ISSN: 2633-4828 Vol. 5 No.3, September, 2023

International Journal of Applied Engineering & Technology

E- WASTE MANAGEMENT IN INDIA: CURRENT STATUS AND CHALLENGES

[1]Japneet Dhillon and [2]Dr. Vikram Sandhu
[1]Research Scholar and [2]Associate Professor, University Business School, Guru Nanak Dev University, Amritsar
[1]japneetaulakh27@gmail.com and [2]sandhu.vikram@yahoo.com

ABSTRACT
Due to the tremendous rise in the generation and consumption of Waste Electrical and Electronic Equipment (WEEE), e-waste has emerged as a significant global concern. E-waste is viewed as one of the exponentially expanding waste streams worldwide. The UNEP report states that the global annual generation of electronic waste exceeds 50 million tonnes. In India, the growth rate is 30 per cent per annum. Developed countries usually export their electronic waste (e-waste) to developing countries such as India because of the availability of inexpensive labour and the lack of strict regulations for e-waste disposal. The paper focuses on the problems related to the production and handling of electronic trash. Additionally, it investigates the environmental and health risks that result from inadequate handling of e-waste.

Keywords: consumer electronics, e-waste, India, informal recycling, WEEE

INTRODUCTION
The exponential expansion in the manufacturing and use of electrical and electronic equipment (EEE) has resulted in a sudden surge in the amount of trash produced by these goods when they reach the end of their lifespan (Kiddee et al., 2013). The rapid pace of technological advancements, the affordability of electronic equipment, and the evolving lifestyle of individuals have accelerated the rate at which electrical and electronic equipment (EEE) becomes outdated and no longer useful (as stated in the study "What India Knows About E-Waste" conducted by environmental NGO Toxics Link 2015). Waste that is generated from electrical and electronic equipment (EEE) is referred to by many terms such as e-waste or waste electrical and electronic equipment (WEEE), and is defined differently in the literature (Widmer et al., 2005).

Table 1: Selected definitions of e-waste

Reference	Definition
European Directive 2002/96/EC	"Waste electrical and electronic equipment, including all components, subassemblies and consumables which are part of the product at the time of discarding". The Directive 75/442/EEC, Article I (a), defines as "waste" "any substance or object which the holder discards or is required to discard in compliance with the national legislative provisions".
OECD (www.oecd.org)	"Any household appliance consuming electricity and reaching its life cycle end".
Basel ActionNetwork (Puckett and Smith,2002)	"E-waste encompasses a broad and growing range of electronic devices ranging from large household devices such as refrigerators, air conditioners, cell phones, personal stereos, and consumer electronics to computers which have been discarded by their users."
Sinha-Khetriwal,2005	"E-waste can be classified as any electrical powered appliance that has reached its end-of-life."
StEP Initiative (StEP,2014)	"E-Waste is a term used to cover items of all items of electrical and electronic equipment (EEE) and its parts that have been discarded by the owner as waste without the intent of re-use."

Source: Literature

Regardless of the diverse interpretations, E-waste has become a pressing and enduring issue due to the sheer amount of e-waste being produced and the harmful substances it contains. Inadequate management of electronic waste can result in risks that pose a threat to both human health and the environment. E-waste consists of six categories listed in Table 2.

Table 2: Six Categories of E-waste

Temperature Exchange Equipment/ cooling and freezing equipment	Screen, Monitors	Lamps	Large Equipment	Small Equipment	Small IT and Telecomm-unication Equipment
Refrigerators, Freezers, Air Conditioners, Heat pumps, Dehumidifying Equipment	Television, Monitors, Laptops, Notebooks, Tablets, LCD Photo Frames	Straight Fluorescent lamps, Compact Fluorescent lamps, High Intensity Discharge lamps, Low Pressure Sodium Lamps, LED lamps	Washing Machines, Clothes Dryers, Dish Washing Machines, Electric Stoves, Large Printing Machines, Copying Equipment and Photovoltaic Panels.	Vacuum Cleaners, Microwaves, Ventilation Equipment, Toasters, Electric Kettles, Electric Shavers, Scales, Calculators, Radio sets, Video Cameras, Electrical and Electronic Toys, Small Electrical and Electronic Tools, Small Medical Devices, Small Monitoring and Control Instruments).	mobile phones, GPS, pocket calculators, routers, personal computers, printers, telephones

Source: UNU-IAS, The Global E-waste Monitor 2020.

Two primary characteristics of e-waste are its harmful and useful nature. Because e-waste contains harmful materials including selenium, nickel, manganese, mercury, lead, PCBs (polychlorinated biphenyls), arsenic, cadmium, etc., improper processing before disposal could have a harmful effect on the human health as well as the environment. The inclusion of rare minerals like indium and gallium, as well as pricey metals like copper, silver, palladium, gold, and platinum, makes e-waste lucrative. Recovering these precious materials from electronic waste offers a substantial financial prospect (Toxics Link, 2005).

Table 3: The concentration of heavy economical metals in electronic waste

No	Electronic Equipment	Copper	Silver (ppm)	Gold (ppm)	Palladium (ppm)
1	Television (TV)	10%	280	20	10
2	Computer	20%	1000	250	110
3	Mobile Phone	13%	3500	340	130
4	Portable Audio Scrap	21%	150	10	4
5	DVD Player	5%	115	15	4

(***Source:*** Department of information technology & Umicore Precious Metals Refining. Geneva)

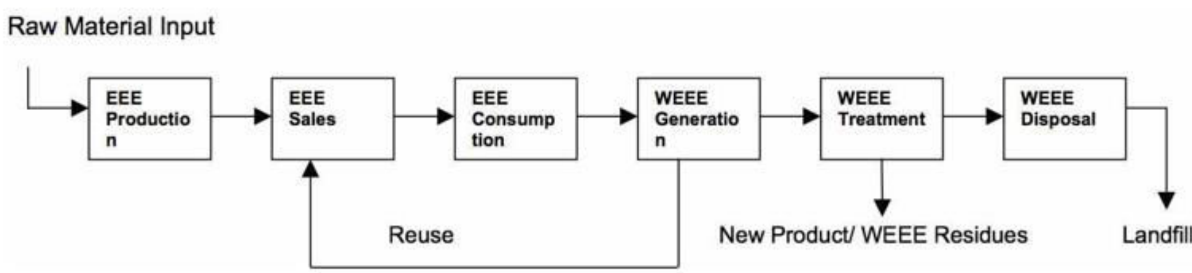


Figure 1: Life Cycle of an Electrical and Electronic Equipment

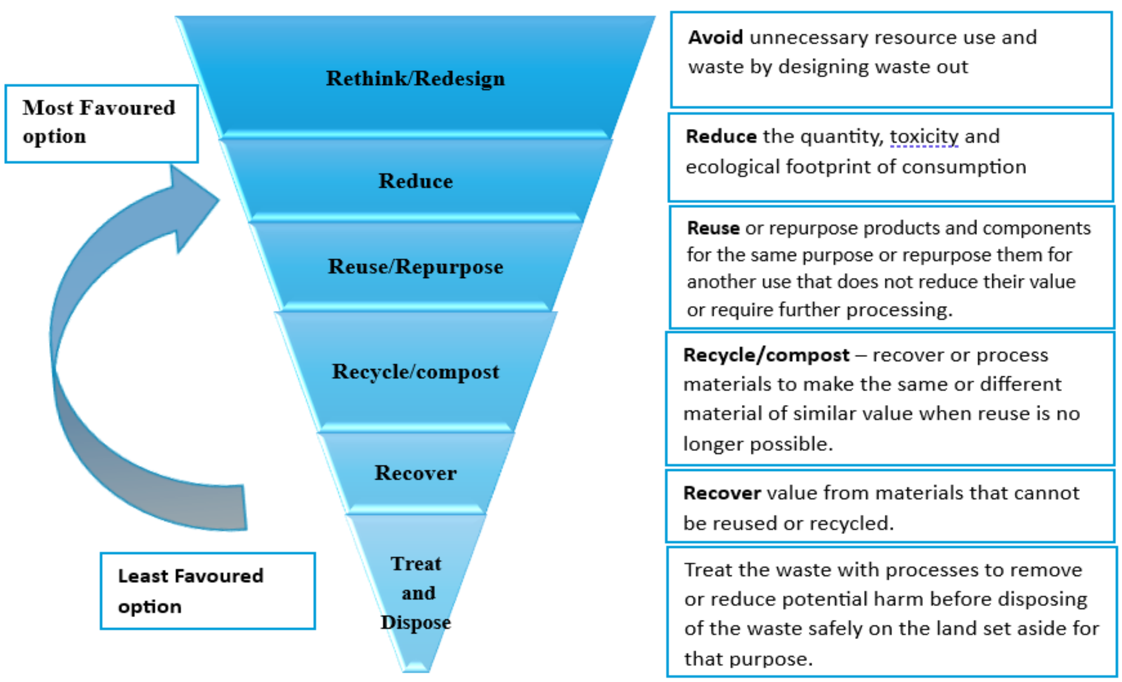


Figure 2: Moving up the waste Hierarchy
Source: *The GPSC.org*

Majority of the e-waste is produced in developed and technologically advanced nations. They dispose of their growing accumulation of e-waste to poor nations rather than managing it in an environmentally responsible manner. In order to efficiently recover resources from e-waste and avoid health and environmental risks throughout the waste processing process, valuable and dangerous substances must be carefully recovered and extracted using scientific methods. This paper aims to present a summary of the problems related to the generation and handling of electronic waste. It also investigates the risks to the environment and human health that result from inappropriate handling of e-waste. In order to provide a uniform framework of knowledge in the subject of e-waste, the study attempts to look into and summarize the information available.

GLOBAL SCENARIO

According to projections from 2019, approximately 53.6 million metric tonnes (mMT) of e-waste was generated worldwide. By 2030, that amount is projected to nearly double, to 74.7 million tonnes, in only sixteen years. The United States was the largest producer of e-waste, producing 7.1 million tonnes (Mt). China came in second, producing about 6.0 Mt (Baldé et al. 2015). Just 6.5 Mt of electronic waste are thought to have been gathered by the national take-back programmes in 2014. United States is the top generator of e-waste globally, followed by China. With a total of 24.9 Mt in 2019, Asia produced the most e-waste followed by the Americas with 13.1 Mt and Europe falls on third position with 12 Mt, while Africa and Oceania produced 2.9 Mt and 0.7 Mt, respectively (Global E-waste Monitor,2020).

Year	E-waste generated (Mt)
2010	33.8
2011	35.8
2012	37.8
2013	39.8
2014	41.8

Table 4: Quantity of E-waste Generated globally

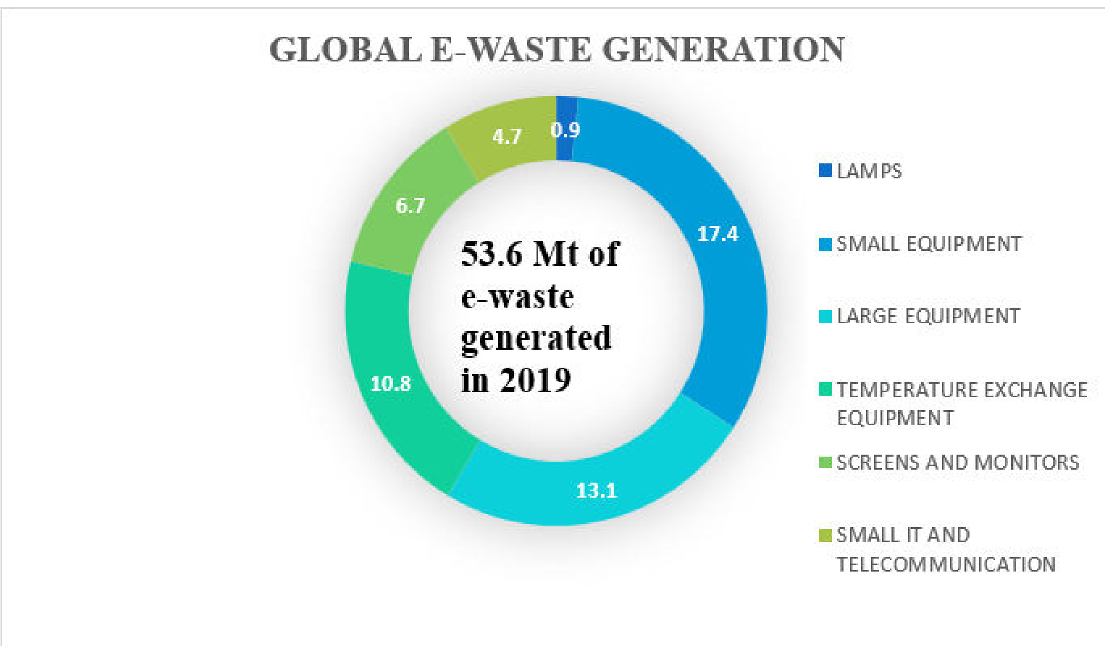


Figure 3: Global E-waste Generation per category
Source: Global E-waste Monitor Report 2020

In terms of e-waste generation per capita, Europe, with 16.2 kg per capita, ranked first globally followed by Oceania, with 16.1 kg per capita, and the Americas with 13.3 kg per capita, on the other hand, Asia and Africa generated e-waste amounting to 5.6 kg per capita and 2.5 kg per capita, respectively. Table 5 highlights the top e-waste generating countries worldwide along with the per capita generation in the year 2019.

Table 5: The top five e-waste producing countries in 2019

Rank	Country and rank in e-waste generation	EEE placed on the market (kg/capita)	E-waste generation (kg/capita)	E-waste collection rate (per cent)
1	China	13.3	7.2	16
2	USA	25.3	21	15
3	India	5.8	2.4	1
4	Japan	21.3	20.4	22
5	Germany	18.2	19.4	52

Source: Data retrieved from CSE 2020

Research has shown that people frequently discard electronic devices—particularly computers and cell phones—not because they break but rather because new technology makes them unattractive and outdated. Over 50% of computers that were thrown away were still functional, as per the data gathered at a single-day recycling event (Rajya Sabha Report "E-waste in India", 2011). Compared to the amount of e-waste generated in the year 2019, the official documented collection and recycling was 17% or 9.3 Mt.

Majority of the e-waste produced is transferred to underdeveloped countries, about 80% of it. According to the Global E-Waste Monitor 2020, official data on the transboundary flow of e-waste from developed to underdeveloped countries are unclear.

E-WASTE: THE PROBLEM

The part of municipal waste that is expanding the fastest is e-waste. The problems associated with e-waste are no longer limited to the borders of the nation where it is produced. Under the guise of free trade, rich nations sell their e-waste to underdeveloped nations (Toxics Link, 2004). The influx of used electronics from industrialized nations is exacerbating the complexity of e-waste management issues. In order to regulate the transboundary movement of WEEE, India is a party to the Basel Convention; nevertheless, its implementation is contradictory. Because e-waste is a concoction of various poisonous and dangerous chemicals, inappropriate handling, recycling, and disposal of it can lead to serious health risks, environmental degradation, and social problems for those who handle it, the communities in which it is generated, and society at large.

STATUS OF E-WASTE IN INDIA

ASSOCHAM-NEC(2018) found that India ranks fourth globally in terms of e-waste production. Indian e-waste production in 2019 was estimated to have been 3.2 million metric tonnes (mMT) by the Global E-waste Monitor, 2020. The nation's e-waste is increasing at a compound annual growth rate of almost 30%, which is very concerning.

The projected year-on-year growth in e-waste generation i.e. 13 per cent, only takes into consideration the domestic production as well as consumption patterns. Import data is excluded since it is hard to find, particularly in terms of weight and units of e-waste and second-hand items. The projected year-on-year growth in generation of e-waste would go up, if import data were also included.

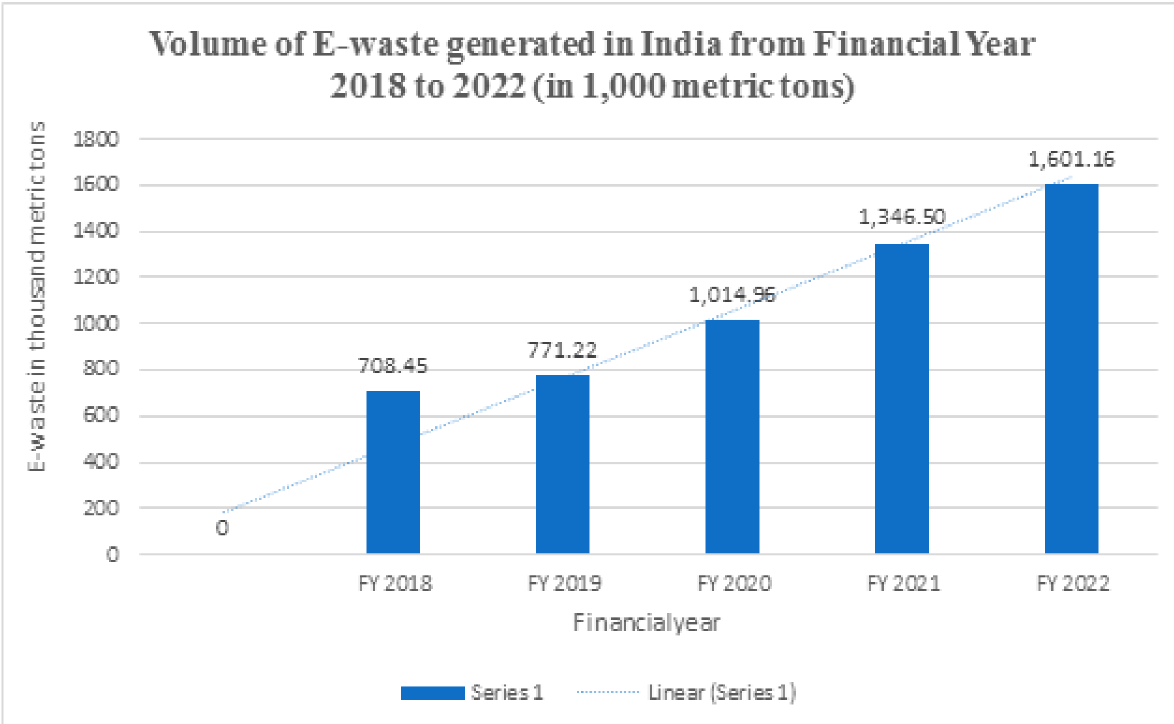


Figure 4: E-waste Generation in India
Source: India: volume of e-waste generated 2022 | Statista

The amount of outdated, abandoned devices that accumulate in India is growing over time. The amount of waste produced and disposed of in India is not officially or conclusively recorded. The government agencies' impartial studies serve as the foundation for data estimations. Figure 5 shows projected e-waste generation in India.

Table 6: E-waste generation in India

Year	E-waste generation (million metric tonnes)
2015	1.97
2016	2.22
2017	2.53
2018	2.86
2019	3.23

Source: CSE, 2020 compiled from The Global E-waste Statistics Partnership

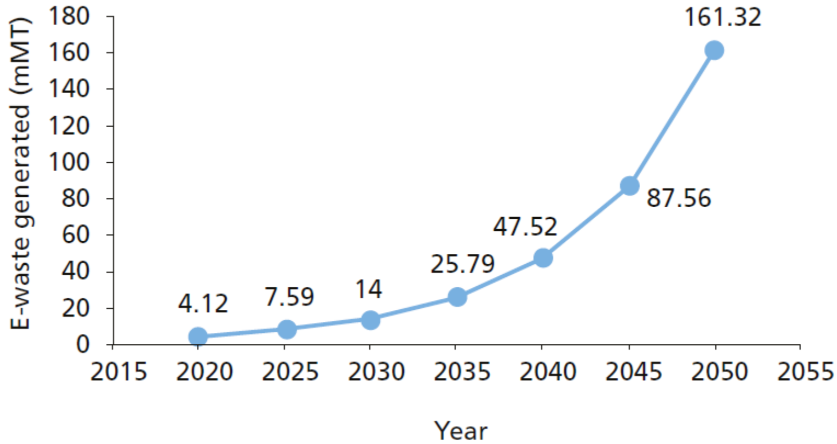


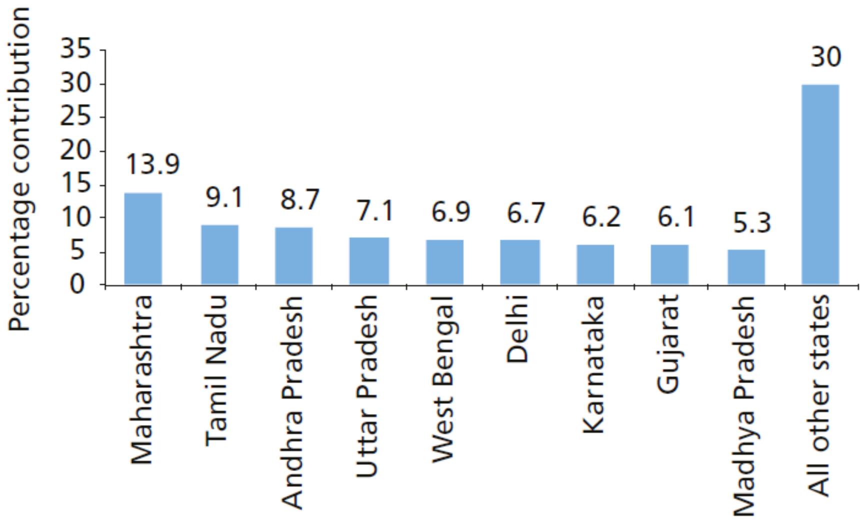
Figure5: E-waste generation figures in India: Past and forecasts for the future
Source: CSE, 2020

The top 10 cities producing e-waste are Mumbai, Delhi, Bengaluru, Kolkata, Chennai, Ahmedabad, Hyderabad, Pune, Surat, and Nagpur, according to the Central Pollution Control Board (CPCB). Mumbai is the nation's top producer of e-waste, producing 19,000 tonnes of it annually; Delhi and Bangalore are next in line. 36,165 hazardous waste-generating enterprises in India produce 6.2 million tonnes of hazardous garbage annually. 2.7 million of the 6.2 million tonnes of garbage are suitable for landfilling, 0.41 million are suitable for incineration, and 3.08 million are recyclable hazardous waste. Sixty-five cities produce more than 60% of the nation's e-waste, with ten states accounting for 70% of the total. The top 10 states in India that produce the most e-waste are West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh, Uttar Pradesh, Maharashtra, and Tamil Nadu. Maharashtra ranks first and produces 19.8% of the total, electronic waste generated annually. The industrialized world disposed of 70% of the entire amount of e-waste that was gathered at recycling facilities. Research conducted in Delhi found that there are over 25,000 persons working in junk yards there (Toxic Link, 2004).

Table 7: WEE Generating top ten cities

State	WEE (Tonnes)
Ahmadabad	3287.5
Bangalore	4648.4
Chennai	4132.2
Delhi	4730.3
Hyderabad	2833.5
Kolkata	4025.3
Mumbai	11017.1
Nagpur	1768.9
Pune	2584.2
Surat	1836.5

Figure 6: State wise percentage contribution to annual e-waste generation
Source: MAIT, GTZ, 2007



Source: Electrical and Electronics manufacturing in India compiled from ASSOCHAM & NEC Technologies Report, 2018.

With no consideration for the environment or the health and safety of their workforce, developed nations sell their electronic garbage to developing nations like India. The main causes are Lax environmental regulations concerning e-waste, a dearth of national occupational norms and low-cost labour (Shagun, 2013). In US, its costs $30 per computer and in India, cost is $2 per computer resulting in a saving of $ 28 per computer.

Only 40% of the total e-waste production in the country is made available for recycling; the remaining 60% is stored in warehouses or other similar locations. In the nation, informal recyclers handle 95% of the e-waste, while formal recyclers handle only 5% of it [MAIT,2017].In homes, workplaces, warehouses, and other locations, 75% of electronic trash is left unattended.

The main methods for disposing of electronic waste at the end are landfill, incineration, recycling, and storing. Furthermore, no official data is available to estimate the amount or proportion of e-waste that is disposed of. Landfilling is the most commonly used method of disposing of e-waste in the nation. The problem in India is made worse by the absence of public awareness about the proper disposal of outdated electrical and electronic equipment and by insufficient regulations and policies to address e-waste-related issues (Anwesha, 2012).

HEALTH AND ENVIRONMENT CONCERNS OF E-WASTE

If not recycled utilizing cutting-edge technology, e-waste is a concoction of chemicals that can be harmful to both human health as well as environment. These pollutants include brominated flame retardants (BFRs), lead, cadmium, beryllium, mercury and arsenic. The batteries in cell phones, fluorescent lights, switches, LCD monitors and flat panel screens all contain the harmful chemical mercury. Mercury exposure can result in tremors, emotional changes, cognitive decline, motor dysfunction, sleeplessness, migraines, altered nerve response, kidney problems, respiratory difficulties, and even death. It can also impair the neurological development of fetuses and young children (Grant et al., 2013). Lead can be found in the circuit boards of cell phones, batteries, TV CRTs, computer monitors, and PVC products as a stabilizing agent. Lead exposure may be linked to a potential human carcinogen, neurological and brain damage, delayed child development, hearing issues, blindness, diarrhea, altered cognition, behavioral abnormalities (such as delinquent behavior), and physical disorders (Toxics Link, 2005). Mobile phones are among the many electrical products whose microchips contain arsenic. High amounts of arsenic can be fatal, while low levels of exposure are linked to detrimental effects on the skin, liver, neurological system, and respiratory system. Cadmium is utilized in cell phone batteries and light-sensitive resistors. It can harm the kidneys and impair a child's cognitive, learning, behavior, and neuromotor abilities. One of the ingredients in polymers used in cell phones, chlorine, has been related to the damage of tissues and the breakdown of cell structure. Brominated flame retardants, or BFRs, can cause endocrine disorders, cancer in the lymphatic and intestinal systems, and plastic casings and circuit boards (Rajya Sabha report, 2011). Human scalp hair samples were collected in a Chinese study to determine the extent of heavy metal exposure for workers at e-waste recycling facilities. The exposed group's hair had higher amounts of Lead, Copper, Manganese, and Barium metals than the control groups.

To recover copper from wires, open-sky burning is used in developing nations. Lead leaks into groundwater when electronic garbage is landfilled. Toxic vapors are emitted into atmosphere when the Cathode Ray Tubes (CRT) are burnt and smashed. E-waste contains toxic materials that pollute the environment when burnt in the incinerators or dumped in the landfills. In the informal sector, E-waste is manually disassembled, without any protective gear, and sorted. The risk of handling this e-waste, in the informal sector, is unknown to the workers. They remove various materials without the need of machinery or safety gear. They work without facemasks and with their bare hands. Women and children work for meagre pay in the unofficial recycling industry. Due to inadequate safety precautions and dismantling workshops, about two thirds of e-waste workers in India suffer from respiratory problems such as tremors, difficulty in breathing, irritation, choking, irritation and coughing. (Assocham kinetics study, 2016). The inhalation of toxic fumes, the contamination of chemicals in food, water and soil, as well as direct contact with hazardous chemicals like chromium, mercury, lead, cadmium, brominated flame retardants, or polychlorinated biphenyls (PCBs), can all pose health risks associated with e-waste (Duan et al., 2011). Dismantling equipment is one such recycling process that carries a higher risk of worker injury.

E-waste Rules, Regulations and Policies

In 2002, e-waste became a recognized environmental problem. In India, the unorganized sector handles the majority of trash. Inadequate input materials for recycling are a concern for organized recyclers. The country did not have any e-waste laws until 2000.This waste stream is partially covered by the rules created under the EPA's provisions such as the Batteries (Management and Handling) Rules and the Hazardous Waste (Management and Handling). In 2008, the Central Pollution Control Board (CPCB) published e-waste management recommendations. The E-waste (Management and Handling) Rule of 2011, implemented by the Ministry of Environment and Forests under the Environmental Protection Act of India, mandates electronics manufacturers to recycle at least 15% of their products as e-waste. The Ministry of Environment, Forests, and Climate Change has issued the Waste Management Rules, 2016. These regulations impose objectives and Extended Producer Responsibility (EPR) on producers. Additionally, a clause introducing a financial punishment for breaking the rules has been added. As of December 29, 2016, the country had 178 officially registered recyclers and dismantlers of electronic waste with the Central Pollution Control Board (CPCB). These facilities had a total recycling and dismantling capacity of 438085.62 metric tons per year (MTA) for managing e-waste with environmentally sound options. The main reasons the e-waste legislation does not work are laxity and a lack of awareness (Dhillon & Sandhu, 2020). Given its exponential expansion and the antiquated recycling methods used by the unorganized sector, e-waste management is crucial in India (Dhillon & Sandhu, 2017).

CONCLUSION

Solid waste management, which is already a significant problem in India, is becoming more complicated due to the exponential growth of electronic waste. The nation's e-waste management system faces numerous obstacles. The main obstacle is the prevalence of the unorganized sector. It is necessary to take action to formally recognize the unorganized sector by enforcing laws strictly and punishing noncompliant parties severely. It is necessary to raise awareness by employing commercials to persuade people to return electronic gadgets for recycling or pickup. Reuse, recycling, recovery, and a decrease in the usage of hazardous materials are all important strategies for reducing e-waste. An efficient take-back programme is required, one that incentivizes manufacturers to build products with less harmful elements and that are simpler to dismantle, reuse, and recycle. It will assist in cutting down on e-waste. Managing e-waste is a collective effort rather than the exclusive domain of a single person or the government. To ensure efficient e-waste management and build a greener India, it is the collective responsibility of all individuals.

REFERENCES

1. Atin Biswas and Siddharth Ghanshyam Singh 2020. E-waste Management in India: Challenges and Agenda, Centre for Science and Environment
2. Associated Chambers of Commerce of India (ASSOCHAM), India. 2018. Electricals and Electronics manufacturing in India. NEC Technologies in India. 1-56. Assessed on 28 September 2020.
3. Dr S Chatterjee 2011. Electronic Waste in India, Department of Information Technology. Available at https://www.meity.gov.in/ writereaddata/files/EWaste_Sep11_892011.pdf, as accessed on 20 November 2020
4. Agarwal R. (1998) India: The World's Final Dumpyard!, January, Basel Action News, Vol.1 at www.ban.org accessed on 14th September 2019.
5. CII (2006). "E-waste management", Green Business Opportunities, Vol.12, Issue1, Confederation of Indian Industry, Delhi.
6. Devi B.S, Shobha S. V, Kamble R. K. (2004). E-Waste: The Hidden harm of Technological Revolution, Journal IAEM, Vol.31, pp.196-205.
7. DIT (2003). Environmental management for Information Technology industry in India, Department of Information Technology, Government of India, pp.122-124.
8. Radha G. (2002). A Study of the Performance of the Indian IT Sector' at www.nautilus.org accessed on 21st June 2005.
9. Ramachandra T.V and Saira V. K. (2004). Environmentally sound options for waste management, Envis Journal of Human Settlements, March 2004.
10. Sergio J. and Tohru M. (2005) Waste management of electric and electronic equipment: comparative analysis of end-of-life strategies, J. Mater. Cycles Waste Manag. 7:24–32
11. Shobana Ramesh and Kurian Joseph (2006). Electronic waste generation and management in an Indian city, Journal of Indian Association for Environmental Management, Vol. 33, No.2, pp 100-105
12. Toxic links (2003). Scrapping the Hi-Tech Myth Computer Waste in India, www.toxiclink.org accessed on June 2019.
13. Toxics Link. (2004). E-Waste in Chennai Time is running out, www.toxicslink.org accessed on 14th June 2019.
14. Trick J. (2002). A mobile is not just for Christmas, Tuesday, 24th December 2002, http://news.bbc.co.uk accessed on 19th August 2019.
15. A study on 'Electronic Waste Management in India,' conducted by The Associated Chambers of Commerce and Industry of India (ASSOCHAM)--cKinetics available at http://timesofindia.indiatimes.com/city/delhi/Indias-e-waste-growing-at-30-pct-per-annum-ASSOCHAM-cKinetics-study/articleshow/52570598.cms
16. Borthakur A. (2012). Generation, management and policy implications of electronic waste in India. M.Phil. dissertation, Central University of Gujarat, Gandhinagar
17. Carisma, B. (2009). Drivers of and barriers to E-waste management in the Philippines. Lund University, Lund.
18. CPCB (Central pollution Control Board), The Hazardous Materials (Management, Handling and Transboundary Movements) Rules, 2008.

19. Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on Waste Electrical and Electronic Equipment (WEEE)
20. http://www.e-wasteproject.org/docs/del_amitjain.pdf & Report on "E-waste Inventorisation in India", MAIT-GTZ Study, 2007).
21. Kiddee P, Naidu R and Wong MH (2013) Electronic waste management approaches: An overview. Waste Management 33: 1237–1250
22. Puckett J and Smith T (2002) Exporting harm: The high-tech trashing of Asia. The Basel Action Network, Seattle7 Silicon Valley Toxics Coalition.
23. Secretariat RS (2011) E-waste in India. India Research Unit (Larrdis), Rajya Sabha Secretariat, New Delhi.
24. Dhillon, Japneet, and Vikram Sandhu. "Waste Management in Indian Cities: A Review." *ICRBS-2017* (2017).
25. Shagun, Ashwani Kush, and Anupam Arora (2013). Proposed Solution of e-Waste Management. International Journal of Future Computer and Communication, Vol. 2, No.
26. StEP Initiative (2014) Available at: http://www.step-initiative.org/index.php/ Initiative_WhatIsEwaste.html
27. Widmer R, Oswald-Krapf H, Sinha-Khetriwal D, et al. (2005) Global perspectives on e-waste. Environmental Impact Assessment Review 25: 436–458.
28. Grant, K., Goldizen, F.C., Sly, P.D., Brune, M.N., Neira, M., Berg, M.V.D., Norman, R.E., 2013. Health consequences of exposure to E-waste: a systematic review. The Lancet Global Health. http://dx.doi.org/10.1016/S2214-109X(13)70101-3
29. GTZ-MAIT., 2007. A study on E-waste assessment in the country. The German Technical Cooperation Agency (GTZ) and Manufacturer's Association for Information Technology Industry (MAIT). http://www.mait.com/admin/press_images/press77-try.htm.
30. Ministry of Environment Forestry (MoEF). 2008. Guidelines for environmentally sound management of E-waste. http://www.moef.nic.in/divisions/hsmd/guidelines-e-waste.pdf
31. Ministry of Environment Forestry and Climate Change (MoEF&CC). 2016. E-Waste (Management) Rules. 2016. http://www.moef.gov.in/sites/default/files/EWM%20Rules%202016%20english%2023.03. 2016.pdf.
32. Step Initiative. 2014. One global definition of E-Waste. United Nations University, Bonn, Germany, Retrieved from http://www.step-initiative.org/files/step/documents/StEP WP One Global Definition of E waste 20140603 amended.pdf.
33. Step Initiative. 2016. Guiding principles to develop E-waste management systems and legislations. 1-15. ISSN: 2071-3576 (Online) | ISSN: 1999-7965 (Print). http://www.stepinitiative.org/files/_documents/whitepapers/Step_WP_WEEE%20systems %20and%20legislation_final.pdf
34. Toxic Link. 2018. Informal E-waste recycling in Delhi-unfolding impact of two year of E-waste (Management) Rules 2016. A primary study report by Toxic Link. http://www.toxicslink.org/docs/Informal%20E-waste.pdf