E-Waste Generation, Management and Impacts: A Review in Present Indian Scenario

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Abstract

Background:

The field of information and communication technology has made enormous strides, which have resulted in a massive rise in the use of electronic devices, particularly computers and mobile phones. Electronic garbage, or "e-waste," has become enormous due to the increase in the manufacturing and consumption of electronic equipment as well as its shorter lifespan. Furthermore, a significant amount of these gadgets are transported across borders as used electronics from developed nations in an effort to narrow the digital divide.

Objectives:

This paper reviews e-waste produced in India its sources, composition, and current management practices. The paper also studies the state wise, city wise e-waste collected and processed. The paper also talks about the global scenario of e-waste. The paper ends with the study of environmental and health implications of e-waste. Fixing responsibility for waste disposal on producers, establishment of formal recycling facilities, and strict enforcement of legislation on e-waste are some of the options to address this rapidly growing problem.

Discussion:

The exponential growth in production and consumption of electronic equipment has resulted in a surge of e-waste generation. Many electronic items contain hazardous substances including lead, mercury and cadmium. Informal recycling or disposing of such items poses serious threat to human health and the environment.

Conclusions:

Strict enforcement of waste disposal laws is required along with the implementation of health assessment studies to mitigate inappropriate management of end-of-life electronic wastes in developing countries.

Keywords: E-Waste, Environmental Impact, Health Effects, Indian & Global Scenario

I. INTRODUCTION

Electronic waste, often abbreviated as e-waste, is a rapidly growing global concern that stems from the constant evolution of technology and the increasing use of electronic devices in our daily lives. E-waste comprises discarded or obsolete electronic devices and their components, which include everything from old mobile phones and computers to discarded televisions and refrigerators. The management and disposal of e-waste have become pressing issues due to the sheer volume of electronic devices being consumed and discarded.

E-waste is characterised by its diverse range of items, from small handheld gadgets to large appliances, all containing a variety of valuable and hazardous materials. These materials can include precious metals like gold and silver, as well as toxic substances like lead, mercury, and cadmium. The presence of both valuable and harmful elements in e-waste makes its responsible management crucial for environmental protection and human health. As the world becomes more technologically advanced, the generation of e-waste continues to escalate. The improper disposal and mismanagement of e-waste pose significant environmental and health risks. This is why it is essential to address the challenges associated with e-waste, implement effective recycling and disposal practices, and promote awareness of the environmental and health implications.

In this context, it is important to explore the composition, consequences, impacts and potential solutions related to e-

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waste. This research seeks to shed light on the ever-increasing issue of e-waste, examining its impact on the environment, the health risks it poses, and the strategies needed to mitigate these challenges and create a sustainable, responsible approach to dealing with electronic waste.

E-waste Composition

The e-waste stream consists of more than 1000 different substances that fall into "hazardous" and "non-hazardous" categories. Broadly, it consists of ferrous (50%) and non-ferrous metals (13%), plastics (21%) and miscellaneous wastes. The hazardous elements category includes lead, mercury, arsenic, cadmium, selenium and hexavalent chromium and flame retardants. Below Table shows different electronic waste components and their potential environmental hazards.

Constituents	Realff *et. al.* (2004)	Kong *et. al.* (2012)	Vats and Singh (2014)	Hossain *et. al*, (2015)
Metals	49%	13%	60.20%	39.50%
- Copper		7%		20.10%
- Iron				8.10%
- Tin				4%
- Nickel				2%
- Lead				2%
- Aluminium				2%
- Zinc				1%
- Silver				0.20%
- Gold				0.10%
- Palladium				0.01%
Plastics	33%	21%	15.20%	30.30%
Metal-plastic mixture			5%	
Cables			2%	
Screens (CRT and LCD)	12%		11.90%	
PCB			1.70%	
Others	1%		1.40%	
Pollutants			2.70%	
Wood	5%			
Refractory Oxides				30.20%

Table No. 1: Electronic waste components and their potential environmental hazards

II. E-Waste Problem in India

On January 29, 2023 during his monthly radio programme Mann Ki Baat, Prime Minister Narendra Modi highlighted the issue of electronic waste (e-waste) accumulation in India. He referred to a report by the UN, stating that a staggering 50 million tonnes of e-waste is discarded annually. Modi brought out the context of this scale by pointing out that the weight of all commercial planes ever constructed put together would be less than that of the e-waste being generated. In fact, he likened the rate of e-waste disposal to discarding 800 laptops every single second.

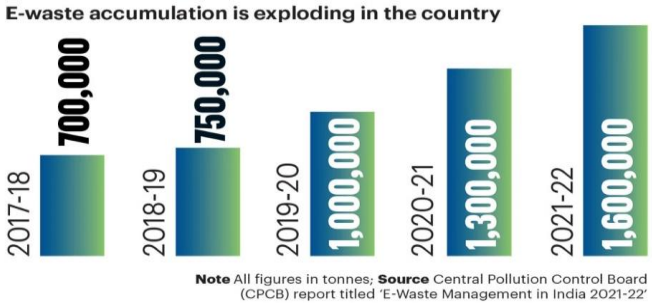
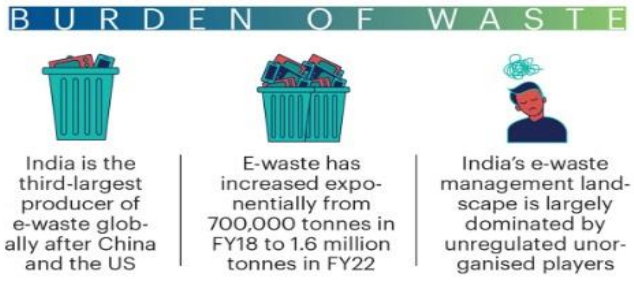


Figure No. 1: E –Waste accumulation in exploding in the country

The PM's decision to address the mounting problem of e-waste is not without reason. India currently ranks third among the largest generators of e-waste globally, behind only China and the US. The volume of e-waste in India has witnessed a significant surge—from 700,000 tonnes in 2017-18 to 1.6 million tonnes in 2021-22 (see chart). This explosion is being fed by a parallel explosion of electronic goods' consumption in India, with over 17 million TV sets, 148 million smart phones, 14 million refrigerators, 19 million audio devices and 6.5 million washing machines being sold across the country annually and growing, according to industry experts.

However, the issue extends beyond mere waste management. It also poses a significant environmental and health concern. E-waste consists of various hazardous substances, including lead, mercury and cadmium, which, if not disposed of properly, can contaminate the environment and lead to health problems. Adding to the challenge, a staggering 85 per cent of burgeoning e-waste is managed by the un-organised sector, primarily consisting of scrap dealers scattered across the country." "India's e-waste problem is complex, driven by the growing electronics market and rapid technological advancements.

Fully aware of the enormity of this challenge, the government has acknowledged the imperative to promptly and decisively tackle the issue of e-waste, and introduced the new E-Waste (Management) Rules, 2022, which supersede the previous regulations established in 2016. "India's e-waste policy was designed in 2011 and a lot of amendments were made in 2016 and 2018. Now, we have a new set of e-waste rules which was announced in 2022. In 11 years, the policy underwent several changes, keeping in tune with global demands and our own requirements in India.



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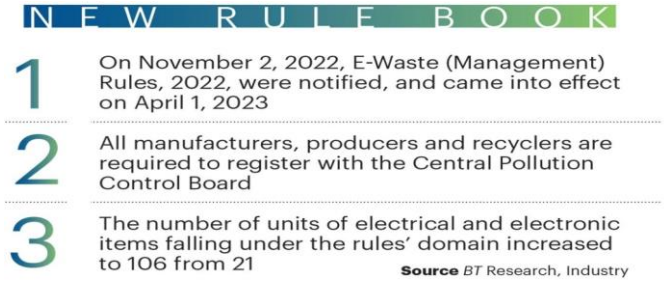

Figure No. 2: New e-waste rules notified in November 2022

III. E-WASTE MANAGEMENT

As required by the E-waste Management Rules, 2016, the Central Pollution Control Board (CPCB) calculates the amount of e-waste generated nationally using data from producers on nationwide sales as well as the average lifespan of notified electrical and electronic equipment (EEE). e-waste generated in the nation from twenty-one (21) types of EEE notified under the E-Waste (Management) Rules, 2016 was estimated to be 13,46,496.31 tonnes and 16,01,155.36 tonnes in the financial years (FY) 2020–21 and 2021–22, respectively, according to information available with CPCB. These figures are not significant when compared to other major economies of the world.

The Ministry completely updated the prior set of regulations, notifying the public in November 2022 of the E-Waste (Management) Rules, 2022, which will go into effect on April 1st, 2023. With the strengthened Extended Producer Responsibility (EPR) regime for e-waste recycling, these new regulations aim to handle e-waste in an environmentally sound manner. All manufacturers, producers, refurbishers, and recyclers must register on the CPCB-developed portal.

The proposed regulations would ensure that e-waste is recycled in an environmentally responsible manner and channel the informal sector into the formal sector for business purposes. Additionally, provisions for environment compensation as well as verification and audit have been added. These regulations also support the Circular Economy by promoting the EPR regime and scientific e-waste recycling and disposal.

State Pollution Control Boards (SPCBs) and Pollution Control Committees in every state and territory have put in place an Action Plan to enforce the E-Waste (Management) Rules nationwide. Additionally, a platform for reviewing e-waste management has been created to upload the progress and status of e-waste action plans. 5, 27,131.57 tons of e-waste were collected and processed in FY 2021–2022.

States/UTs wise details of e-waste collected and processed during FY 2021-22

There are presently 567 e-waste processing plants in the nation, with a combined yearly capacity of over 17.23 lakh tonnes. State processing is led by smaller states. 208 of these are recycling plants, having an installed capacity of 10.69 lakh tonnes per year for recycling. The Central Pollution Control Board (CPCB) statistics shows that just 33 percent of the total e-waste generated by India in 2021–2022 was collected and treated.16.01 lakh tonnes of e-waste were produced nationwide in 2021–2022. Just 5.27 lakh tonnes of material were gathered and processed.

Only Just Over a Third of India's E-Waste Gets Processed

As of 2021-22 (in tonnes)

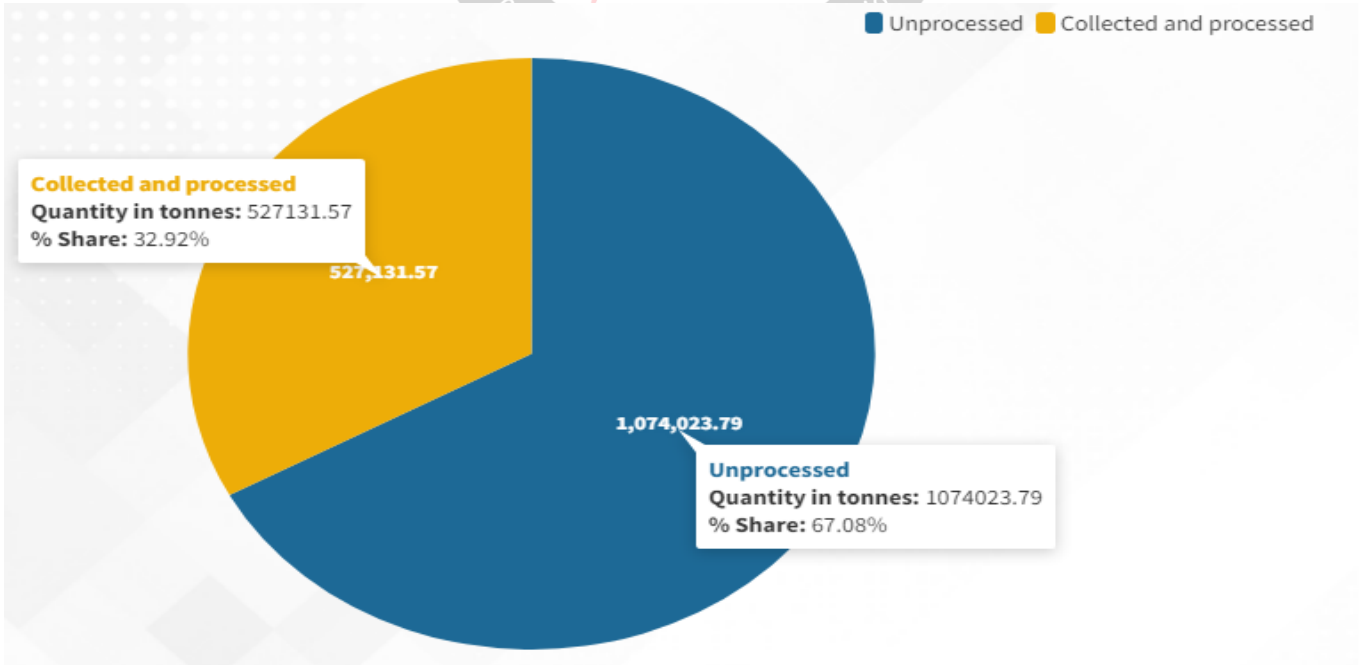

Figure No. 3: Processed and unprocessed E –Waste

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The details of e-waste collected and processed during FY 2021-22 States/UTs wise is given

S. No.	Name of the State	E-Waste collected and processed (in Tonnes)	S. No.	Name of the State	E-Waste collected and processed (in Tonnes)
1.	Andhra Pradesh	2021.19	15.	Kerala	1249.61
2.	Assam	67.00	16.	Madhya Pradesh	553.59
3.	Andaman &Nicobar Island	0.78	17.	Maharashtra	18559.30
4.	Bihar	41.07	18.	Mizoram	14.85
5.	Chhattisgarh	4167.90	19.	Odisha	477.54
6.	Chandigarh	67.92	20.	Punjab	28375.27
7.	Delhi	2130.79	21.	Puducherry	31.77
8.	Dadra and Nagar Haveli & Daman Diu	12.34	22.	Rajasthan	27998.77
9.	Gujarat	30569.32	23.	Sikkim	8.47
10.	Haryana	245015.82	24.	Tamil Nadu	31143.21
11.	Himachal Pradesh	373.20	25.	Telangana	42297.68
12.	Jammu & Kashmir	561.61	26.	Tripura	13.67
14.	Jharkhand	366.71	27.	Uttarakhand	51541.12
15.	Karnataka	39150.63	28.	West Bengal	320.44
Total (Sr. No. 1 to 28)		**5,27,131.57**			

Table No. 2: E-waste collected and processed during FY 2021-22 States/UTs

Source: PIB through Ministry of Environment, Forest and Climate Change – July 2023

According to the data provided by the ministry, in 2021-22, of the 16,01,155 tonnes of e-waste generated, 5,27,131 tonnes (32.9 per cent) were recycled. In 2020-21, 26.33 per cent of e-waste was processed, while in 2019-20, the figure stood at 22.07 per cent. It was 21.35 per cent in 2018-19 and 9.79 per cent in 2017-18.

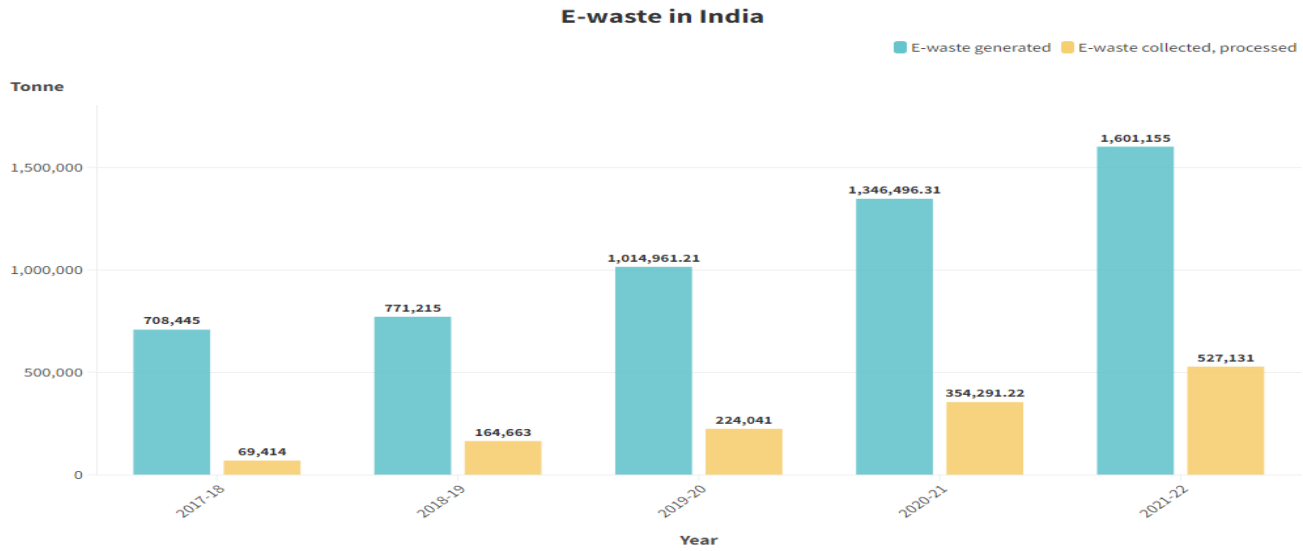

Figure No. 4: Year wise E –Waste generated and processed in India

Source: PIB through Ministry of Environment, Forest and Climate Change – July 2023

India currently has 567 e-waste processing facilities with a total capacity of around 17.23 lakh tonnes annually. Among these, 208 are recycling facilities with a total installed recycling capacity of 10.69 lakh tonnes annually.

Rank	Indian State	E-waste Collected and Processed
1	Haryana	245,015.82
2	Uttarakhand	51,541.12
3	Telangana	42,297.68
4	Karnataka	39,150.63
5	Tamil Nadu	31,143.21
6	Gujarat	30,569.32
7	Punjab	28,375.27
8	Rajasthan	27,998.77
9	Maharashtra	18,559.30
10	Chhattisgarh	4,167.90

Table 3: Top 10 states/UT in terms of e-waste collected and processed

Source: Government reply to the Parliament in 2023

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The states that gathered and processed the most amounts of e-waste between 2021 and 2022 were also listed in the data. With 2.45 lakh tonnes of e-waste collected and processed, Haryana topped the list. Telangana, which processed 42,298 tonnes of e-waste, came in second place on the list after Uttarakhand, which collected and processed 51,541 tonnes.

As of 2019, India is the third-largest producer of electronic garbage worldwide. Nevertheless, the nation nevertheless produces very little e-waste per person. China is the world leader in e-waste generation, yet its per-capita garbage generation remains lower than that of other nations.

Source: This information was given by Union Minister of State for Environment, Forest and Climate Change Shri Ashwini Kumar Choubey in a written reply in the Rajya Sabha on 20th July 2023. https://pib.gov.in/PressReleasePage.aspx?PRID=1941054

By Region: Major e-waste generating cities in India

In India, the amount of e-waste generated differs by state. The three states that produce the most e-waste are as follows: Maharashtra, Tamil Nadu and Andhra Pradesh. Other states that produce significant e-waste are Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab.

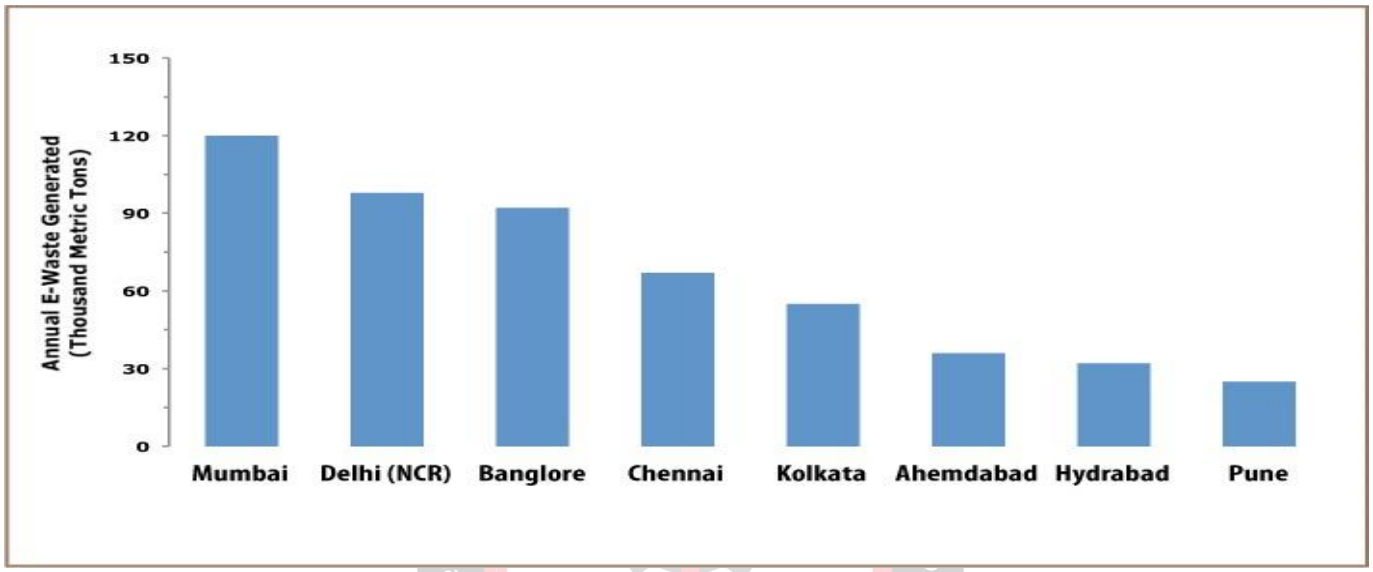

Figure No. 5: City wise E –Waste generated in India

Source: Government reply to the Parliament in 2023

Additionally, e-waste is disproportionately generated in urban areas—65 Indian cities generate more than 60% of India's total e-waste. Mumbai is the top e-waste producer followed by Delhi, Bengaluru, Chennai, and Kolkata.

IV. GLOBAL SCENARIO

As of 2019, India is the third-largest producer of electronic waste worldwide. Nevertheless, the nation still produces relatively little e-waste per person.

Biggest Producers of E-Waste across the World

(Ranked by total waste generated)

As of 2019(in kilotonne)

Rank	Country	E-waste generated
1	China	10,129.00
2	United States	6.92
3	India	3,230.00
4	Japan	2,569.00
5	Brazil	2,143.00

Table No. 4: Biggest Producers of E-Waste across the World (Ranked by total waste generated)

Source: Global E-Waste Monitor 2020

China produces the most e-waste globally, but, like India, it still scores lower when it comes to the amount of waste produced per person. Developed economies generate higher per capita amounts of e-waste.

Norway leads the world in the amount of e-waste produced per person in 2019 with 26 kg. With the exception of the US (ranked ninth) and Australia (ranked fifth), every other nation in the top ten producers of e-waste per person is in Europe.

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Biggest Producers of E-Waste across the World

(Ranked by per-capita waste generated)

As of 2019(in kg per capita)

Rank	Country	E-waste generated
1	Norway	26.0
2	United Kingdom	23.9
3	Switzerland	23.4
4	Denmark	22.4
5	Australia	21.7
91	**China**	**7.2**
132	**India**	**2.4**

Table No. 5: Biggest Producers of E-Waste (Ranked by per-capita waste generated)

Source: Global E-Waste Monitor 2020

Which Country is best in E-waste Recycling?

According to the most recent data available, Estonia, Norway, and Iceland have the best rates of recycling electronic waste when considering the percentage of waste that each nation produces.

Rank	Country	E-Waste Recycled (Kt)	Recycling Rate
1	Estonia	13	76%
2	Norway	99	72%
3	Iceland	5	71%
4	Sweden	141	70%
5	Austria	116	69%
6	Switzerland	123	63%
7	Finland	65	61%
8	Poland	246	60%
9	Ireland	52	59%
10	UK	871	57%

Table No. 6: Top 10 countries with highest recycling rate E-Waste across the World

The top 10 e-waste recycling countries are ranked by the percentage of their waste that is formally collected for proper recycling, while the total amount recycled (in KiloTons) is also shown for reference.

V. National E-Waste Legislation/Policy or Regulation in Place:

The global status of e-waste laws and regulations is depicted in the map below. The data used in this visualization comes from a number of sources, including government websites, online media outlets, and The Global E-waste Monitor.

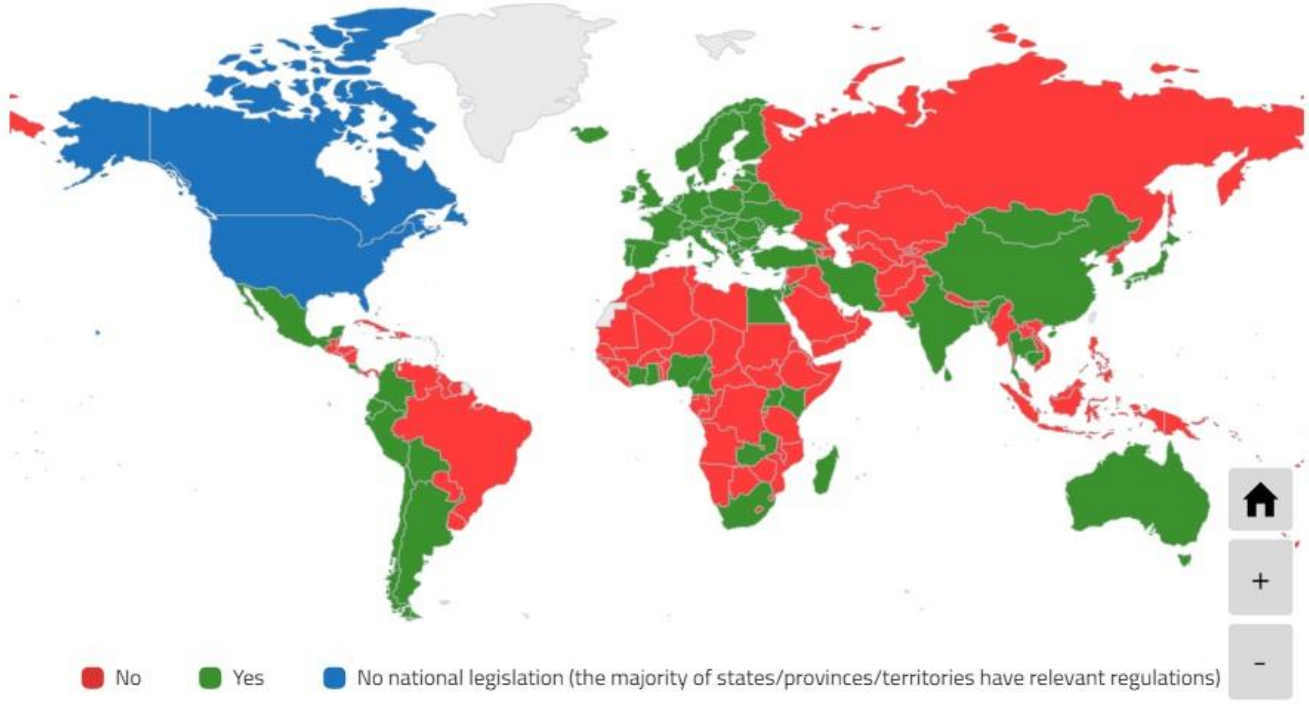

Figure No. 6: Graphical presentation of countries with E –Waste policies

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Sources: Regional E-Waste Monitor CIS + Georgia 2021, The Global E-Waste Monitor 2020

The UN has also spoken out about the escalating issue of e-waste, frequently announcing a "global tsunami of e-waste." Numerous international organizations have stressed how critical it is to address the global e-waste problem quickly and effectively.

VI. Environmental and Health Implications of E-waste

A. Three Scary Effects of E-Waste on Environment

In this section, three scary effects of e-waste are discussed in greater depth.

a. E-waste negatively Impacts the Soil

Initially, the soil in a given area may suffer harm due to electronic waste. Toxic heavy metals are released when electronic waste decomposes. These heavy metals consist of cadmium, lead, and arsenic. These poisons affect the plants and trees that are growing out of the soil when they seep into it.

As a result, these pollutants may find their way into the food chain, increasing the risk of birth defects and other illnesses.

b. E-waste negatively Impacts the Water

Groundwater contamination also results from residents' or businesses' inappropriate disposal of e-waste. A large number of surface streams, ponds, and lakes are supported by this groundwater. These waterways provide food for a wide variety of animals. Therefore, these toxins have the potential to harm these animals and throw the planet's ecosystem out of balance.

E-waste can affect people who depend on this water as well. Lead, barium, mercury, and lithium are among the toxins that are thought to be carcinogenic.

c. E-waste negatively Impacts the Air

When e-waste is dumped at a landfill, it is typically burned in on-site incinerators. This process has the potential to release hydrocarbons into the atmosphere, which contaminates the air that many humans and animals depend on for survival.

Moreover, the greenhouse gas effect, which many scientists believe plays a major role in global warming, can be exacerbated by these hydrocarbons.

B. Scary Effects of E-Waste on Health

Diseases caused by E-waste in human beings

Hazardous Components	Present In	Consequences of hazardous components being present in E-waste	References
Arsenic	Semiconductors, diodes, microwaves, LEDs, solar cells	The nervous system and the skin may be impacted. Long-term asbestos exposure can cause lung cancer.	(Yang et al., 2020, Kumarathilaka et al., 2018, El-Ghiaty and El-Kadi, 2021)
Asbestos	Insulators in heating equipment's	Breathing problems, coughing, lung damage, and even cancer are all serious adverse effects.	(Debnath et al., 2021, Disposal of Asbestos, 2022)
Barium	Fillers for plastics and rubbers, as well as electron tubes.	Heart muscle can be affected by this	(Pinto, 2008, Ari, 2016)
BFR	Different Casing, circuit boards, chips	The reproductive and immune systems may be harmed. Hormone imbalances and endocrine system issues are possible side effects.	(Julander et al., 2014, Segev et al., 2009)
CD	PCB, batteries, some pigments, solders, and alloys	Joints and the spine are particularly vulnerable, resulting in terrible pain. It weakens the bones and damages the kidneys.	(Ari, 2016, Yang et al., 2013, Grant et al., 2013)
CFC	Cleaning solvents, refrigerants, and aerosol propellants.	There is a risk of skin cancer and perhaps genetic harm as a result.	(Salhofer, 2017)
CR	Dyes, pigments	Asthma, bronchitis, lung cancer, as well as damage to the liver and kidneys, are all possible side effects.	(97% of collected E-waste recycled for useful applications, 2022)
Dioxins	(PWB), different type of cables and from metal smelting	Increased cancer risk	(Tue et al., 2019)
Pb	Thermal elements that convert heat into electricity, such as thermoelectric elements, thermocouples, and thermostats	The kidneys, reproductive system, and nervous system may all be impacted. It's possible that this causes blood and brain	(Yang and Zhang, 2018, Zeng et al., 2020)

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		illnesses.	
Li	Batteries of mobiles, photographic equipment	Long-term exposure to lithium vapours can cause nausea, vomiting, disorientation, and muscular weakness, among other things.	(A Closer Look, 2022, Saha et al., 2021, Zhang et al., 2012)
Hg	Batteries, flat screen monitors, copper machines, switches,	It has a deleterious influence on the central nervous system, kidneys, and immunological system, as well as on foetal development. It has the potential to harm the brain or liver, as well as cause skin issues.	(Decharat, 2018)
PAH	Wiring, printed circuit boards	Eye discomfort, nausea, vomiting, diarrhea, and disorientation are all possible side effects of this medication. Long-term exposure can result in cataracts, kidney and liver damage, as well as jaundice and other symptoms.	(Wang et al., 2012, Sánchez-Quiles and Tovar-Sánchez, 2015)
PVC	Cables, insulation coating	It can cause respiratory and immune system damage.	(E-Waste – Silicon Valley Toxics Coalition, 2022, Kurup and Senthil Kumar, 2017, Stapleton et al., 2008)
(PCB	Transformers, capacitors, softening agents	Damage can occur to the immunological system, reproductive system, neurological system, and endocrine system. PCBs are a concern to the environment as a result of their continual pollution.	(Stapleton et al., 2008, Tai et al., 2020, Managing And Reducing E-Waste From PCBs, 2022)

Table No. 7: Diseases caused by E-waste in human beings

Indian Enforcement Agencies involved in E-waste:

1. **Ministry of Environment Forest and Climate Change, Government of India** is responsible for identification of hazardous wastes and provides permission to exporters and importers under the Environment (protection) Act, 1986.
2. **Central Pollution Control Board (CPCB) was constituted under the Water (Prevention and Control of Pollution) Act, 1974.**
   - CPCB coordinates activities with the State Pollution Control Boards and ensures implementations of the conditions of imports.
   - It also monitors the compliance of the conditions of authorization, import and export and conduct training courses for authorities dealing with management of hazardous wastes.

VII. Current Challenges for e-Waste Elimination

1. **Cost of recycling e-Waste exceeds the revenue recovered:**
   - In many cases, the cost of recycling e-Waste exceeds the revenue recovered from materials especially in countries with strict environment regulations.
2. **e-Waste Dumped in poor countries:**
   - E-Waste mostly ends up dumped in countries where environmental standards are low or nonexistent and working conditions are poor.
3. **Lack of Waste Removal Infrastructure:**
   - Most developing countries lack the waste removal infrastructure and technical capacities necessary to ensure the safe disposal of hazardous waste.
4. **Variety of Health Problems:**
   - E-Waste has been linked to a variety of health problems, including cancer, neurological and respiratory disorders, and birth defects.

VIII. Solution & Ways to Manage e-Waste

1. **Store Data Online:**
   - By storing data online, we can still access our data from anywhere around the world, without the need to carry a storage device at all times.
   - Cloud storage also gives us a large amount of storage, for free or very cheap.
2. **Buy Energy Star Rated Electronics:**
   - A device with a high Energy Star rating uses less energy, which dramatically lowers our electricity bill.
   - Moreover, by preventing overuse, it prevents the depletion of resources (energy) because less energy is needed.
3. **Spread awareness:**
   - Appropriate awareness-raising, education, and—above all—the provision of alternative, reasonably priced technology are necessary in order to give individuals who depend on this for their livelihood better options.

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Suggestions

- To address India's e-waste management challenges, a comprehensive strategy is required. To integrate big organized sector units and small unorganized sector units into a single value chain, an appropriate mechanism must be developed.
- Hazardous materials found in e-waste must be handled carefully because they pose a risk to human health and the environment if improperly handled or disposed of.
- Tight regulations regarding e-waste are urgently needed.
- Efforts to educate consumers about "post-life" disposal of outdated electronics, such as government-implemented take-back programs.

CONCLUSION

In conclusion, e-waste management is a critical issue that must be addressed in order to protect the environment and human health. By reducing, collecting, recycling, properly disposing of, and regulating e-waste, we can ensure that hazardous materials are properly handled and valuable resources are recovered and reused, consequently helping us move towards a sustainable future.

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ASSOCHAM-KPMG report on E- Waste 2019, 2020 and 2021

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