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Electronic Gadgets Bane Or Boon For The World – A Summary Of The Consequences Of Electronic Wastes

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Abstract
With the swift advances in technology, producers already are bringing out smarter televisions, smartphones, as well as other computing equipment at an exponential rate. To meet the needs of customers all across, an increasing number of electronic products are being made, which consumes more resources. Global production of electronic waste reached 44.7 million tonnes in 2016, and by 2021, it is anticipated to increase by 17% to 52.2 million tonnes. Mercury, lead, and brominated flame-retardants are just a few of the hazardous products found in e-waste. A rise of 9.2 Mt over the preceding five years is anticipated to have brought e-waste generation to a historic amount of 53.6 million metric tonnes (Mt) in 2019. A recent projection from the World Resources Institute predicts that by 2030, the global EEE output will reach 74.7 Mt. (WRI).

Keywords: e-waste, per capita production, poly vinyl chloride, polychlorinated biphenyls, recycling

1. Introduction

Technology waste makes up the fastest-growing solid waste sources in contemporary society. Metals, ceramics, polymers, and other unwanted by-products are all part of its complex composition (Karimi-Maleh et al., 2021a; 2021b). Approximately 44.7 million tonnes of electronic garbage were created globally in 2016, and by 2021, that number is expected to increase to 52.2 million tonnes, a 17% increase. Electrical devices have a crucial components known as Printed circuit boards (PCBs) and are used in computer motherboards with random access memory and network interface cards for computers. Capacitors, resistors, microchips, diodes, and other crucial components are included in it, along with toxic metals that are bad for the environment. (Awasthi et al., 2017). For PCB recycling, temperatures between 300℃ and 900℃ are necessary. Sulfuric acid, nitric acid, hydrochloric acid, and other chemical solutions are used to recycle PCBs.

Nowadays, E-waste has become a topic of concern, globally, locally and at national level. As per the recent estimates, per year 50-80 million tonnes of e-waste produce and their 75% to 80% are shipped to Asia and Africa for recycling and disposal (Perkins et al., 2014). Electronic waste has a peculiar and variable chemistry since it contains a variety of metals and non-metals. Typically, 40% of e-waste is made up of inorganic elements, 30% of which are ceramics (such silica, mica, and alumina), and 30% of which are organic materials (including polymers, flame retardants, and glass fibre) (e.g., ferrous and non-ferrous metals). Among the inorganic elements included in e-waste are base metals (such as aluminium, iron, copper, and tin), noble metals (such as silver, gold, and palladium), heavy metals (such as cadmium, nickel, chromium, zinc, mercury, beryllium, and lead), and rare earth metals (e.g., gallium, tantalum, and platinum groups) (Kaya, 2016; Rautela et al., 2021).

When referring to obsolete electronics that are near to being unproductive and are discarded, given, or sent to a recycler, terms like "e-waste," "electronic garbage," "e-scrap," and "end-of-life electronics" are frequently used. We are quite concerned about the improper handling of discarded electronics and e-waste in developing countries, which puts the human health and environmental health in peril. Among the hazardous products identified in e-waste include mercury, lead, and brominated flame-retardants. These compounds cause damage to nearly all major bodily systems, including the nervous and circulatory systems, brain development, skin problems, lung cancer, heart, liver, and spleen damage, after prolonged exposure during dangerous e-waste recycling procedures.

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The term "EEE" refers to things that have a power wire or a battery (Electrical and electronic equipment). The three main categories into which e-waste produced from discarded EEE is typically segmented into consumer equipment, Communications and information technology (IT) (laptops, personal computers and monitors). TVs, DVD players, cell phones, mp3 players, shopping and leisure equipment are some additional typical categories. Every year in the European Union, phones, televisions, and laptops contribute approximately 9 million tonnes of electronic garbage. (Pahari and Dubey, 2019). UNEP predicts that by 2020, the amount of electronic trash generated by computers will have increased by around five times, that of cell phones by about eighteen times, and that of old televisions by about two times. (Leung, 2019). All waste produced by hospitals, labs, and research [i]institutes is by definition included in the term "health care waste." Waste from other rubbish categories are included as well. The remaining 20% of waste generated by healthcare facilities is labelled "hazardous" because it could endanger the environment or people's health in some way, either chemically, radio logically, or physically. The phrase "non-hazardous" refers to the approximately 80% of this garbage that is identical to typical home waste.

2. Hazardous substances in E-waste

Generally speaking, Hazardous substances are those that pose a threat and may have an adverse impact on the health of human and environment. There are numerous sources for its production, including the industrial sector and their production methods.

2.1 List of few hazardous e-wastes

Compounds	Sources
Polychlorinated Biphenyls (PCB)	Transformers, Capacitors Etc.
Chlorofluorocarbons	Ac's, Refrigerators Etc.
Poly Vinyl Chloride	Wire Ropes, Construction, Electrical Cables Etc.
Americium	Radioactive Sources
Mercury	Mechanical Doorbells, Fluorescents Tubes, Etc.
Cadmium	Nickel-Cadmium Batteries
Lead	Lead Acid Batteries, CRT Monitors Etc.

Source: ECS environment

Arsenic: In soluble substances and dust, arsenic is a dangerous metallic element. Numerous skin conditions and slowed nerve conduction can be brought on by prolonged exposure to arsenic. Lung cancer and death can result from long-term exposure to arsenic.

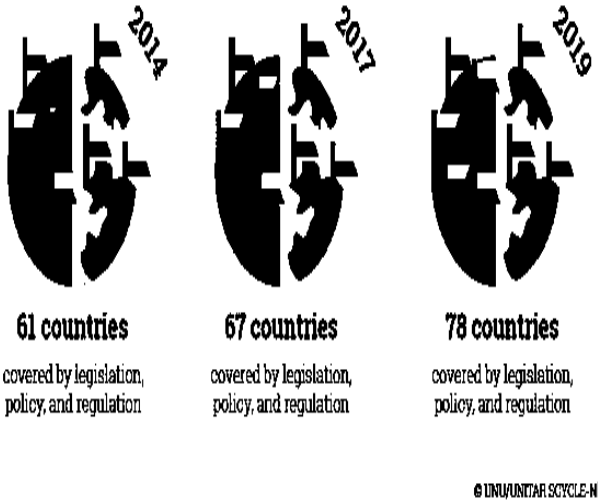
Mercury: However, while being extremely dangerous, mercury is the most commonly utilised component. Muscle deterioration, dermatitis, cognitive decline, and sensory impairment can all be brought on by ingesting a very toxic heavy metal. Animals affected by environmental factors may die, have fewer offspring, or grow and develop more slowly.

Polychlorinated Biphenyls (PCB): In the environment, PCBs are found to be one of the persistent pollutants. PCB's have the ability that it gets bio accumulated in the fatty tissues of the living creatures. Few studies claimed that PCBs can lead to cancer in animals. In addition to their impacts on the biological systems like reproductive system, immune system, endocrine system, neurological system, and many other systems, polychlorinated biphenyls (PCBs) have been found to have a number of significant non-cancer health effects in animals.

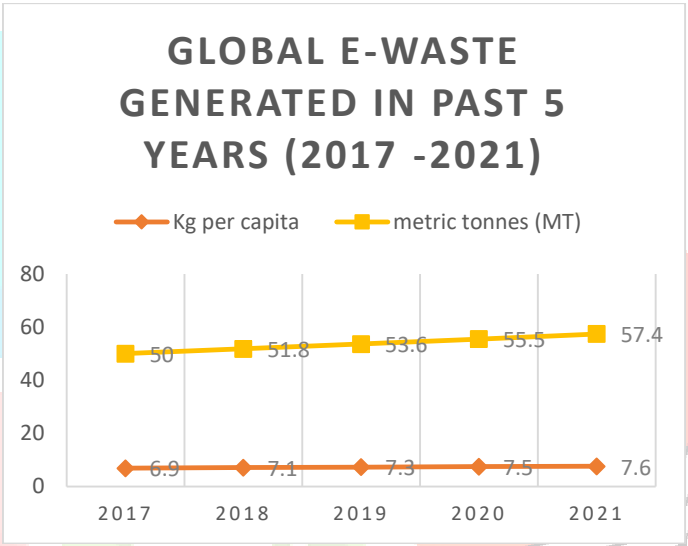
Poly vinyl chloride (PVC): Whilst PVC is toxic because it contains up to 56% chlorine, which when burned releases huge amounts of hydrogen chloride gas. Hydrochloric acid is then formed when this gas reacts with water, and it is harmful since it can cause respiratory issues if it is inhaled.

3. Per capita production of e-waste

More than 1.6 million metric tonnes (MT) of municipal solid waste are generated daily in the country. Depending on the population size, cities produce 0.2 kg to 0.6 kg of garbage per person every day (Garg et al., 2019). E-waste, which includes outdated devices like computers and phones with batteries or connectors, is anticipated to have reached a record 53.6 million metric tonnes (Mt) worldwide in 2019. 9.2 Mt more have been added in the last five years. According to the most recent projection, worldwide e-waste will nearly double from 2014 levels to 74.7 Mt by 2030 due to rising rates of energy and technology use, decreased lifecycles, and few repair possibilities. As far as Asian countries go, China (6.1 million MT), Japan (2.2 million MT), and India have the highest rates of e-waste creation (1.8 million MT).



According to research, Asia generated the most e-waste in 2019 (24.9 Mt). Africa and Oceania contributed 0.7 and 2.9 million tonnes, respectively, whereas America and Europe contributed 13.1 and 12 million tonnes after that. Europe produced 16.2 kg of electronic garbage for every person, followed by Oceania (16.1 kg) and America (13.3 kg) (Misra et al., 2021). 40 million metric tonnes of e-waste, or 5% of all solid wastes, are produced globally each year (Hazra et al., 2019).



We can see from this graph that the global production of E-waste has been steadily rising over time. The majority of the world's e-waste in 2019 is made up of large equipment (13.1 Mt), temperature exchange equipment (10.8 Mt), and tiny equipment (17.4 Mt). According to the study of the global e-waste monitor 2020, luminaires (6.7 Mt), Minor IT and telecommunication equipment (4.7 Mt), and Screens and monitors (0.9 Mt) make up a lesser fraction of the e-waste created in 2019.

4. Management of e- waste

The management of e- waste plays a very crucial role nowadays. The management helps in reducing the negative impacts on environment and on human health. Lots of health issues can be occurred if the e- waste is mishandled or not managed properly. There are few ways with which we can manage the e-waste (Global E-waste monitor, 2020). Firstly, e-waste can be managed in a formal way, in such formal collection all the activities works according to the guidelines given by national e-waste legislation. In this the collection processes are done by the retailers, pick up services and municipal collection points which are controlled or designated by the organizations, governments etc. Then these wastes are treated and the residues are then proceed for practices like incineration or landfills.

Secondly, e-waste in the waste bins, this scenario include the producer of e-waste disposes-off their e- waste in their regular household dustbin or nearby municipal dustbins which as a results gets mixed with normal waste and hence treated by the process of incineration without material recycling. Both options are thought to be inappropriate methods for handling e-waste because they could potentially harm the environment and deplete resources.

Thirdly, E-waste that is gathered outside of official channels in nations with well-developed e-waste management infrastructure. In countries with well-established waste management legislation, e-waste is collected by one-off trash dealers or companies and sold through a number of channels. E-waste may end up in the metal and plastic recycling process in this situation, but the dangerous elements are probably not cleaned up. In this case, e-waste is frequently not managed in a facility specifically designed for recycling e-waste and may even be exported.

Lastly, E-waste gathered outside of established procedures in nations with underdeveloped e- waste management infrastructure. In this scenario, most of the informally self-employed people collects the e- waste door to door by buying or collecting them from houses, institution and offices and sell them for repairing, refurbishment and dismantling. The equipment is manually disassembled

into usable, marketable pieces and materials by dismantlers. By being burned, leached, and melted, e-waste is recycled into secondary raw materials. This "backyard recycling" has a negative impact on both the environment and public health.

5. Recycling of e- waste

E-waste is one of the waste sources growing at the fastest rate, increasing by 3-5% annually (European Parliament Briefing, 2015). Although the market for EEE is expanding, the life expectancy and replacement interval of these devices are getting shorter as technology develops. Computers, refrigerators, and cell phones are just a few examples of the numerous goods that are included in waste from electrical and electronic equipment. This type of waste is composed of a complex mix of materials, some of which are hazardous. The environment and human health may suffer greatly if abandoned technology is not properly handled. Modern electronics also contain rare and valuable resources that, with proper waste management, can be recycled and utilised again. Enhancing the collection, handling, and recycling of electrical and electronic equipment (EEE) at the end of its useful life can: improve resource efficiency; enhance sustainable production and consumption; and support the circular economy.

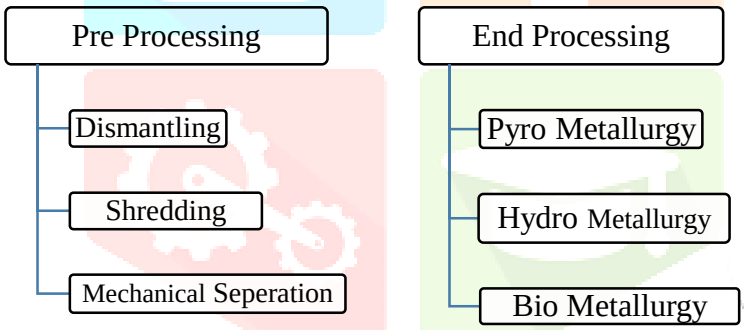
5.1 Few Categories of E-waste covered by WEEE directive in the European Union

Category	Description
Massive home appliances	Washing machines, refrigerators, AC's, stoves etc.
Consumer electronics	Televisions, MP3 players, telephones, calculators, etc.
IT equipment's	Laptops, scanners, printers etc.
Electrical and electronic tools	Drills, marble cutter etc.
Medical devices	Ultrasounds machines, x- ray machines etc.
Sports and leisure equipment's	Treadmill, electrical cycles etc.
Small home appliances	Toasters, curlers, mixer grinders etc.

Source: @ CTCN UN Climate Technology Centre and Network

Dismantling, or removing components of electronic waste that include hazardous materials like PCBs and mercury, as well as separating plastics and CRTs from other materials and separating ferrous and non-ferrous metals from printed circuit boards, is a necessary step in the recycling process. You can recycle monitors, CRTs, keyboards, laptops, modems, telephone boards, hard drives, floppy drives, Compact discs, mobile phones, fax machines, printers, CPUs, memory chips, connecting wires, and cables.

5.2 Common recycling methods worldwide



Source: Kumar et al., 2017

By keeping hazardous trash out of landfills and lowering the dangers associated with disposal, the recycling industry plays a crucial part in environmental conservation. Mercury, cadmium, and other dangerous substances are present in large amounts in the e-waste stream. Lead, chromium, flame retardants made of poly- or brominated compounds, CFCs, etc (Balde et al., 2015). Dealing with these when chemicals or metals are disposed of or burned, they can cause harm. Environmental effects. A landfill that is well-run and governed and incineration could offer a temporary remedy to the world e-waste issue but not long-term practical, especially for the countries like Japan and Europe that have few large landmasses and it also lessens the chance of resource recovery (Kumar et al., 2017).

6. Some disposal methods for e- waste

Few disposable methods for e-waste includes incineration, landfills, acid bath etc.

Acid bath

To dissolve the copper, the circuit board is submerged in sulfuric acid for around 12 hours. The precipitated copper sulphate is then removed, the solution is then heated, and scraped particles are added to the remaining solution. Finally, copper smudges are removed. Lead is also dissolved in acid baths, which are widely used to extract gold and silver.

Landfilling

It is said that e-waste is a hazardous time bomb that ends up in landfills. After some time, they might be released into the environment naturally, and there's a chance that trash like batteries, which contain lead, zinc, nickel, copper, mercury, and cadmium, could also leach heavy metals like mercury and nickel. These may mingle with other sources of fresh water, such rivers and streams, and reach animals and humans as well as the soil. The majority of the e-waste produced in the US and Australia is sold to Asia and Africa, while around half is disposed of in landfills.

Pyrolysis

Pyrolysis is another term for incineration; substances produced during incineration are likely to be more toxic than their natural state. Pyrolysis is the process of heating a substance without oxygen; no burning takes place here; instead, the heated substance is transformed into fumes, oils, and charcoal. However, only a small amount of air is used in the gasification process to turn the materials into fume, ash, and tar. In China, Africa, India, and Pakistan, incineration is a widespread technique of e-waste disposal. When the plastic or PVC circuit board is heated, toxic fume is released that contains recognised carcinogens such carbon monoxide, sulphur dioxide, and nitrogen oxides as well as polycylic aromatics (PCA), polychlorinated dibenzo-para-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs). Antimony, lead, thallium, arsenic, copper, manganese, mercury, and nickel oxides are also found in trace amounts in smoke, though they mostly end up in the ashes.

E-waste recycling

Mobile phones, monitors, CPUs, floppy drives, laptops, keyboards, connectors, and linking connections are just a few examples of the types of electronic waste that can be recycled and used again. It involves taking apart the electronic device, isolating the parts that contain hazardous elements, such as CRTs and printed circuit boards, and then recovering valuable metals, like copper, gold, or lead, using an efficient and powerful e-waste recycler. Choosing the right kind of recycler who manages the e-waste in an environmentally responsible manner while adhering by the law is crucial in this circumstance.

E-waste reuse

This is the most ideal method of recycling e-waste because it allows for the reuse or sale of electronics such as printers, computers, and mobile phones with only minor adjustments. Additionally, used electronics can be donated to many charitable causes, aiding those in need. Additionally, there is a better option by selling your old laptops or cell phones to recycling and refurbishment businesses. Between recyclers and users of electronic goods, a number of websites serve as the intermediary. For the users, it's a win-win situation because they not only get rid of their old cell phones but also get paid when they sell them.

Incineration

With this method, PCB can be compressed to a volume that is half of its original size. During burning, harmful, dangerous compounds such as fly ash, heavy metals, poly-brominated/poly-chlorinated dibenzo-dioxins (PBDD/PCDD), and others are released into the environment. Incineration is not presumed of it as being eco-friendly strategy because the process releases potentially dangerous elements.

7. Harmful effects on environmental factors

An increasing amount of electronic waste is dumped in landfills each and every year, which contributes to pollution. The following are three main ways that e-waste can harm the environment: air pollution, water pollution, and soil pollution. An increasing amount of dumping of e- waste takes place through landfills which somehow harms the environment. The management of e-waste somewhere releasing harmful chemicals in air and hence degrading the quality of air leading into air pollution. To obtain the rich copper present inside the cables many traffickers burn the copperwires in open air. Conjointly, when computer chips are stripped of their gold plating, hydrocarbons are discharged into the atmosphere (Kaushik 2018).

If we look into the past, at that time people used to consume ground water directly. Now a days, it is impossible for a person to drink groundwater without filtering it. Lead present in the electronic devices that we throw in the water with other wastes pollutes the water and make water unfit for drinking. When Cathode ray tubes from outdated computer monitors, video cameras, and televisions are disassembled to remove the yoke and discard the shell, the water becomes contaminated. The presence of lead and barium in the shell may result in soil leaching, which ultimately contaminates groundwater.

One of the most important channels for human exposure to heavy metals is the "soil-crop-food channel," which is travelled by hazardous heavy metals and parts from e-waste. These toxic compounds increase the danger of exposure, which may lead to potentially major health consequences, because of their long-term persistence in the environment and lack of biodegradability.

8. Conclusion

E-waste has somewhere turned into a poison that is steadily poisoning the environment. Electronic waste pollutes water supplies, rendering them unfit for household or human use, killing animals, and reducing biodiversity, among many other negative consequences for the environment. The global requirement for new metal manufacturing will be decreased by recycling e-waste, which lowers greenhouse gas emissions. The safest technique is recycling and reusing materials, including metals, and this involves a system used by the entire industry to collect e-waste. E-waste management and disposal must be done properly in order to prevent disorders of the skin, respiratory, digestive, immunological, endocrine, and mental systems, including cancer. E-waste is known to be a major source of heavy metals, toxic compounds, and carcinogens.

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