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Article

NAVIGATING INDIA'S E-WASTE PROBLEM: POLICIES, PRACTICES, AND FUTURE DIRECTIONS

Shashi V. Ranga[1], Lopa K Sanghavi[2], Abhinav M. Mehta[3]

[1]Government engineering college, near Sanskar Kendra, behind B. K. M. Science College on Tithal Road, Valsad, Gujarat, India 396001
[2]Government Polytechnic College, Airport Ring Rd, Uma Nagar, Bhuj, Mirjapar Part, Gujarat, India 370040
lopasanghavi.sh@gpbhuj.ac.in
[3]The Geographical Information System, 526, Iscon Emporio, Jodhpur Cross Rd, Satellite, Ahmedabad, Gujarat, India 380015

Abstract: E-waste refers to discarded electrical and electronic devices that are obsolete or no longer useful to their owners. This waste stream is highly complex, containing both valuable materials like gold and copp er, and hazardous substances such as lead, mercury, and cadmium. Improper handling of e-waste poses serious health and environmental risks. India is currently the third-largest generator of e-waste globally, and the volume is expected to grow rapidly with increasing digitization and consumer demand. Although India has introduced a legal framework for e-waste management under the E-Waste (Management) Rules, 2016 and its 2022 amendment, the implementation still faces major challenges. Until recently; most e-waste was handled by the informal sector, using unsafe methods such as open burning and acid baths. With the new rules in place, efforts are being made to regulate collection, recycling, and disposal through formal systems. However, e-waste management remains complex due to the involvement of multiple stakeholders—manufacturers, consumers, collectors, and recyclers. Awareness is still low, and infrastructure for proper handling is lacking in many regions. This paper reviews current practices, the associated risks of unscientific disposal, and the legal mechanisms in place, while highlighting the ongoing challenges in achieving effective e-waste management in India.
Keywords: E-waste, Electronic waste, E-waste management, India, Informal recycling, Extended Producer Responsibility (EPR), Hazardous materials, Legal framework, Sustainable disposal, Digital waste

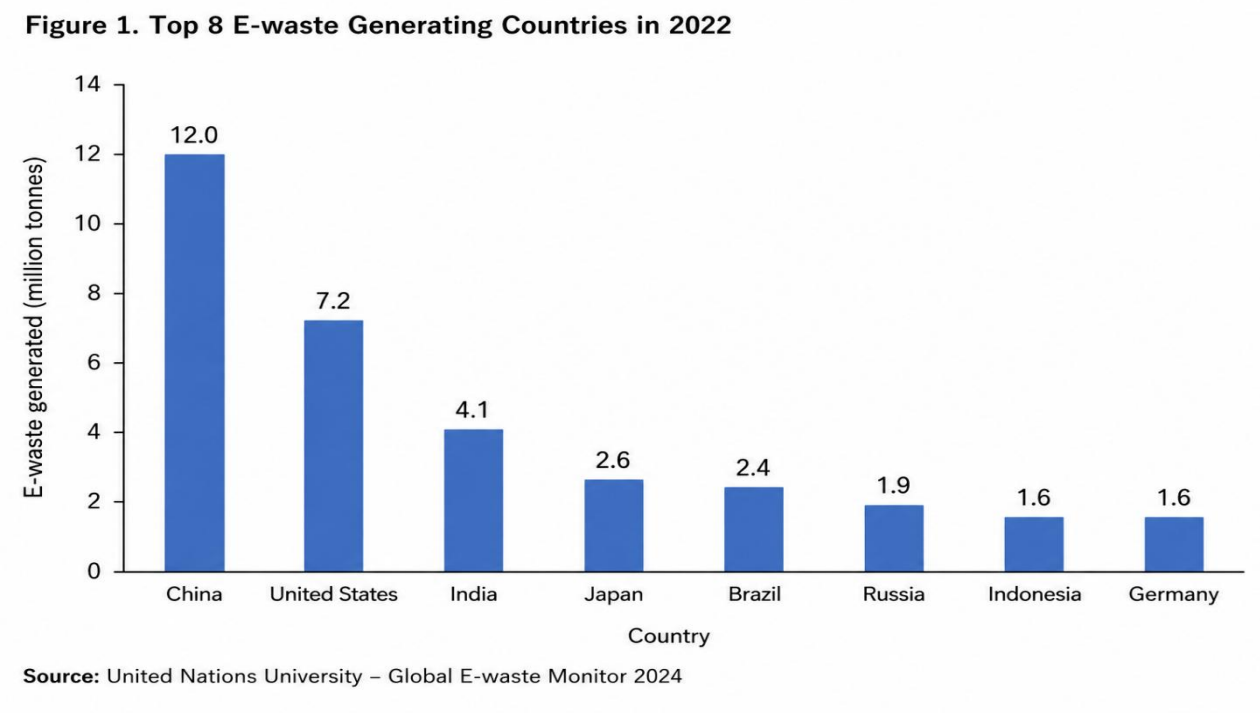
1.Introduction

E-waste is a highly complex waste stream containing both valuable materials and toxic components, including lead, cadmium, mercury, and flame retardants (Kahhat et al., 2008). The global production of electrical and electronic equipment (EEE) is rapidly increasing due to technological advancements, evolving consumer behavior, and economic growth (Terazono et al., 2006; Needhidasan et al., 2014).

Managing e-waste is a significant global challenge, particularly for rapidly industrializing and highly populated countries. According to the Global E-waste Monitor 2024, approximately 62 million tonnes of e-waste were generated worldwide in 2022, of which only 22.3% was documented as formally collected and recycled. China was the largest generator of e-waste, followed by the United States and India, which generated approximately 12.0, 7.2 and 4.1 million tonnes, respectively. Other major generators included Japan, Brazil, Russia, Indonesia and Germany. These figures highlight the growing pressure on countries to strengthen e-waste collection, recycling infrastructure and environmentally sound management practices. (Global E-Waste Monitor, 2024; Down to Earth, 2024).

In the current digital age, where electronic consumption is growing rapidly, recycling e-waste in a safe, scientific, and efficient manner is crucial. India has introduced a comprehensive legal framework under the E-Waste (Management) Rules, 2022, which extended the list of regulated EEE items from 21 to 106 categories (MoEFCC,

2022). However, implementation challenges remain, as over 95% of e-waste is still processed by the informal sector, which uses unsafe methods (Agarwal, 1998; Wikipedia, 2024). Though India has over 320 authorized recyclers, only 43% of the e-waste generated in 2023–24 was treated formally, with the rest unaccounted for (CrackitToday, 2024).



(Source: Global E-Waste Monitor, 2024; Down to Earth, 2024)

Fig. 1 Global E-waste generation by country

2.Composition of E-Waste and Associated Health Hazards

E-waste is a highly complex waste stream containing both valuable materials (like copper, gold, and palladium) and hazardous components (such as lead, cadmium, and brominated flame retardants) (Kahhat et al., 2008). It includes items like computers, mobile phones, refrigerators, televisions, and various electrical appliances. On average, ferrous metals account for about 60%, plastics 30%, and hazardous substances around 2–3% of total weight (Puckett et al., 2002). Recent 2026 research of WHO highlights an expansion of this composition to include "new-age" waste streams, notably lithium-ion batteries, solar photovoltaic (PV) panels, IoT sensors, and AI server hardware. Several toxic components in e-waste pose serious risks to human health:

- Lead (Pb): Found in CRTs and solder; causes cognitive impairment, kidney damage, and reproductive issues (Grant et al., 2013).
- Cadmium (Cd): Used in batteries and semiconductors; causes kidney damage and bone demineralization (WHO, 2017).
- Mercury (Hg): Present in LCDs and switches; affects the nervous system and kidneys, especially in children and pregnant women (WHO, 2021).
- Hexavalent Chromium (Cr-VI): Used for metal coatings; known to damage DNA and the respiratory tract (Robinson, 2009).
- Polybrominated Diphenyl Ethers (PBDEs): Flame retardants used in plastic casings; endocrine disruptors and linked to developmental neurotoxicity (Sepúlveda et al., 2010, WHO, 2026).

In India, much of e-waste is handled by the informal sector, where open burning and acid baths are common for recovering metals. This has resulted in air, water, and soil contamination in cities like Delhi, Moradabad, and Bengaluru, with elevated levels of lead, cadmium, and mercury found in blood samples of workers and residents (Chatterjee, 2012; CSE, 2023). Children and women are especially vulnerable due to long-term exposure to these toxicants.

Although India has introduced e-waste rules with an extended producer responsibility (EPR) framework, enforcement remains weak, and recycling practices are still predominantly unsafe and unscientific (CPCB, 2021).

Table 1: Toxic Chemical Constituents in E-Waste and Their Health Effects

Chemical	Common Sources in E-Waste	Health Effects	Citations
Lead (Pb)	CRT glass, solder in PCBs, monitors	Neurotoxicity, impaired cognitive development in children, anemia, kidney and reproductive damage	Grant et al., 2013[1]
Cadmium (Cd)	Batteries, semiconductors, PCBs	Cumulative toxin; kidney damage; bone demineralization; lung cancer	WHO, 2017[2]
Mercury (Hg)	Switches, relays, CFLs, LCDs	Neurobehavioral deficits, kidney damage, respiratory and skin disorders; bioaccumulates in fish	WHO, 2021[3]; Robinson, 2009[4]
Hexavalent Chromium (Cr-VI)	Circuit coatings, metal plating	DNA damage, asthmatic bronchitis, carcinogenic	Robinson, 2009[4]
Beryllium (Be)	Motherboards, ceramics, power supplies	Lung cancer, chronic berylliosis, skin lesions	Sepúlveda et al., 2010[5]
Antimony (Sb)	Circuit boards	Dermatitis, respiratory irritation, suspected carcinogen	Sepúlveda et al., 2010[5]
BFRs (PBDEs/PBBs)	Plastic casing, insulation	Endocrine disruption, neurodevelopmental effects, immune system dysfunction, releases dioxins when burned	Sepúlveda et al., 2010[5]; WHO, 2021[3]
PCBs	Capacitors, cable insulations	Liver damage, neurotoxicity, tumors, reproductive disorders	Grant et al., 2013[1]
Chlorobenzenes/PAHs	Pigment solvents, combustion byproducts	CNS, liver, and thyroid toxicity; carcinogenic; oxidative DNA damage	Sepúlveda et al., 2010[5]
CFCs, HFCs, HCFCs	Refrigerants in air conditioners and refrigerators	Ozone layer depletion, indirect contribution to global warming	Robinson, 2009[4]
Phthalates	Plasticizers in cables, rubber, housing	Endocrine disruption, reproductive toxicity, liver/kidney damage,	WHO, 2021[3]

		developmental effects in male fetuses	

3. Environmental & Health Impacts in India

Improper e waste recycling in India—commonly performed by the informal sector through open burning, acid leaching, or manual dismantling—has resulted in significant contamination of soil, air, and water, along with several public health hazards. The Study conducted in Moradabad, Uttar Pradesh, found zinc levels 15 times, copper 5 times, and mercury in water 8 times above safety thresholds. These heavy metals have been shown to act as neurotoxins and pose risks of entering the food chain (Centre for Science and Environment [CSE], 2023; Grant et al., 2013).In Delhi's Seelampur and parts of Bengaluru, residents and workers have reported respiratory illnesses, skin disorders, neurological symptoms, and blood lead levels up to 10 times above WHO-permissible limits (The Times of India, 2022; WHO, 2021).Research also indicates that populations residing near e-waste recycling hubs have higher exposure to polybrominated diphenyl ethers (PBDEs) and polychlorinated biphenyls (PCBs)—linked to thyroid dysfunction, immune suppression, and DNA damage (Sepúlveda et al., 2010; WHO, 2021).

4. India's Position in Global E-Waste Generation

India ranks as the third-largest generator of e-waste globally. Official data from the Ministry of Environment, Forest and Climate Change (MoEFCC) and Central Pollution Control Board (CPCB) indicates that India generated ~1.41 million metric tonnes (14.14 lakh MT) of formal e-waste in FY 2025–2026, with overall actual generation estimates exceeding 4.5 to 5.2 million tonnes annually.

- Informal Processing Hotspots: An estimated 85%–90% of unmanaged e-waste in India continues to be handled by informal networks. In hubs across Delhi-NCR, Moradabad, Bengaluru, and Bhopal, informal processing—via open burning, wire stripping, and unregulated acid leaching—releases high levels of heavy metals into soil, ambient air, and groundwater reserves (Chatterjee, 2012; CSE, 2023; DTE, 2026).
- Vulnerable Populations: Informal sector workers, nearby residential communities, pregnant women, and children experience chronic toxicant exposure, resulting in elevated blood lead levels, respiratory diseases, and developmental delays (WHO, 2026).
- Regulatory Enforcement & Compliance (2026 Framework): While India introduced the E-Waste (Management) Rules under an Extended Producer Responsibility (EPR) structure, full compliance historically faced enforcement bottlenecks (CPCB, 2021). As of 2026, regulatory mechanisms have tightened through mandatory registration on the CPCB online EPR portal, stricter performance auditing, and mandated implementation of high-grade air filtration and Zero Liquid Discharge (ZLD) systems for authorized recyclers.

5. Regulatory Framework and Policies

To address the growing e-waste problem, the Ministry of Environment, Forest and Climate Change (MoEFCC) introduced the E-Waste (Management) Rules in 2016, which were later amended in 2018 and again in 2022. These rules emphasized Extended Producer Responsibility (EPR), requiring producers to collect back their electronic waste and channel it through registered recyclers (MoEFCC, 2018). The framework also mandates the registration of dismantlers and recyclers, tracking e-waste flows, and safe disposal.

Despite these progressive regulations, the implementation remains weak due to inadequate enforcement, limited awareness among stakeholders, and lack of adequate recycling infrastructure (Borthakur & Govind, 2017).

6. The Role of the Informal Sector

In India, over 70% of e-waste is processed by the informal sector, which includes small-scale workers and unlicensed dismantling units. These entities often use unscientific methods such as open burning, acid baths, and manual dismantling without protective equipment (Sepúlveda et al., 2010). This poses serious risks not only to the

health of the workers but also to the environment. Hazardous substances leach into the soil, contaminate water bodies, and pollute the air.

In places like Seelampur (Delhi) and Moradabad (Uttar Pradesh), high levels of heavy metals and toxins have been reported in soil and water samples (CSEIndia, 2021). Informal workers have also shown symptoms of respiratory issues, neurological damage, and reproductive health disorders (WHO, 2021).

7. Current Challenges in E-Waste Management (India)

Despite having a defined regulatory framework, India continues to struggle with the efficient management of electronic waste. The following are the major challenges:

7.1 Low Consumer Awareness

One of the foremost challenges is the lack of awareness among consumers—both individual and institutional, regarding the proper disposal of electronic products. Most users are unaware that e-waste contains toxic substances like lead, cadmium, mercury, and flame retardants, which pose serious environmental and health risks. This lack of knowledge leads to improper disposal methods, such as mixing e-waste with household garbage or selling it to informal scrap dealers. There is also minimal awareness about formal collection centers and recycling options. Campaigns for behaviour change and widespread sensitization have not yet reached a critical mass.

7.2 Informal Sector Dominance

India's e-waste landscape is largely dominated by the informal sector, which manages more than 70% of the total e-waste generated. Informal recyclers often employ unsafe methods like open burning, manual dismantling without protective gear, and acid leaching to extract valuable materials. These processes not only cause significant environmental pollution but also endanger the health of workers. The informal sector is deeply rooted and preferred by many due to its door-to-door services, immediate cash payment, and lower costs compared to formal channels.

7.3 Limited Recycling Infrastructure

India lacks adequate infrastructure to manage and recycle the large volume of e-waste it produces. Only a limited number of cities and industrial zones have formal e-waste dismantling and recycling units that are environmentally compliant and technologically equipped. Moreover, many existing authorized recyclers operate below capacity due to insufficient input supply, often because e-waste is diverted to the informal sector. The absence of a strong reverse logistics system also hampers the collection and channelization of e-waste to authorized recyclers.

7.4 Weak Enforcement of Rules

Although India has introduced detailed rules such as the E-Waste (Management) Rules, 2016 (amended in 2018 and 2022), their enforcement on the ground remains weak. Monitoring mechanisms are either under-resourced or poorly implemented. Many producers and importers either fail to fulfill their Extended Producer Responsibility (EPR) obligations or report misleading data. Local authorities often lack the technical expertise, manpower, or coordination required to ensure that all stakeholders comply with the law. Corruption and administrative inefficiency also hinder enforcement efforts.

7.5 Data Gaps

Reliable and up-to-date data on e-waste generation, collection, and recycling are critically lacking. This data deficiency hampers effective policy-making, planning, and monitoring. Although producers are mandated to report e-waste volumes, discrepancies in reporting and lack of third-party audits make the data unreliable. Furthermore, the informal sector's operations are undocumented, creating a significant "data black hole" in understanding the full scale and impact of e-waste in the country.

8. Recommendations and the Way Forward

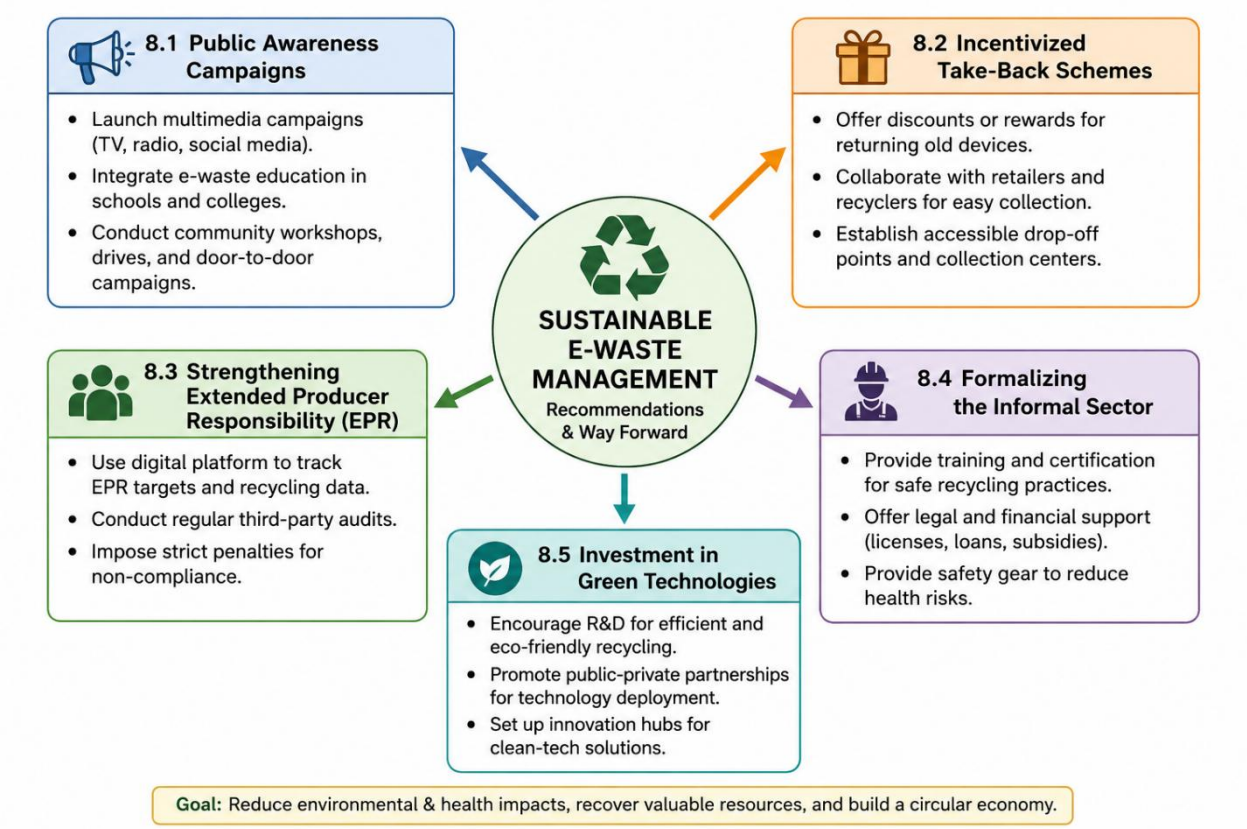


Fig. 2 Recommendations for E-Waste Management

8. 1 Public Awareness Campaigns

- Building public awareness is essential to tackle the growing problem of e-waste. Citizens often lack the knowledge about how to dispose of electronic items responsibly or the environmental and health hazards associated with improper handling.
- Launch Multimedia Campaigns: Run national awareness drives using TV, radio, and social media to inform people about e-waste hazards and proper disposal methods.
- Integrate E-Waste Education in Schools: Include e-waste and environmental education in the school and college curriculum to develop eco-consciousness among the youth.
- Community Workshops and Drives: Conduct workshops, door-to-door campaigns, and e-waste collection drives in residential areas, promoting community involvement in proper disposal practices.

8. 2 Incentivized Take-Back Schemes

- Consumers are more likely to return old electronics if they are rewarded or provided with convenient options. These schemes help divert e-waste from the informal sector to authorized channels.
- Offer Discounts or Rewards: Give financial incentives like discounts on new products or reward points when consumers return old devices Collaborate with Retailers and Recyclers: Form alliances with electronics retailers to ensure easy collection and proper channeling of e-waste.
- Establish Drop-Off Points: Install clearly marked, accessible drop-off bins or collection centers in shopping areas, service centers, and public institutions.

8. 3 Strengthening Extended Producer Responsibility (EPR)

- EPR mandates that producers take responsibility for managing their products once they reach the end of their lifecycle. However, enforcement and tracking remain weak.
- Digital Monitoring: Use a centralized digital platform to track EPR targets, collection quantities, and recycling metrics for each producer.
- Third-Party Audits: Conduct regular independent audits to verify the authenticity of producer-submitted data.
- Strict Penalties: Impose financial penalties and revoke licenses for repeated non-compliance or underperformance.

8. 4 Formalizing the Informal Sector

- A large portion of India's e-waste is processed by informal workers, often without proper tools or safety measures, leading to environmental and health issues.
- Training and Certification: Conduct training programs to educate informal workers on safe recycling practices and certify them to ensure standardization.
- Legal and Financial Support: Provide licenses, micro-loans, or subsidies to help informal recyclers operate within the formal framework.
- Provision of Safety Gear: Equip workers with gloves, masks, and protective clothing to reduce health risks during handling and dismantling.

8. 5 Investment in Green Technologies

- Eco-friendly innovations in recycling can help recover valuable materials while minimizing environmental impact. Currently, the adoption of such technologies in India is limited.
- Encourage R&D: Support research on new methods of recycling that are less polluting and more efficient.
- Promote Public-Private Partnerships: Involve startups, industry, and academic institutions in pilot projects and technology deployment.
- Set Up Innovation Hubs: Establish incubators and technology parks dedicated to clean-tech solutions in e-waste management.

9. Legislative Frameworks for E-Waste Management in India

9.1 Implementation Agencies

- The Ministry of Environment, Forest and Climate Change (MoEF&CC) is responsible for formulating national policies, issuing notifications, and revising the regulatory framework as needed.
- The Central Pollution Control Board (CPCB) serves as the implementing and coordinating authority at the national level. It monitors compliance, manages the online EPR portal, and provides guidance to state authorities.
- The State Pollution Control Boards (SPCBs) act as the local enforcement agencies. They handle authorization and registration processes, conduct inspections, monitor e-waste collection centers and recyclers, and ensure compliance within their respective states (CPCB, 2023).

India's e-waste policies have evolved through major regulatory milestones over the past two decades. The Ministry of Environment, Forest and Climate Change (MoEF&CC) initiated formal regulation in 2011, with the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) playing major roles in enforcement, authorization, and compliance (MoEF&CC, 2011).

9.2 Legal Foundation and Preceding Regulations

The foundation of India's environmental governance lies in the *Environmental Protection Act, 1986*. This act empowers the central government to take necessary measures to protect and improve the environment. It provides the legal authority for developing and implementing environmental rules, including those related to the management of electronic waste (Government of India, 1986).

Before e-waste was recognized as a distinct category, it was managed under the *Hazardous Wastes (Management, Handling & Transboundary Movement) Rules, 2008*. These rules classified discarded electrical and electronic products as hazardous waste and established guidelines for their handling, storage, transportation, and disposal. This framework laid the groundwork for specialized e-waste legislation (MoEF&CC, 2008).

Environmental Protection Act, 1986:

This foundational act empowers the Central Government to take necessary actions for environmental protection. It serves as the legal base for all environmental regulations, including e-waste management (Government of India, 1986).

Hazardous Wastes (Management, Handling & Transboundary Movement) Rules, 2008:

Before e-waste-specific regulations were introduced, electronic waste was classified under hazardous waste, requiring special handling and disposal protocols (MoEF&CC, 2008).

2011 – E-Waste (Management & Handling) Rules, 2011:

India's first dedicated e-waste regulation came into effect in May 2012. These rules introduced Extended Producer Responsibility (EPR), emphasizing collection centers, take-back systems, and defined roles for stakeholders (MoEF&CC, 2011).

2016 – E-Waste (Management) Rules, 2016:

These rules replaced the 2011 framework, expanding product coverage, setting quantitative collection and recycling targets, and requiring stricter authorization for all handlers of e-waste (MoEF&CC, 2016).

2018 – E-Waste (Management) Amendment Rules, 2018:

This amendment relaxed some compliance deadlines, especially for small businesses, and refined mechanisms within the EPR framework (MoEF&CC, 2018).

2022 – E-Waste (Management) Rules, 2022 (Effective April 1, 2023):

The latest revision digitized the compliance process, emphasized traceability, introduced digital EPR certificates, and imposed environmental compensation for non-compliance. It also integrated Producer Responsibility Organizations (PROs) to support collection and recycling (CPCB, 2022; MoEF&CC, 2022).

9.3 Main Key Points of E-Waste Policies

- **Extended Producer Responsibility (EPR)**

The core principle of India's e-waste management system is EPR. It mandates that producers, including manufacturers, importers, and brand owners, are accountable for the lifecycle of their electronic products. They must ensure that products reaching the end of their life are collected and properly recycled. Producers can fulfill this obligation through individual collection mechanisms, collective take-back systems, or through Producer Responsibility Organizations (PROs). This approach encourages sustainable design, reduces waste generation, and promotes a circular economy (MoEF&CC, 2022).

- **Registration and Authorization**

All entities involved in e-waste handling — including producers, dismantlers, recyclers, and collection centers — must register with the relevant Pollution Control Board through the centralized online EPR portal. Registration ensures accountability and helps authorities track the flow of e-waste. Unregistered operators are not permitted to handle e-waste, a measure designed to eliminate unsafe and informal recycling practices (CPCB, 2023).

- **Collection and Recycling Targets**

Each version of the e-waste rules has included mandatory collection and recycling targets for producers. Initially set at 30% in the 2016 rules, these targets have gradually increased to push producers toward greater environmental responsibility. Producers must report their progress through the EPR portal, and failure to meet targets can result in penalties or loss of authorization (MoEF&CC, 2016).

- **Hazardous Substance Restrictions**

The regulations restrict the use of hazardous substances such as lead, mercury, cadmium, and certain flame retardants in the manufacture of electronic equipment. This measure aligns India's standards with global directives like the EU's Restriction of Hazardous Substances (RoHS) Directive. Limiting these materials minimizes environmental contamination and protects human health (MoEF&CC, 2016).

- **Worker Safety and Skill Development**

The e-waste management framework emphasizes worker protection and capacity building. Recycling and dismantling facilities must provide workers with appropriate safety equipment and training to reduce occupational hazards. The rules also promote formal training and certification programs to improve the skills of workers transitioning from the informal to the formal recycling sector (CPCB, 2023).

- **Consumer and Dealer Responsibility**

Bulk consumers such as corporations, government departments, and educational institutions must maintain records of e-waste generated and ensure that discarded items are sent only to authorized recyclers. Dealers and refurbishers are also required to channel collected or obsolete items to authorized dismantlers or recyclers. This inclusion of consumers and intermediaries strengthens the accountability chain (MoEF&CC, 2022).

- **Awareness and Public Participation**

The rules encourage awareness campaigns, community participation, and collaboration with NGOs and private organizations to educate the public about the hazards of improper e-waste disposal. Public-private partnerships are promoted to improve collection efficiency and foster behavioral change toward responsible disposal practices (MoEF&CC, 2022).

- **Applicability of the Rules**

The e-waste regulations cover a wide range of products, including information technology and communication equipment (computers, mobile phones, printers), consumer electronics (televisions, refrigerators, washing machines), and lighting equipment. The 2022 rules also allow for periodic updates to include emerging technologies and devices, ensuring continued relevance in a rapidly changing electronic market (MoEF&CC, 2016).

India's e-waste management journey reflects an evolving approach toward environmental governance. From its roots in the *Environmental Protection Act* to the digitized EPR framework of 2022, the policy progression shows a clear shift toward sustainability, accountability, and modernization. The combined efforts of MoEF&CC, CPCB, and SPCBs have strengthened formal recycling systems, reduced unsafe informal practices, and advanced India's commitment to a circular economy and the "right to repair" movement (CPCB, 2023).

10.Limitations & Future Recommendations

Although integrating India's informal and formal e-waste recycling sectors offers a promising path toward a more efficient and sustainable system, the reality is complex:

10.1 Limitations

- **Scope of informal workforce:** The informal sector handles approximately **95% of e-waste**, involving nearly **1% of the national population**—primarily kabadiwalas, rag-pickers, and small scrap dealers (MDPI, 2022; PubMed, 2021).

- **Identification & Registration Challenges:** Registering and formalizing such a dispersed, informal workforce is arduous and time-consuming, affecting both compliance tracking and resource allocation (MDPI, 2022).
- **Limited infrastructure:** There are only **472 authorized dismantlers and recyclers**, whose collective capacity remains insufficient to manage nationwide e-waste volumes (MDPI, 2022; PubMed, 2021).
- **Competing informal incentives:** The informal sector offers convenient doorstep services and cash payments, drawing waste away from formal systems and exacerbating collection shortfalls (Hindrise 2024; MDPI, 2022).
- **Data & system gaps:** Lack of reliable national- and state-level datasets on e-waste generation severely limits policy planning and monitoring (ScienceDirect, 2022; Hindrise 2024)

10.2 Future Recommendations

To overcome these constraints and build a more equitable system, the following measures are recommended:

- Cluster-based formalization: Local authorities should deploy cluster models—like those piloted in Chandigarh—to register informal workers, support collective certification, and create shared logistics frameworks (Chandigarh study, 2025).
- Digital integration tools: Implement mobile or app-based platforms (similar to Uber models) to track and connect kabadiwalas, enable instant payments, and provide real-time reporting (Reddit insight, 2025).
- Capacity expansion in formal recycling: Boost capacities of authorized recyclers through incentives—grants, tax benefits, or public-private partnerships—to set up smaller, decentralized processing facilities across regions (MDPI, 2022; ScienceDirect, 2022).
- Public awareness and behavior change: Conduct targeted campaigns, especially in smaller towns and rural areas, to educate consumers about e-waste hazards and available collection options (Hindrise, 2024).
- Standardized data infrastructure: Establish a centralized, GST-like digital system for tracking e-waste generation, sales, imports, and recycling flows to improve transparency and enforcement (ScienceDirect, 2022).

11. Conclusion

Despite being the world's third-largest producer of e waste, India recycles only a small fraction—estimated at 5–10%—through formal systems, with the vast majority (~95%) handled by informal channels using unsafe practices (ScienceDirect, 2022; PubMed, 2021; Reuters, 2025). This not only results in poor material recovery but also poses grave environmental and public health risks.

E waste comprises both valuable recovery components and hazardous substances. Its dangerous chemical constituents—such as lead, mercury, cadmium, and brominated flame retardants—pose serious threats to human health, affecting the central nervous system, kidneys, respiratory tract, immune, endocrine, and reproductive systems. Informal recycling methods, which often involve open burning or acid leaching without protection, release toxins into the air, water, and soil, contaminating ecosystems and endangering lives (MDPI, 2022; PubMed, 2021).

To shift toward a circular and sustainable e-waste economy, India must strengthen formal recycling capacity, inclusively integrate the informal sector, and enforce Extended Producer Responsibility (EPR) more rigorously. Urgent scientific, regulatory, and infrastructural reforms are essential to protect both public health and the environment. Collaborative action involving government agencies, private industry, academic institutions, and grassroots collectors is critical to transforming this pressing challenge into a national opportunity.

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