E-waste

Treasure or Threat

Editor
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AUTHORS PRESS

Worldwide Circulation through Authorspress Global Network
First Published in 2023
by
Authorspress
Q-2A Hauz Khas Enclave, New Delhi-110 016 (India)
Phone: (0) 9818049852
E-mail: authorspressgroup@gmail.com
Website: www.authorspressbooks.com

E-waste: Treasure or Threat

ISBN 978-93-5529-774-7

Printed in India at Thomson Press (India) Limited

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E-waste Can't Be A Treasure, It's Hazardous

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Abstract

How can E-waste be considered Treasure - when it consists of both hazardous and non-hazardous parts which have ferrous and non-ferrous metals like platinum, gold, silver, palladium, aluminum, copper, etc., and if it is extracted and reutilized could prove to be a treasure for someone. Since it is also assembled with printed circuit boards, plywood, glass, wood and plastics, rubber, concrete, and ceramics, it leaves many hazardous gases and soil of dump yard or sea sore becomes most hazardous. Globally on October 14 every year, the day has been observed International E-waste Day since 2018. Waste electronic and electrical equipment (WEEE), a Brussels-based non-profit organisation gave some shocking statistics about the rising dump of E-waste. During 2021, E-waste was found total about 57.4 million tonnes (Mt) while Global E-waste Monitor reported that 53.6 Mt of WEEE were generated in 2019. That represented a 21% jump in the five years since 2014 (with E-waste predicted to reach 74 Mt by 2030). Thus, the 57.4 Mt E-waste will be greater than the weight of the great wall of China, earth's heaviest artificial object.

Keywords: E-waste, toxicity, environmental & occupational hazard,

Introduction

We know that E-waste is short for Electronic-Waste and the term is used to describe old, end-of-life or discarded electronic appliances. It includes their components, consumables, parts and spares:

First Published in 2023 by Authorspress
ISBN 978-93-5529-774-7

It is categorized into 21 types under two broad categories:

- Information technology and communication equipment.
- Consumer electrical and electronics.

Laws to manage E-waste have been in place in India since 2011, mandating that only authorized dismantlers and recyclers collect E-waste. E-waste (Management) Rules, 2016 was enacted in 2017. India's first E-waste clinic for segregating, processing and disposal of waste from household and commercial units has been be set-up in Bhopal, Madhya Pradesh.

E-waste treated as Treasure

E-waste consists of both hazardous and non-hazardous items including ferrous and non-ferrous metals like copper, aluminum, silver, gold, platinum, palladium, etc. Plastics, glass, wood and plywood, printed circuit boards, concrete, ceramics and rubber. These precious earth metals like copper, aluminum, silver, gold, platinum, palladium if extracted and reutilized could prove to be a treasure trove.

E-waste Treated as Threat

Out of the 44 Mt of E-waste, only 20% of total global E-waste was collected and recycled sustainably, there is also environmental and health hazard as E-waste contains over 1,000 harmful substances, including lead, mercury, nickel, brominated flame retardants and polycyclic aromatic hydrocarbons (PAHs). Mercury for example damages the human brain and or coordination system. E-waste is particularly hazardous as the extraction and recycling of E-waste is largely manually done and the sector is majorly dependent on informal workforce especially in developing or middle-income countries. More than 18 million children and adolescents are actively engaged in the informal industrial sector, of which waste processing is a sub-sector, exposing themselves to toxic E-waste risk.

E-waste Generation in India

Asia generated the greatest volume i.e., 24.9 Mt of E-waste in 2019 with China and India being the two largest contributors ranking first and third globally. India alone generated 3 Mt of E-waste in 2019 and about 95% of India's E-waste is recycled in the informal sector and in a crude manner. In 2018, the Ministry of Environment had told the tribunal that 95% of E-waste in India is recycled by the informal sector and scrap dealers unscientifically dispose of it by burning or dissolving it in acids. The presence of elements like lead, mercury, arsenic, cadmium, selenium and hexavalent chromium and flame retardants beyond threshold quantities of E-waste classifies them as hazardous waste. Thus, E-waste is considered more as hazardous rather than treasure.

E-waste Needs To Be Tapped

Recently, Delhi's civic body tied up with a private firm to collect and dispose of E-waste while Bihar government authorized 142, E-waste collection points in various districts. So, what is this E-waste, and why is it important to collect and dispose it of?

Electronic waste

It can be broadly described as discarded, surplus, obsolete, broken, electrical or electronic devices. It includes all such waste from electronic and electrical appliances that have reached their end-of-life period or are unfit for their original intended use and are meant for recovery, recycling or disposal. It could be a computer and its accessories like monitors, printers, keyboards, central processing units; typewriters, mobile phones and chargers, remotes, compact discs, headphones, batteries, LCD/Plasma TVs, air conditioners, refrigerators and other household appliances. Categorized as hazardous and non-hazardous E-waste includes ferrous and non-ferrous metals like copper, aluminum, silver, gold, platinum, palladium, etc., plastics, glass, wood and plywood, printed circuit boards, concrete, ceramics and rubber. It is the presence of elements like lead, mercury, arsenic, cadmium, selenium, hexavalent chromium, and flame retardants that makes E-waste risky. Containing over 1000 different substances, with several being highly toxic, E-waste disposal creates serious pollution.

Figure 1 E-waste Dump

(Source: Economy & Nation Exclusive)

Quantum of E-waste Generation

The 2019 United Nations report states that the consumers discarded 44 Mt worth of electronics each year with only 20% recycled sustainably. India generates about 3 million tonnes annually and stands third among the E-waste producing countries,

after China and the US. An Assocham-EY report suggests that given this growth rate, the country will have 5 Mt by 2021. The rapid technology advancements and newer electronic products makes consumers switch their existing models. This decreases the life cycle of these goods while exponentially increasing E-waste generation. Another factor this time is the ongoing Covid-19 pandemic which has kept people indoors resulting in higher usage of electronics goods. While the mounting quantity of discarded E-waste is overwhelming, its improper disposal is particularly worrisome. It usually reaches either the landfills or the unregulated markets. Summing this process in an article published in india.mongabay.com Ashley Delaney, Founder of Group TenPlus, a Goa company managing collection of electronic waste said: "An ordinary circuit board from a mobile or laptop contains roughly 16 different metals. Most informal sectors will probably be able to retrieve a couple of metals and landfill the rest. Hazardous chemicals like mercury, which are used to extract these metals, leach into the soil, which will be damaged forever. If you find discarded batteries, tube lights, CFL bulbs, chances are the soil around them will be barren."

Increased quantities will result in the leaching of metal to reach everywhere, including food. E-waste reaching oceans in large quantities contaminates water with gaseous or liquid toxins, which are not visible.

Recycling Helps

The extracted metals and plastics from E-waste can be used to make more electronic goods. Sounds good, but the process is not easy. Metals are tough to extract as pointed out by a United Nations report It states that the total recovery rate for cobalt is 30% though technology exist that could recycle 95%. Notably the energy efficiency of recycled metals are two to 10 times more than metals smelted from virgin ore. So it makes sense to have effective reuse methods by ensuring a sustainable chain in manufacturing and recycling. Further, extraction provides access to rare earth metals - which are definitely to obtain - and so worth recycling. According to estimates, the worth of global E-waste is around $62.5 billion annually.

Formal Sector's Dilemma

India has few formal recyclers and their role is limited to segregation, dismantling of E-waste till the size reduction stage of printed circuit boards (PCBs). The pre-processed PCBs are sent abroad to smelting refineries for further recovery of precious metals like copper, silver, gold, aluminum, palladium, tantalum, ruthenium, platinum, etc., and treating the slag byproduct in an eco-friendly manner. The limited organized recyclers face stiff competition from the informal sector and they receive a very small proportion of the obsolete goods. A Rajya Sabha document on E-waste cites the example of a Noida-based 500 tonnes capacity unit processing only 200 tonnes so far. Likewise, a Roorkee unit with 36,000 tonnes annually processes just 600.

Hazards of the Informal Segment

The informal sector dominates the collection, transportation, processing, and recycling of E-waste. Well networked and unregulated, it is unable to recover materials that can be besides creating serious hazards in terms of release of toxins in the environment and affecting the workers' health and safety. For instance, Delhi's Seelampur is India's largest E-waste dismantling centre with adults and children spending 10 hours daily to extract reusable components and precious metals. They use processes like open incineration and acid-leaching both to the detriment to self and ecology. Such workers suffer from stress, headaches, shortness of breath, chest pain, weakness, and dizziness and even DNA damage. Same situation prevails elsewhere as shown in a 2018 documentary "Welcome to Sodom" exploring the Agbogbloshie dump in Ghana, where life revolves around toxic waste as every year about 2,50,000 tons of sorted out computers, smartphones, air condition tanks and other devices from outside are dumped here. In India too large amounts of waste electrical and electronic equipment (WEEE) enters from foreign countries."

Interestingly the informal channel includes repair shops, used product dealers, E-commerce portal vendors, who use discarded electronics for reuse and cannibalisation of components.

India is ahead of most other countries in the region being the only country in Southern Asia with E-waste legislation. The law mandates only authorized dismantlers and recyclers to collect E-waste. In 2016, the E-waste (Management) Rules, mandated collection targets and transferred responsibilities to the producers - extended producer responsibility (EPR). For E-waste collection and disposal, the integration of the informal sector into a transparent recycling system is crucial. Talking to india.mongabay.com, Pranshu Singhal, Founder, Karo Sambhav said: "We work with waste collectors and aggregators and help them get formalized - ensure everyone has pan cards, bank accounts and give invoices, and ensure that waste is traceable." In E-waste management, manufacturers, too, play a key role. They need to integrate in their production process use of recycled material besides acting as collector of their old products for recycling.

Role of Consumers

Consumers should use their gadgets for longer and change it only when necessary and not for style. In case a fault in the gadget is repairable, then they should opt for that rather than discarding. While buying any product, they need to keep in mind that it should be recyclable. As pointed out in a World Economic Forum report, products should be designed so that they can be reused, durable, and safe for recycling. Further, producers should also have buy-back or return offers for old equipment. Emphasizing on the value of E-waste, an article on teriin.org states: "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. There is significant economic

potential in the efficient recovery of valuable materials in E-waste and can provide income-generating opportunities for both individuals and enterprises."

E-waste – An Emerging Threat To The Environment

Electronic gadgets are meant to make our lives happier and simpler, but they contain toxic substances, their disposal and recycling becomes a health nightmare. It has penetrated every aspect of our lives and most of us do not think about what happens to these gadgets when we discard or upgrade (Arwidsson & Allard, 2009). The use of electronic devices has proliferated in recent decades and proportionality, the quantity of electronic devices that are disposed of, is growing rapidly throughout the world (Aston et al., 2010, Baba et al., 2010). E-waste is an emerging problem given the volumes of E-waste being generated and the content of both toxic and valuable materials in them. This fast-growing waste stream is accelerating because the global market for personal computers (PC) is far from saturation and the average life span of a PC is decreasing rapidly. The life span of central processing units (CPU) had reduced from 4–6 years in 1997 to 2 years in 2005 (Babu et al., 2007, Culver, 2005). Over the past two decades, the global market of EEE continues to grow exponentially, while the life span of those products becomes shorter and shorter. Predictably, the number of electrical devices will continue to increase on the global scale, and microprocessors will be used in ever increasing numbers in daily objects. The production of EEE is one of the fastest growing global manufacturing activities. Rapid economic growth, coupled with urbanisation and a growing demand for consumer goods, has increased both the consumption and the production of EEE (Balabanic et al., 2011, Bandyopadhyay, 2008, CPCB, 2007).

This new kind of waste is posing a serious challenge in disposal and recycling to both developed and developing countries. While having some of the world's most advanced high-tech software and hardware developing facilities, India's recycling sector can be called medieval (Cui & Zhang, 2008). The dumping of E-waste, particularly computer waste, into India from developed countries and all this has made E-waste management an issue of environment and health concern. Compared to conventional municipal wastes, certain components of electronic products contain toxic substances, which can generate a threat to the environment as well as to human health (Bhutta et al., 2011, Puckett et al., 2002 & Sinha-Khetriwal, 2002). For instance, television and computer monitors normally contain hazardous materials such as lead, mercury, and cadmium, while nickel, beryllium, and zinc can often be found in circuit boards. Due to the presence of these substances, recycling and disposal of E-waste becomes an important issue.

Most people are unaware of the potential negative impact of the rapidly increasing use of computers, monitors, and televisions. When these products are placed in landfills or incinerated, they pose health risks due to the hazardous materials they contain. The improper disposal of electronic products leads to the

possibility of damaging the environment. As more E-waste is placed in landfills, exposure to environmental toxins is likely to increase, resulting in elevated risks of cancer and developmental and neurological disorders. A major driver of the growing E-waste problem is the short life span of most electronic products—less than two years for computers and cell phones (Widmer R, 2005, Davis C, 2006). In a 2006 report, the International Association of Electronics Recyclers projected that, with the current growth and obsolescence rates of the various categories of consumer electronics, somewhere in the neighborhood of 3 billion units would be scrapped by 2010 or an average of about 400 million units a year.

This review article provides a concise overview of India's current E-waste scenario, namely magnitude of the problem, environmental and health hazards, current disposal and recycling operations.

E-waste

It is a generic term embracing various forms of electric and electronic equipment that have ceased to be of any value to their owners. Puckett et al., (2002) define E-waste as "a broad and growing range of electronic devices ranging from large household devices such as refrigerators, air conditions, cell phones, personal stereos, and consumer electronics to computers which have been discarded by their users". According to Sinha-Khetriwal et al., (2005), "E-waste can be classified as any electrically powered appliance that has reached its end-of-life". As there does not seem to be a standard definition for E-waste, the definition offered by Sinha-Khetriwal et al., (2005). can be adopted for this paper. It is comprised of discarded computers, television sets, mobile phones, microwave ovens and other such appliances that are past their useful lives. The composition of E-waste is very diverse and differs in products across different categories. It contains more than 1000 different substances, which fall under 'hazardous' and 'non-hazardous' categories. Broadly, it consists of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards (PCB), concrete and ceramics, rubber and other items. Iron and steel constitute about 50% of the E-waste followed by plastics (21%), non-ferrous metals (13%) and other constituents. Non-ferrous metals consist of metals like copper (Cu), aluminum (Al) and precious metals, e.g., silver (Ag), gold (Au), platinum, palladium, etc. The presence of elements like lead, mercury, arsenic, cadmium, selenium and hexavalent chromium and flame retardants beyond threshold quantities of E-waste classifies them as hazardous waste.

Global Scenario of E-waste

Quantity of E-waste generated and the content of toxic and valuable materials, it has become an emerging problem throughout the world. In 1994, it was estimated that approximately 20 million that is about 7 million tons of PCs became obsolete. In 2010 this figure has increased to over 150 million PCs. Over the past two decades, the

global market of EEE continues to grow exponentially, while the lifespan of those products becomes shorter and shorter. In the United States (US) market, less than 80 million communication devices were sold in 2003, 152 million by 2008, a growth of over 90 percent in 5 years and by 2015 this numbers would be skyrocketing. Meanwhile, in 2006, more than 34 million TVs have been exposed in the market, and roughly 24 million PCs and 139 million portable communication devices have been produced. In the European Union (EU), the total units of electronic devices placed on the market in 2009 were more than 3.8 billion units, including 265 million computers, roughly 245 million in home consumer electronics, and 197 million consumer appliances. In China, approximately 20 million refrigerators and more than 48 million TVs were sold in 2001, and nearly 40 million PCs were sold in 2009. The situation is exacerbated by the rapid turnover of electronic devices. Because of the fast pace at which technology is evolving, most electronics have only a 2-to-3-year useful life. Apple sells more than 300,000 new phones every day in the world market and in this same time frame, more than 150,000 new Blackberries are also sold and 700,000 new Android phones are being activated. Most of the phones that are replaced by these new devices end up in a draw or in municipal landfills (EPA, 2008, Dagan et al., 2007, Karn et al., 2009).

E-waste has raised concerns because many components in these products are toxic and are not biodegradable. Based on these concerns, many European countries banned E-waste from landfills long before in the 1990s. Alarming levels of dioxin compounds, linked to cancer, developmental defects, and other health problems in the samples of breast milk, placenta, and hair, these compounds are linked to improper disposal of electronic products. Furthermore, surveys have indicated that much exported, E-waste is disposed of unsafely in developing countries, leaving an environmental and health problem in these regions. Impacts from those countries, especially Asia, have already been reported. Meanwhile, recycling and disposal of E-waste are also grown in the regions beyond Asia, particularly in certain African countries. Today's paradigm is one of disposable electronics, and as a result we now stand at the forefront of a growing environmental catastrophe (Kelly & Dagle, 1974, Hilty, 2005, Macauley et al., 2003, Monika, 2010).

Problem in Urban India

Indian information technology (IT) industry has been one of the major drivers of change in the economy in the last decade and has contributed significantly to the digital revolution being experienced by the world (Minyard et al., 1960; Pan et al., 2010). New electronic gadgets and appliances have infiltrated every aspect of our daily lives, providing our society with more comfort, health and security and with easy information acquisition and exchange (Padiyar et al., 2011; Poon, 2008). India has generated about 0.2 million tons of E-waste in 2006 and in 2010 it is about 0.4 million tons and at present the quantum is increasing rapidly. Studies so far reveal

that the total E-waste generation in India from both households and corporate will reach 0.5 to 0.6 Mt by 2013–2014 (Tsydenova & Bengtsson, 2011).

Personal Computer Penetration in India

Penetration of personal computers in India has increased drastically in the recent years. Figure 2, shows the usage of personal computers for every 1000 persons increases year after year.

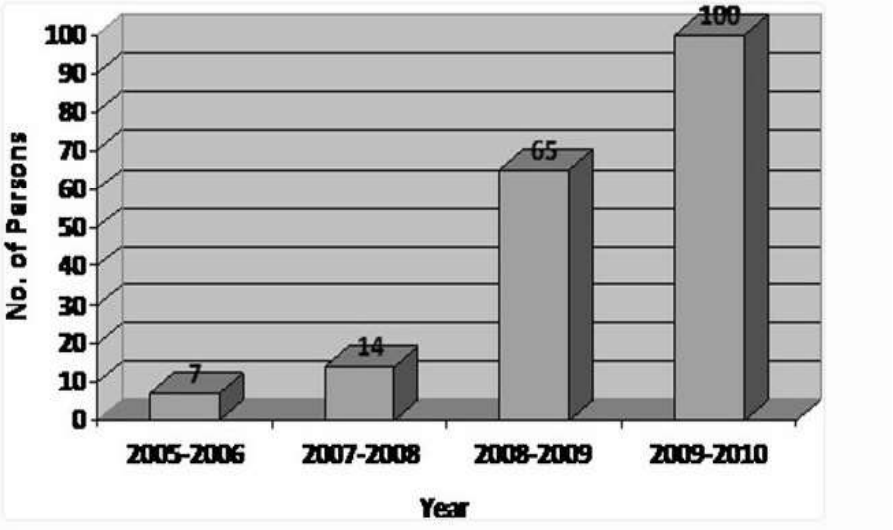

Figure 2 Usage of PCs for every 1000 persons.

Of the total E-waste generated in the country, western India accounts for the largest volume at 35%, while the southern, northern and eastern regions account for 30, 21 and 14%, respectively. The top states in the order of highest contribution to waste WEEE include Maharashtra, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab. Table 1, gives the total WEEE generation in the State of Maharashtra. Figure 2, shows the major Indian ports which receives E-waste in large from other countries as well. The city-wise ranking of the largest WEEE generators is Mumbai, Delhi, Bangalore, Chennai, Kolkata, Ahmadabad, Hyderabad, Pune, Surat and Nagpur.

Table 1 Total WEEE generation in the State of Maharashtra

S. no	Place	Quantity of generation (tonnes)
1	Navi Mumbai	4636.96
2	Greater Mumbai	11,017.06
3	Pune	3584.21
4	Pimpri-Chinchwad	1032.37
	Total	**20,270.60**

An estimated 30,000 to 40,000 computers become obsolete every year from the IT industry in Bangalore alone. Home to more than 1200 foreign and domestic technology firms, Bangalore figures prominently in the danger list of cities faced with an E-waste hazard. As much as 1000 tons of plastics, 300 tons of lead, 0.23 ton of mercury, 43 tons of nickel and 350 tons of copper are annually generated in Bangalore. While on the basis of scrap handled by the Delhi-based scrap dealers, their total number of PCs meant for dismantling would be around 15,000 per year. This figure does not include PCs handled by large dealers who get scraps from foreign sources. Mumbai, the financial nerve-center of India, alone throws away 19,000 to 20,000 tons of electronic waste a month, excluding the large E-waste it imports from developing nations through its port(Barbosa et al., 2005; Johri et al.2010, Jomova et al., 2011; Sheng PP & Etsell, 2007). There are only two formal recyclers one at Chennai and another in Bangalore for the whole of South India and one in western India (Gupta, 2007). Currently, there are no formal recyclers operating in the north or the east. Over 1 million poor people in India are involved in the manual recycling operations of E-waste and most of the people working in this recycling sector are the urban poor with very low literacy levels and hence very little awareness regarding the hazards of E-waste toxins. There are a sizeable number of women and children who are engaged in these activities and they are more vulnerable to the hazards of this waste. The following three categories of WEEE account for almost 90% of the generation:

- Large household appliances: 42%,
- Information and communications technology equipment: 33.9% and
- Consumer electronics: 13.7%.

Health and Environmental Impact of E-waste

Electronic products are a complex mixture of several hundred tiny components, many of which contain deadly chemicals. These chemicals are a strain on human health and the environment (Chen et al., 2011). Most of the components in electronic devices contain lead, cadmium, mercury, polyvinyl chloride (PVC), brominated flame retardants (BFRs), chromium, beryllium etc., TVs, video and computer monitors use CRTs, which have significant amounts of lead and the long term exposure to these substances can damage the nervous system, kidney and bones and the reproductive and endocrine systems and some of them are carcinogenic (Fowler & Weissberg, 1974). These E-waste will have long lasting effects on the environment, when improperly disposed (incinerated/land filled instead of recycling) with domestic waste, without any controls, can contaminate the soil, water and air. EEEs are made of a multitude of components, some containing toxic substances that have an adverse impact on human health and the environment if not handled properly (Bosshard et al., 1996). Often, these hazards arise due to the improper recycling and disposal processes used. It can have serious repercussions for those in

proximity to places where E-waste is recycled or burnt. In general, the electronic goods/gadgets are classified under three major heads:

- White goods: Household appliances
- Brown goods: TVs, camcorders, cameras
- Grey goods: Computers, printers, fax machines, scanners etc.

Table 2 Toxic Metals Present in E-waste and Their Effects on Humans

Materials	Weight (%)	Recycling (%)	Location	Effects
Lead	6.2988	5	Acid battery, CRT	Kidney failure, central and peripheral nervous systems, damage to the reproductive systems
Cadmium	0.0094	0	Battery. CRT. housing	Long term cumulative poison. Bone disease
Mercury	0.0022	0	Batteries, switches, housing	Chronic damage to brain, liver damage, causes damage to the central and peripheral nervous systems as well as the fetus
Chromium VI	0.0063	0	Decorative hardener, corrosion protection	DNA damage, lung cancer
Plastic	22.99	20	Computer mouldings, cablings	Generates dioxins and furans

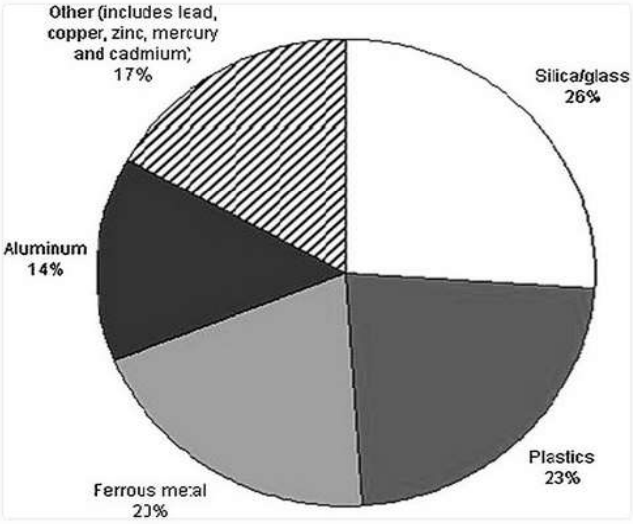

Figure 3 Material Composition of Desktop Computer

Waste from the white and brown goods is less toxic when compared to grey goods (Coram, 2002; Bala & Goel, 2012). Even a personal computer contains highly toxic chemicals like lead, mercury, cadmium, etc., and its effect on health is shown and tabulated in Table 2 and Figure 3 (Clark & Norris, 1996).

E-waste Management Rules, 2016

- Ministry of Environment, Forest and Climate Change notified the E-waste Management Rules, 2016 in supersession of the E-waste (Management & Handling) Rules, 2011.
- Over 21 products (Schedule-I) were included under the purview of the rule. It included compact fluorescent lamp (CFL) and other mercury containing lamps, as well as other such equipment.
- For the first time, the rules brought the producers under Extended Producer Responsibility (EPR), along with targets. Producers have been made responsible for the collection of E-waste and for its exchange.
- Various producers can have a separate producer responsibility organisation (PRO) and ensure collection of E-waste, as well as its disposal in an environmentally sound manner.
- Deposit refund scheme has been introduced as an additional economic instrument wherein the producer charges an additional amount as a deposit at the time of sale of the EEE and returns it to the consumer along with interest when the end-of-life EEE is returned.
- The role of state governments has been also introduced to ensure safety, health and skill development of the workers involved in dismantling and recycling operations.
- A provision of penalty for violation of rules has also been introduced.
- Urban Local Bodies (Municipal Committee/Council/Corporation) have been assigned the duty to collect and channelize the orphan products to authorized dismantlers or recyclers.
- Allocation of proper space to existing and upcoming industrial units for E-waste dismantling and recycling.

What Type of Difficulties We Face to Manage E-waste in India?

- The producers/manufacturers do not have adequate information on their website regarding e waste management.
- Customer care representatives do not have inkling about any take back or recycling programme and even if they have set up collection centres, they are simply not enough for a geographically vast country like India.
- India being a vast country, setting up collection mechanism is a big challenge. If any of the brands try individually to reach out to all corners of the country, it will economically not be sustainable or feasible.
- Improper enforcement of the existing laws is another hurdle.

Government Efforts

- NITI Aayog India's public policy think tank has put prominent emphasis on E-waste among 11 end-of-life products, recyclable materials, E-waste that continue to pose considerable challenges.
- They have formed 11 committees to be led by the concerned line ministries and comprising officials from MoEFCC and NITI Aayog, domain experts, academics and industry representatives.
- Greens cape Eco Management is one such company that has been involved in NITI Aayog's Committee for E-waste Management Rules and Regulation. They provide end of Life IT asset solutions ranging from collection and disposal to reintegration solutions including re-use, de-manufacturing, brand security and E-waste recycling.
- The organisation actively pursues projects and initiatives that benefit the E-waste industry and the communities that serve the environment.
- As of now they're ongoing projects over 427 locations across India. Currently they have collaborated with partners in all parts of India, Singapore and Australia.

Conclusion

India is placed among the other global nations which have generated more E-waste in quantity and especially urban India needs an urgent approach to tackle this issue. Technical and policy-level interventions, implementation and capacity building and increasing the public awareness can convert this challenge into an opportunity to show the world that India is ready to deal with future problems and can set global credible standards concerning environmental and occupational health. Microsoft has created a Vision of 2020 that neutralizes the appeal of physical devices, regulating them to the background and it is not waiting for consumers to determine the future of electronics. The current situation is very hopeful with policy intervention, brand accountability, general public awareness, and technological advance in recycling. However, much is yet to be done to achieve desired results. Getting quantifying data on the depth and spread of effort to sustainably process E-waste is necessary to get the actual scenario and increase the scale of momentum.

References

Arwidsson Z, Allard B. "Remediation of metal-contaminated soil by organic metabolites from fungi II-metal redistribution." *Water Air Soil Pollut.* 2009;207(4):5–18.

Aston JE, Apel WA, Lee BD, Peyton BM. *Effects of cell condition, pH, and temperature on lead, zinc, and copper sorption to Acidithiobacillus caldus strain* BC13. J Hazard Mater. 2010;184:34–41. doi: 10.1016/j.jhazmat.2010.07.110.

Baba A, Adekola F, Ayodele D. "Study of metals dissolution from a brand of mobile phone waste." *Metalurgija – J Metallurgy*. 2010;16(4):269–277.

Babu R, Parande AK, Basha AC. "Electrical and electronic waste: a global environmental problem." *Waste Manag Res*. 2007;25:307–318. doi: 10.1177/0734242X07076941.

Bala S, Goel S. "A study of e-waste management in relation to awareness of college students." *Int J Educ Psychol Res*. 2012;2:31–35.

Balabanic D, Rupnik M, Klemencic AK. "Negative impact of endocrinedisrupting compounds on human reproductive health." *Reprod Fertil Dev*. 2011;23(3):403–416.

Bandyopadhyay A. "A regulatory approach for E-waste management: a crossnational review of current practice and policy with an assessment and policy recommendation for the Indian perspective." *Int J Environ Waste Manage*. 2008;2:1–2.

Barbosa FJ, Tanus-Santos JE, Gerlach RF, Parsons PJ. "A critical review of biomarkers used for monitoring human exposure to lead: advantages, limitations, and future needs." *Environ Health Perspect*. 2005;113:1669–1674. doi: 10.1289/ehp.7917.

Bhutta KS, Adnam O, Xia Ozhe Y. "Electronic waste: a growing conern in today's environment." *Economics Research International*; 2011. Article ID 474230

Bosshard PP, Bachofen R, Brandl H. "Metal leaching of fly ash from municipal waste incineration by Aspergillus niger." *Environ Sci Tech*. 1996;30:3066–3070.

Chen A, Dietrich KN, Huo X, Ho SM. "Developmental neurotoxicants in Ewaste: an emerging health concern." *Environ Health Perspect*. 2011;119(4):431–433.

Clark DA, Norris PR. "Acidimicrobium ferrooxidans Gen. Nov., Sp. Nov.: mixed-culture ferrous iron oxidation with sulfobacillus species." *Microbiology*. 1996;142:785–790. doi: 10.1099/00221287-142-4-785

Coram NJ, Rawlings DE. "Molecular relationship between two groups of Leptospirillum and the finding that Leptospirillum, Ferriphilum Sp. Nov. dominates South African commercial biooxidation tanks which operate at 40°C." *Appl Environ Microbiol*. 2002;68:838–845. doi: 10.1128/AEM.68.2.838-845.2002.

CPCB. *Draft guidelines for environmentally sound management of electronic waste*. 2007. pp. 10–25. http://ewasteguide.info/newsandevents/new-dr.

Cui J, Zhang L. "Metallurgical recovery of metals from electronic waste: a review." *J Hazard Mater*. 2008;158:228–256. doi: 10.1016/j.jhazmat.2008.02.001.

Culver J. *The life cycle of a CPU*. 2005. http://www.cpushack.net/life-cycle-of-cpu.html.

Dagan R, Dubey B, Bitton G, Townsend T. "Aquatic toxicity of leachates generated from electronic devices." *Arch Environ Contam Toxicol*. 2007;53:168–173.

Davis C. "Why is electronic waste a problem?" *Earthtrends*. 2006. http://earthtrends.wri.org/updates/node/130.

EPA. *Electronics Waste Management in the United States approach 1 final*. Washington, DC, USA: Office of Solid Waste US Environmental Protection Agency; 2008. http://www.epa.gov/epawaste/conserve/materials/ecycling/docs/app-1.pdf.

Fowler BA, Weissberg JB. "Arsenic poisoning." *N Engl J Med*. 1974;291(22):1171–1174. doi: 10.1056/NEJM197411282912207.

Gupta RK. *E-waste recycling and health effects: a review.* Centre for Education and Communication-Working Paper; 2007. http://cec-india.org/images/stories/pdf/CECWork_paper/e_waste_report.pdf.

Hilty LM. *Electronic waste—an emerging risk? Environ Impact Assess Rev.* 2005;25(5):431–435. doi: 10.1016/j.eiar.2005.04.002.

Johri N, Jacquillet G, Unwin R. "Heavy metal poisoning: the effects of cadmium on the kidney." *BioMetals.* 2010;23(5):783–792. doi: 10.1007/s10534-010-9328-y.]

Jomova K, Jenisova Z, Feszterova M, Baros S, Liska J, Hudecova D, Rhodes CJ, Valko M. "Arsenic: toxicity, oxidative stress and human disease." *J Appl Toxicol.* 2011;31(2):95–107.

Karn B, Kuiken T, Otto M. "Nanotechnology and in situ remediation: a review of the benefits and potential risks." *Environ Health Perspect.* 2009;117(12):1813–1831.

Kelly S, Dagle A. *Cytogenetic damage in americium poisoning.* N Y State J Med. 1974;74(9):1597–1598.

Macauley M, Palmer K, Shih JS. "Dealing with electronic waste: modeling the costs and environmental benefits of computer monitor disposal." *J Environ Manage.* 2003;68(1):13–22. doi: 10.1016/S0301-4797(02)00228-1.

Minyard JA, Dinkel CA, Olson OE. "Selenium poisoning in beef cattle." *J Anim Sci.* 1960;19:260–264.

Monika JK. "E-waste management: as a challenge to public health in India." *Indian J Commun Med.* 2010;35(3):382–385. doi: 10.4103/0970-0218.69251.

Padiyar N. "Nickel allergy-is it a cause of concern in everyday dental practice." *Int J Contemp Dent.* 2011;12(1):80–81.

Pan J, Plant JA, Voulvoulis N, Oates CJ, Ihlenfeld C. "Cadmium levels in Europe: implications for human health." *Environ Geochem Health.* 2010;32(1):1–12. doi: 10.1007/s10653-009-9273-2.

Poon CS. "Management of CRT glass from discarded computer monitors and TV sets." *Waste Manag.* 2008;28:1499. doi: 10.1016/j.wasman.2008.06.001.

Puckett J, Byster L, Westervelt S, Exporting Harm. *The high-tech trashing of asia, the basel action network (BAN) and Silicon Valley Toxics Coalition (SVTC) 2002.* http://www.ban.org/E-waste/technotrashfinalcomp.pdf.

Sheng PP, Etsell TH. "Recovery of gold from computer circuit board scrap using aqua regia." *Waste Manage Res.* 2007;25:380–383. doi: 10.1177/0734242X07076946.

Sinha-Khetriwal D. *The management of electronic waste: A comparative study on India and Switzerland.* St. Gallen, Switzerland: M.S. thesis, University of St. Gallen; 2002.

Tsydenova O, Bengtsson M. "Chemical hazards associated with treatment of waste electrical and electronic equipment." *Waste Manag.* 2011;31(1):45–58.

Widmer R, Oswald-Krapf H, Sinha-Khetriwal D, Schnellmann M, Böni H. "Global perspectives on e-waste." *Environ Impact Assess Rev.* 2005;25(5):436–458.

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E-WASTE: Treasure or Threat
Editor: Dr. Suresh Kumar
First Published in 2023 by Authorspress
ISBN 978-93-5529-774-7

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