kalinga Institute of Industrial Technology (KIIT). She has published around 45 peer-reviewed articles. She has completed an MHRD project and two Institute funded projects.

This Book may be Cited as

- Suresh Kumar, (Eds). (2024) *E-WASTE: Impact, Disposal and Recycling* (1st ed.) ISBN 978-93-6095-258-7, Authorspress, New Delhi, India.

Our Previously Published Books on E-waste Themes are

- Suresh Kumar, (Eds). (2023) *E-WASTE: Treasure or Threat* (1st ed.) ISBN 978-93-5529-774-7, Authorspress, New Delhi, India.
- Suresh Kumar, (Eds). (2022) *E-waste in India: Management, Challenges & Opportunities, Vol-II* (1st ed.) ISBN 978-93-5529-322-0, Authorspress, New Delhi, India.
- Suresh Kumar, (Eds). (2021) *E-waste in India: Management, Challenges and Opportunities, Vol-I* (1st ed.) ISBN 978-93-91314-55-2, Authorspress, New Delhi, India.
- Suresh Kumar & J.K. Pradhan, (Eds). (2021) *E-waste: Management and Procurement of Environment* (1st ed.). ISBN 978-93-90588-87-9, Authorspress, New Delhi, India.