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Current Affairs of E-waste in India and its Future Strategies

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Abstract

It is now a well-known fact that electronic waste (E-waste), which is generated by the end of life of electronic products such as computers and mobile phones, is one of the fastest growing waste sectors in the developing and developed countries today. India is also producing E-waste to the extent of 3.2 million metric tonnes (Mt) is the third largest in the world where the United States is second with 6.9 Mt and China is the largest contributor with 10.1 Mt of E-waste, as per recent UN's Global E-waste Monitor 2020. The global production of E-waste in 2019 is approximately 53.6 Mt, while only 17.4% (9.3 Mt) of total E-waste was collected and recycled. Thus, India has to look at its current activities in waste electrical and electronics equipment (WEEE) activities and explore its short term and long-term strategies for the reuse, renewal and recycling to sustain its economy. This should also be correlated with our Prime Minister's vision of 2019 to make India a USD 5 trillion economies and global economic superpower by 2024-25 so that India becomes the third largest economy in the world. Since the E-waste regulations in India, adopting the extended producer responsibility (EPR) approach came into force in May 2012, with amendments made in 2016. After nine years of its implementation, there has been only a very limited impact on the massive accumulation of E-waste management system in the country. Regulations, on the other hand, have established more than hundreds of new recycling and dismantling units that were formally registered with regulatory authorities. But it appears that Amendment 2016 has set more seriousness towards collection rate targets for electronic products among producers to comply with the rules. More generally, regulations can be credited for bringing more attention to the

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problem of E-waste among various stakeholders. Thus, we have a long way to go in developing a policy framework that can facilitate a substantial E-waste management system in the country to make the monitoring effective.

Keywords: E-waste, WEEE, Disposal, EPR, Regulations, Future Strategies

Introduction

The electronic products such as computers and mobile phones, is one of the fastest growing business worldwide and its adoptability in the public has gone many folds due to its utility in the day to life on other hand it is generating electronic waste (E-waste), that is arising out from end-of-life as serious waste streams in the world today (Misra *et al.*, 2020). In the year 2020, India has generated a total of 10,14,961.2 tonnes of E-waste which is an increase of 31.6% over the previous year. The piling of annual global quantum of E-waste is estimated to above 50 million tons in the year 2020 (Balde *et al.*, 2017). India is among the top five E-waste producing countries in the world with an estimated annual production of 2 million tonnes. Like some other developing countries, E-waste management in India is dominated by the informal sector, with an estimated over 90% of the waste processed in this sector. E-waste includes many precious metals, rare earth metals, ferrous and non-ferrous metals, plastics, wood and glass. Unscientific practices in processing E-waste are linked to several environmental and health externalities (Toxic links, 2014). In response to these concerns, many developed and developing countries have started acting fast.

E-waste Disposal Infrastructure in India

Commonly discarded electronic waste (E-waste) includes computer monitors, motherboards, mobile phones and chargers, compact discs, headphones, television sets, air conditioners and refrigerators. According to the Global E-waste Monitor 2017, India generates about 2 Mt of E-waste annually and ranks fifth among E-waste producing countries after the US, China, Japan and Germany. In 2016-17, India treated only 0.036 Mt of its E-waste. Ninety-five percent (95%) of E-waste in India is recycled in the non-formal sector and five percent (5%) of the volume of E-waste is handled in the formal unit. In and around the metropolitan cities of India, there are more than 3000 units engaged in the non-formal sector for the recycling of E-waste (Figure 1).

A report on E-waste presented by the United Nations (UN) at the World Economic Forum on January 24, 2019 shows that the waste stream reached 48.5 Mt in 2018 and the figure is expected to double if nothing changes. Only 20% of E-waste is recycled globally. The UN report states that due to poor extraction techniques, the overall recovery rate of cobalt (a metal that is in high demand for laptops, smart phones and electric car batteries) from E-waste is only 30%.

Figure 1 E-waste Typically Includes Discarded Computer Monitors, Motherboards, etc.

Development of Waste Recycling Technologies

Ministry of Electronics and Information Technology (MeitY) has developed cost-effective technologies to recycle valuable materials and plastics in environmentally better manner, which include two distinctive PCB recycling technologies, namely 1000 kg/day capacity (~35 Mt E-waste) and 100 kg/batch (~3.5 Mt E-waste) processes with acceptable environmental norms. A 1000 kg PCB/day continuous process plant would be suitable for creating an eco-park in the country, while a 100 kg PCB/ batch process plant would be suitable for the informal sector. This can be done by upgrading and changing the current state of affairs in the informal sector. E-waste also contains plastic, which accounts for about 25% of its weight. Novel recovery and conversion of E-waste plastics into value added products has also been successfully developed. The developed process is capable of converting the majority (76%) of the waste plastic into suitable materials, which can be used for virgin plastic products. The technology has already been transferred for commercialisation.

Professor Veena Sahajwala, an expert based in Australia, suggests setting up micro-factories in India that can transform E-waste into reusable material to be converted into ceramic and plastic filaments for 3D printing. The high-grade metals in E-waste such as gold, silver, copper and palladium – can be segregated for resale under completely safe conditions. She is of the opinion that there is no reason to burn the plastic, micro factories can make filament with the plastic by compressing the waste in a temperature-controlled area.

A modular micro-factory, which would require an area of 50 square meters, can be located wherever the waste accumulates. She says that if funds are made available

to operators for initial capital expenditure, it will help empower people working with waste. There is immense potential for increasing the recycling of E-waste in the country. There are some forward activities in this direction; however, a lot of ground has to be covered through awareness campaigns, skill development, human capital formation and introduction of technology by adopting adequate safeguards in the informal sector of the country. Since India is acutely short of precious mineral resources (while untreated E-waste goes to landfill), there is a need for a well-designed, robust and regulated E-waste recovery system that generates employment as well as wealth.

Extended Producer Responsibility (EPR) and E-waste

EPR, one of the more widely used approaches to regulate E-waste globally, places the responsibility of end-of-life management of products on manufacturers or producers. Conceptually, EPR is designed for manufacturers to internalise the external costs associated with end-of-life disposal of their products (Sachs, 2006). The organisation for economic co-operation and development (OECD) specifies two broad objectives of the EPR approach (OECD, 2006). First, EPR transfers part of the burden of waste management from local governments to the upstream producers. Second, by forcing the internalisation of external costs of disposal, EPR is expected to provide an incentive for producers to take environmental considerations into their product design. For example, producers would be encouraged to design their products using materials that are more recyclable or less toxic if EPR internalises the social costs of disposal after the useful life. Under the EPR approach, the producers can be made responsible in four different ways (Toffel, 2003). The Economic responsibility typically pays producers a tax for the costs processing (*e.g.,* collection, recycling, disposal) of E-waste. Physical responsibility entails, for example, withdrawing products from consumers, after their useful life.

Product recall requirements may also impose collection rate targets. Information responsibility may be mandated to provide information about the characteristics of products (*e.g.,* toxicity, recyclability), including requirements such as product labeling. Finally, liability rules may specify financial liability for environmental damage and cleanup. EPR regulations may include any one or a combination of these four types of producer responsibilities. India's first E-waste rule, known as E-waste (Management and Handling) Rules, 2011 used the EPR approach and required producers of electronic products to establish collection centres (*i.e.*, physical responsibility) and inform the consumers (*i.e.*, information responsibility) as to how the used electronic products can be returned to collection centres. Preliminarily evaluations of these rules have shown that even though they have created demand for new formal dismantling and recycling centres, the rules have been largely ineffective in improving the existing practices (Bhaskar, 2018). Partly in response to the ineffectiveness of the initial rules, the government has amended the rules twice: once in 2016 and again in 2018. These amendments of the rules have inducted take back

targets for producers, requiring producers to collect a certain percentage of their products sold in the last financial year. The take back targets increased from a modest 10% in 2017–2018 to 70% from 2023 onward.

During the last eight years, Indian E-waste sector has seen several changes, partly as a result of the regulations: more serious efforts on the part of the producers, expansion of the formal waste management sector, rise of producer responsibility organisations (PROs), and efforts to develop indigenous technologies to process and recover various components of E-waste, to name a few. However, despite these developments, most of the E-waste in India continues to be handled by the informal sector. The objective of this deliberation is to take stock of the current status of the E-waste management ecosystem by identifying various challenges faced by the sector and possible avenues for improvements. The colloquium includes nine articles by national and global regional experts on various aspects of E-waste related to technology, finance, policies and regulations, formal and informal sector, trade and PROs. Experts come from diverse work backgrounds such as government, international developmental organisations, civil society organisations, industry and academia, taken together, the colloquium articles identify several challenges, such as the insufficient resources to monitor and enforce regulations, lack of awareness among consumers about the nature of E-waste and the related regulations and an emphasis on compliance of narrow focus of producers.

However, the central theme covered over all the articles, is the role of informal sector. The sector has a strong, well-established network of individuals working primarily in this sector, primarily in E-waste collection, but also in recovery and recycling. The sector generates livelihood for a large population, mostly belonging to the marginalised sections of the society. However, the practices they adopt are unscientific and unsafe, posing risk to their own health and potentially imposing environmental and health costs on society at large. Most of the articles in the colloquium deal with this dilemma: how to bring this strong network of people into a robust E-waste management system, that will protect (and increase) their livelihoods while simultaneously reducing the external costs associated with E-waste processing and disposal.

Challenges and Opportunities of E-waste in India

The rapid up-grade of electronic product is forcing consumers to discard old electronic products very quickly, which, in turn, adds E-waste to the solid waste stream. The growing problem of E-waste demands greater emphasis on recycling of E-waste and better E-waste management. Electronic waste or E-waste is generated when electronic and electrical equipment become unsuitable for its original use or exceeds the expiry date. Examples of E-waste are computers, servers, mainframes, monitors, compact discs (CDs), printers, scanners, copiers, calculators, fax machines, battery cells, cellular phones, transceivers, TVs, iPods, medical apparatus, washing

machines, refrigerators, and air conditioners (when unfit for use). These electronic equipments are increasingly replaced with newer models due to the rapid technology advancements and production of newer electronic equipment. This has led to a rapid increase in E-waste generation. People turn to newer models and the life of products has also become shorter.

E-waste usually consists of metals, plastics, cathode ray tubes (CRTs), printed circuit boards, cables, and so on. Valuable metals such as copper, silver, gold, and platinum can be obtained from E-wastes, if they are processed scientifically. The presence of toxic substances such as liquid crystal, 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 destroyed and processed in a crude manner using primary techniques. Piling of 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 present in very small quantities. Consumers are the key to better management of E-waste. Initiatives like EPR; Design for Environment (DfE); Reduce, Reuse, Recycle (3Rs), a technology platform to connect markets to facilitate a circular economy aims to encourage consumers to dispose their E-waste correctly, with increased reuse and recycling rates, and adopt sustainable consumer habits.

In developed countries, high priority is given E-waste management, while in developing countries it is difficult to fully adopt or replicate the E-waste management of developed countries and many related problems including, lack of investment and technically skilled human resources. In addition, there is lack of infrastructure and absence of suitable legislations specially to deal with E-waste. Also, there is inadequate description of the roles and responsibilities of stakeholders and institutions involved in E-waste management, etc. In 2016, the ministry of environment, forest and climate change (MoEFCC) issued the updated E-waste (management) Rules, which led to the encroachment/supersession of E-waste in India (Government of India, 2016).

Global Issues of E-waste

International treaties such as the Basel Convention aim at reducing and regulate the movement of hazardous waste between nations. Despite the convention, illegal shipment and dumping of E-wastes continue. It is estimated that 50 Mt of E-waste was generated globally in 2018. Out of this, half are personal devices such as computers, screens, smart phones, tablets, and TVs, the remainder being large household appliances and heating and cooling equipments. Despite 66% of the world's population being covered by E-waste laws, only 20% of global E-waste is recycled each year, meaning 40 Mt of E-waste or so is either burned for resource recovery or illegally traded and being treated shoddy manner.

In the US alone, more than 100 million computers are thrown away, of which less than 20% are properly recycled. China discards 160 million electronic components annually. In the past, China has been considered the largest E-waste dumping site in the world. Hundreds of thousands of people have expertise in dismantling electronic junk. The rate at which the volume of E-waste is increasing globally is 5-10% yearly. In India, the volume of E-waste generated was 146,000 tonnes per year (Borthakur and Sinha, 2013). However, these figures only include nationally generated E-waste and do not include waste imports (both legal and illegal) which are substantial in emerging economies such as India and China. This is because a large amount of waste electrical and electronic equipment (WEEE) enters India from abroad. Switzerland is the first country in the world to have established and implemented a formal E-waste management system, having recycled 11 kg/capita of E-waste against the target of 4 kg/capita set by the European Union (EU).

In the European Union, the EU WEEE directive explicitly imposes collection, recovery, and recycling goals on its member countries. Thus, it sets a minimum collection target of 4 kg/person per year for all the member states. These collection – and weight-based recycling goals seek to reduce the amount of hazardous materials disposed in landfills and to increase the availability of recyclable materials which indirectly encourage the consumption of less virgin material in new products. One-third of electrical and electronic waste in the EU is reported as separately collected and appropriately treated. The introduction of the EPR scheme in 2003 was the most important step in South Korea, and approximately 70% of E-waste was collected by producers. In the same period, the amount of reused and recycled E-waste was 12% and 69%, respectively. The remainder was shipped to landfill sites or incineration plants, which accounted for 19%.

The lax or zero enforcement of existing regulatory framework or low level of awareness and sensitisation, and inadequate occupational protections for those involved in these processes exacerbate E-waste management in developing countries compared to the European Union and Japan, which have well-developed initiatives at all levels aimed at changing consumer behaviour. Therefore, developing countries need to adopt effective strategies to encourage re-use, refurbishment or recycling E-waste in specialised facilities to prevent environmental pollution and human health risks.

China, Peru, Ghana, Nigeria, India, and Pakistan are the largest recipients of E-waste from industrialised countries (Mmereki, 2016). The Basel action network (BAN) aims to ensure that E-waste is disposed of in an environmentally friendly manner. It protects the planet from toxic waste trade. The BAN, the Silicon Valley toxic coalition (SVTC), and the electronics take-back coalition (ETBC) form an affiliated network of environmental advocacy NGOs in the US. The common objective of the three organisations' is to promote national-level solutions for

hazardous waste management. A recent initiative has been e-Stewards, a system for auditing and certifying recyclers and takeback programmes so that conscientious consumers know which ones meet higher standards.

Issues of E-waste in India

According to a report released in the world economic forum 2018, India is ranked 177 amongst 180 countries and is in the bottom of five countries in the environmental performance index 2018. This was linked to poor performance in environment health policy and deaths due to air pollution categories. In addition, India ranks fifth among the top E-waste producing countries in the world after the United States, China, Japan, and Germany and recycles less than 2% of the total E-waste it formally generates annually. Since 2018, India generates more than two million tonnes of E-waste annually, and imports huge amounts of E-waste from other countries around the world. Open dumping is a common sight that gives rise to issues like groundwater contamination, poor health, and more.

The associated chambers of commerce and industry of India (ASSOCHAM) and KPMG study, electronic waste management in India identified that computer equipment accounts for about 70% of E-waste, followed by telecommunication equipment phones (12%), electrical equipment (8%), and medical equipment (7%) with remaining from household E-waste. The informal sector is dominated by E-waste collection, transportation, processing, and recycling. This area/sector is well networked and unregulated. Often, not all the materials and value that could potentially be recovered, is recovered. In addition, there are serious issues regarding the leakage of toxic substances into the environment and safety and health of workers (Adelphi, 2017).

Seelampur in Delhi is the largest E-waste disposal centre in India. Adults as well as children spend 8–10 hours a day extracting reusable components and precious metals like copper, gold and various functional parts from the equipments. E-waste recyclers use processes such as open incineration and acid-leeching. This situation can be improved by creating awareness and improving the infrastructure of recycling units with the prevailing policies. The most of the E-waste collected in India is managed by an unorganised sector. In addition, informal channels of recycling/reusing electronics such as repair shops, used product dealers, e-commerce portal vendors collect a significant proportion of discarded electronics for reuse and cannibalisation of parts and components.

Impact of Recycling E-waste in Developing Countries

Almost all E-wastes contain some form of recyclable material, including plastic, glass, and metals; however, these materials cannot be retrieved for other purposes due to improper disposal methods and techniques. If E-waste is destroyed and processed in a crude way, its toxic constituents can wreak havoc on the human body. Processes

such as dismantling components, wet chemical processing, and incineration are used to dispose of the waste and result in direct exposure to and inhalation of harmful chemicals. Protective equipment such as gloves and face masks are not widely used, and workers often lack the necessary knowledge and experience required to perform their jobs properly. In addition, manual extraction of toxic metals leads to the entry of hazardous material into the bloodstream of the person doing so. Health hazards range from kidney and liver damage to neurological disorders. It is known facts that recycling of E-waste scrap is polluting the water, soil, and the air. Burning to remove metal from wires and cables emits brominated and chlorinated dioxins as well as carcinogens that pollute the air and, thus, cause cancer in humans and animals. Toxic chemicals that have no economic value are simply thrown away during the recycling process. These toxic chemicals leach into the underground aquifer, degrading the local groundwater and making the water unsuitable for human consumption as well as agricultural purposes. When E-waste is dumped in landfills; lead, mercury, cadmium, arsenic, and PCBs make the soil toxic and unsuitable for agricultural purposes. Recent studies on recycling of E-waste have pointed to increasing concentrations of PCBs, dioxins and furans, plasticizers, bisphenol-A (BPA), polycyclic aromatic hydrocarbons (PAHs), and heavy metals on the surface soil of metro cities of India, such as, New Delhi, Kolkata, Mumbai, and Chennai where E-waste is being processed by the informal sectors (Singhal, 2019).

In those studies, it is learnt that the sites engaged in metal recovery processes are the major sites for such persistent toxic substances. Studies from the same group also reported that persistent organic pollutants produced or released during the recycling process are escaping in the ambient air due to their semi-volatile nature (Figure 2).

Figure 2 Recycling Process in The Ambient Air Due to Their Semi-Volatile Nature

It is estimated that 50 Mt of E-waste was generated globally in 2018. Out of this, half are of personal devices such as computers, screens, smart phones, tablets, and TVs, the remainder being larger household appliances and heating and cooling equipment.

Opportunities of E-waste Management in India

The ministry of environment, forest and climate change implemented the E-waste (Management) Rules in 2016 to reduce the generation of E-waste and increase recycling. The study said that under these rules, the government introduced EPR which makes producers liable to collect 30-70% (over seven years) of the E-waste they produced. The integration of the informal sector into a transparent recycling system is critical for better control over environmental and human health impacts. Some efforts have been made towards integrating the existing informal sector in the emerging scenario. Organisations such as GIZ have developed alternative business models to guide the informal sector association towards authority (Raghupathy, 2017, Chatterjee, & Kumar, 2009). These business models promote a city-wide collection system that feeds a manual dismantling facility and a strategy towards best available technology facilities to generate higher revenues from printed circuit boards. By replacing the traditional wet chemical leaching process for gold recovery with the export to integrated smelters and refineries, safer practices and higher revenue can be generated per unit of collected E-waste.

E-waste is a rich source of metals such as gold, silver, and copper, which can be recovered and brought back into the production cycle. E-waste has significant economic potential in the efficient recovery of valuable materials and can provide income-generating opportunities for both individuals and enterprises.

The E-waste Management Rules, 2016 were amended by the government in March 2018 to facilitate and effectively implement the eco-friendly management of E-waste in India. The amended rules revise the collection targets under the provision of EPR with effect from October 1, 2017. The effective and better management of E-waste will be ensured through of revised targets and monitoring under the central pollution control board (CPCB).

Future Strategies: Governments Administration and Citizens Assistance

The government may consider collaborating with industry to formicate formal/standard operating procedures and a phased approach towards the agenda of reducing E-wastes. Alternatively, the government may also refer to the methods adopted by other countries for efficient collection and recycling of E-wastes. For example, South Korea, one of the largest producers of electronics managed to recycle 21% of the total 0.8 million tonnes of E-waste produced in 2015, according to an ASSOCHAM report 2017).

Taking into account, the adverse effects caused by untreated E-waste on land, water, and air; the government should encourage the new entrepreneurs by providing

the necessary financial assistance and technological guidance. Establishment of start-ups engaged in recycling and disposal of E-waste should be encouraged by giving special concessions. The unorganised sector has a well-established collection network. But it is capital-intensive in case of organised sector, it is capital intensive. Therefore, if both the sectors coordinate and work in a harmonious manner, the materials collected by the unorganised sector can be handed over to the organised sector to be processed in an eco-friendly manner. In such a scenario, the government can play a key role between the two sectors for successful processing of the E-waste. The time has come for the government to take a proactive initiative to recycle and dispose of E-waste safely to protect the environment and ensure the well-being of the general public and other living organisms.

Implementation of EPR by Mixing Economic, Regulatory and Voluntary

The principle of EPR is increasingly being applied to the management of E-waste in many countries, and its relative effectiveness and success has been demonstrated in European Union countries. The methods for implementation of EPR can be a mix of economic, regulatory, and voluntary/informative. While producers are responsible for E-waste management, consumers, retailers, state governments, municipalities, NGOs, CSOs, self-help groups (SHGs), local collection agencies such as extracarbon.com and others are responsible for the appropriate role in collection, facilitation, and creation of infrastructure to make E-waste management successful.

At present, design for environment (DFE) is gaining a lot of attention in the world as a new method to solve environmental pollution. The DFE principle in product design is a process to significantly reducing the environmental impact of products being put on the market. It is often seen that in India strict rules are ineffective due to slackness in implementation. Citizens have a very important role to play in E-waste management. We carelessly throw away many small gadgets along with waste dumped yard and many people openly burn that accumulated waste. In the process in which we breathe, many hazardous substances such as dioxins and furans are released. This is a very unhealthy practice, which we should stop immediately. Some very progressive resident welfare associations (RWAs) have clearly marked separate bins for collecting E-wastes. All other housing societies should follow this practice. Students and women SHGs can be mobilised for this activity in their respective RWAs.

Conclusion

E-waste management is a major challenge for the governments of many developing countries like India. It is becoming a big public health issue and is increasing rapidly day by day. In order to segregate, effectively treat, and dispose of E-waste, as well as divert it from traditional landfills and open burning, it is necessary to integrate the informal sector with the formal sector. The competent authorities in developing and

transition countries need to establish mechanisms to manage and treat E-waste in a safe and sustainable manner (Chatterjee, 2016).

- Information campaigns, capacity building, and awareness raising are important for promoting eco-friendly E-waste management programmes. There is an urgent need for increasing efforts to improve the existing practices such as collection plans and management practices to reduce illicit trade in E-waste.
- Reducing the amount of hazardous substances in e-products will also have a positive impact in dealing with the specific E-waste streams as it will support the containment process.
- Mobile phone producer Nokia is one of the very few companies that has made serious effort in this direction since 2008. The companies were made responsible for creating channels for proper collection and disposal of the E-waste as per CPCB approved EPR authorisation scheme in India.
- Recently, import licenses of some of the big companies were suspended for violating E-waste rules. Such measures have a great impact on the effective implementation of E-waste management in India. Any action taken should have its share of incentives that attract stakeholders.

Therefore, in the field of E-waste management, the government should announce incentives, which can be in the form of tax concessions or rebates, to ensure compliance in the electronics industry. Additionally, E-waste collection targets need to be regularly reviewed and updated to ensure pan-India compliance on E-waste collection.

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Ms. Nandni Mehla is currently pursuing Bachelors in Technology in the branch Information Technology from Indira Gandhi Delhi Technical University for Women, Delhi (IGDTUW). Nandni has seen that everyone around her wants to protect the environment, but people are too busy or even lazy to put up big change that would save the environment. She thinks that her chapter on 'Toxicity and Health Hazards' which are caused by improper management of E-waste, will be a small step towards conservation of the environment. She is thankful to Dr. Tanvi Mehlawat and Dr. Surender Kumar Sharma for inspiring her to write this chapter.

Dr. Surender Kumar Sharma is presently Assistant Professor in Dept. of Applied Sciences & Humanities, Indira Gandhi Delhi Technical University for Women, Kashmere Gate, Delhi. He completed his M.Sc. in Physics from Kirori Mal College, Ph.D. from Dept. of Physics & Astrophysics, University of Delhi and M. Tech. in Engineering Physics from GGSIP University. He also holds Postgraduate Diploma in Biological Big Data Analytics from Jawaharlal Nehru University, Delhi. He has been a recipient of CSIR-JRF, SRF and MHRD's GATE fellowship. His academic career spans over 5+ years of teaching experience coupled with research in the area of nanomaterials based conducting polymer composites for EMI shielding applications. He is actively doing research at RAMAN Lab, IGDTUW with a focus on emerging materials for Energy Storage Devices. He also established "OSA Student Chapter" at IGDTUW which is affiliated to Optical Society of America (now known as Optica) for which he is serving as Faculty Coordinator since 2018 and garnered a couple of grants (Startup, Special Program 2019 and Diversity & Inclusion Grant 2020) from its apex body "OPTICA" for this chapter under the guidance and constant support of Prof. Amita Dev, Hon'ble Vice Chancellor, IGDTUW and Prof. Chhaya Ravi Kant, Head, AS & H Dept. IGDTUW for which he is humbly thankful. He also got selected for "Interstellar Early Career Research Grant" for exploring "AMPK and mTORC1

pathways to enhance Healthy Longevity" with co-investigators from NUS, Singapore and Kyoto University, Japan. The grant was funded by New York Academy of Sciences (NYAS) and Japan Agency for Medical Research and Development (AMED). Google Scholar: https://scholar.google.com/citations?user=S9berE0AAAAJ&hl=en

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Dr. Jai Mala, Associate Professor, University Institute of Legal Studies Panjab University, Chandigarh. She has 13 years of teaching experience. She has presented many papers in the various National and International seminars and conferences. She has contributed numbers of research papers in various journals and books. She was the coordinator of the Moot Court Society (2016-2020) of the Department. She is co-coordinator of Centre of Child Right in UILS.

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Ms. Eeshika Madaan is currently pursuing Bachelors in Technology in Mechanical and Automation Engineering from Indira Gandhi Delhi Technical University for Women, Delhi (IGDTUW). Eeshika has witnessed as every day the world enhances in technology and gazettes people try to get rid of the old one, but without properly decaying it. There is an urgent need for proper management of E-waste in India and in order to prevent the country from disastrous effects there is a serious need to formulate policies in this direction. Also, as a citizen of the country, to create awareness on the topic in the society and to make her contribution to the issue she decided to write a chapter named "E- Waste in India: Management, Policies and Best Practices". She is very thankful to Dr. Surender Kumar Sharma for his support and constant guidance.

Mr. Anchal Saxena (Vice Principal, Kendriya Vidyalaya Kanpur Cantt, Kanpur) is highly qualified with educational qualification like M.A. History, MA English, M.Ed. having professional qualification like UGC-NET with History, UGC-NET with Education, O Level (PGDCA, NIELIT), NELTS (CIEFL, Hyderabad) and PGDSLM (IGNOU), etc. He has 10 years of teaching experience and 04 years of administration experience. He has published 18 research papers and book chapters in various International/National research journals

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Ms. Pushplata Bagati has spent over 20 years in educational administration and has earned B. Level in Computer Science along with the professionally qualified engineer. As a student she has remain a bright student and state topper. She is an expert quality assurance in the higher education, accreditation and ranking. In her other assignment she is also a skill trainer and has trained various IT Professionals and students from Global Corporate House and Universities. She has authored various papers at National/International level in various domains including Artificial Intelligence.

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Ms. Meghna Santosh Khairwar is currently pursuing Bachelors in Technology in the branch of Mechanical and Automation engineering from Indira Gandhi Delhi Technical University for Women (IGDTUW). Meghna focuses on sustainable development and with this vision she aimed to write this chapter. She is also a chassis engineer and a member of Formula Student Society of Automation Engineering.