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Environmental Impact of Burning Electrical and Electronic Components

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Abstract: *Electronic waste (e-waste) has been an increasing problem facing the global village. Much of the problem is due to the profligate disposal and burning of these devices without consideration to the municipality's ability to handle the volume of waste streams that are generated or the effects of the gases released during the burning process. The burning is used as a processing pathway to recovering some of the components of these devices as well as to reduce their volumes to more manageable levels in order to facilitate final disposal as incinerator ash. This paper highlights the effects of burning electronic waste on the local environment. It was found that due to the burning of these e-wastes, there is a tremendous and harmful impact to both the health of the local population as well as that of the environment, particularly the aquatic habitat. Thus, necessitating the need for robust and speedy implementation of legislative oversight in order to ensure a sustainable and long lasting relationship between man and the environment. Some of these laws have been highlighted in this report.*

Keywords : *Electronic devices, Environmental Health, Environmental impact Assessment, Electronic Waste Generation.*

I. Introduction

According to an observation in 1965 by Gordon E. Moore who was one of the co-founders of Intel, the number of transistors per square inch on integrated circuits had doubled every year since the integrated circuit was invented. This observation was an attempt to predict the continued development of integrated circuit used in the creation of electronic devices and it came to be known as "Moore's law" in the semiconductor and modern computing industry [1]. Over the years, "Moore's law" has been applied to numerous different aspects of the culture and society where the observable trend of "Law" is evident and relevant. The trend in question is the doubling of an event or object over a periodic time interval. Some tangible examples include: (a) Moore's law of Photonic and Electronics [2] , (b) A Thermal application of Moore's law [3], (c) Protein Dynamics "Moore's law in Molecular Biology" [4]. As can be observed it is clear that the "Law" is so ubiquitous that it's trend can be found in almost every aspect of the current technological infrastructure and often times, the roadmaps of technological giants are such that they are designed to keep the "Law" relevant. Simply stated: "Moore's law" led to trillions of dollars in added economic value [5]. Unfortunately, this also means that, given the profligate nature in which the society as a whole transitions from one generation of technology to another, on average, each individual member of the society has the capacity to replace their previous technological device every 18 months [1]. While this may seem as though a trivial fact, once it is realized that the average American household spends over $1,000 on electronic devices, the amount of electronic devices that undergo a rapid replacement cycle begins to egress beyond a manageable and sustainable amount [6]. According to the Consumer Electronic Association, this per household expense on electronic devices translates to a $165 billion per year industry [7]. All of these "old" devices have to be disposed of, repurposed, or recycled as newer models and more advanced technologies replace the older models. The rate of change is such that a tremendous chasm between the percentages of these electronic waste devices (e-waste) that are disposed of, compared to the percentages of these devices that are repurposed or discarded [8].

The Environmental Protection Agency (EPA) estimates that the amount of e-waste generated in 2009 was in the excess of 2.37 million tonnes with only 25% of these devices collected for recycling[8]. The vast majority of these e-waste devices end up as export to countries that are ill equipped to reject the imports or lack the regulatory oversight to assure proper treatment of these e-waste as well as the safety of the workers that treat them [8]. Often times the prevailing question given the information of the accumulation of e-waste is "why do the trends exist?"

II. Electric and Electronic Devices

2.1 Influence of Electric and Electronic Devices to our Everyday Life

The electronic devices of the 21st century are expected to make people's working and personal lives even more convenient and productive [9].The proliferation of electric and electronic component (electronic devices ED) in the society is so ubiquitous that it is unfathomable to imagine a world without them. Many people rely on ED to function at the pace that the current society demands, so much so, that as the world becomes more and more globalized, it necessitates a greater reliance on ED to keep up the pace of economic growth. Even the social aspect of the society is not exempt from their effects [6]. There has been evidence of the influence of ED on the level and quality of the relationship that we can attain as humans [6]. Consequently, these electronic devices have come to signify economic progress in our society due to the necessity of rapid information acquisition and dissemination.
Yet, for all of the benefits that they provide, there are also untold consequences to their use. According to the National Sleep Foundation, almost all American adolescents (97%) had at least one electronic device in their bedroom [10], with the presence of these devices further being linked to delayed bedtimes, tiredness, narcolepsy, sleep apnea, and a plethora of other pathologies [11].

2.2 What are Electric and Electronic Devices

According to Greenpeace International, "Electronic devices are a complex mixture of several hundred materials" [12]. They include but are not limited to telecommunications devices, printers, scanners, and personal computers. In simpler terms, any device that is made from an integrated circuit that is operated by some software is considered an electronic device. The problem arises when a more thorough assessment of these devices is done to ascertain it's environmental and health impacts. Each of those hundreds of component that are used to create these electronic devices can contain toxic chemicals that are harmful to health and environment. The primary objective of this report is to show the harmful effects of e-waste burning as well as to assess its environmental and health impact**.**

1. E-WASTE STATISTICS (ACROSS THE GLOBE)

1.1. AVERAGE CONTENT OF E-WASTE

The global content of e-waste in 2014 is around 41.8 megatonnes (Mt) including 1.0 Mt lamps, 3.0 Mt of small information technology device (IT), 6.3 Mt of screens and monitors, 7.0 Mt of temperature exchange equipment (cooling and freezing equipment), 11.8 Mt large equipment, and 12.8 Mt of small equipment [13]. With an annual growth rate approximated 4 – 5%, the predicted amount of e-waste that would be generated in 2018 will be 49.8 Mt [13].

TABLE 1.1 TOTAL E-WASTE PER CATEGORY IN 2014 [13]

Equipment	E-waste generated (Mt)
Lamp	1.0
Small IT	3.0
Screens	6.3
Temperature exchange equipment	7.0
Large equipment	11.8
Small equipment	12.8
Total	41.9

1.2. GLOBAL QUANTITY OF E-WASTE GENERATED

The amount of e-waste that is disposed in waste bins is unknown for many countries but the members of European Union (EU) dispose about 0.7 Mt of e-waste into the waste bin [13]. In general, today there is a wide disparity between the official reported amount of e-waste collected outside of formal take-back systems, the e-waste in the waste bin, and the total e-waste generated. Table 1.2 shows the quantities of e-waste generated, the population and the ratio of e-waste generated in kilograms (kg) per inhabitant between the years 2010 and 2015. The data has also been extrapolated using the observed 4 – 5% appreciation estimate for 2016, 2017 and 2018. Figure 1.1 shows a graphical representation of these values, that is, the growth of e-waste generated over time.

TABLE 1.2 GLOBAL QUANTITY OF E-WASTE GENERATED FROM 2010 TO 2018 [13]

Year	E-waste generated (M	Population (billions of people)	E-waste generated (kg/inhabita
2010	33.8	6.8	5
2011	35.8	6.9	5.2
2012	37.8	6.9	5.4
2013	39.8	7	5.7
2014	41.8	7.1	5.9
2015	43.8	7.2	6.1
2016	45.7	7.3	6.3
2017	47.8	7.4	6.5
2018	49.8	7.4	6.7

FIGURE 1.1 THE GROWTH OF E-WASTE GENERATED OVER TIME

1.3. *CATEGORIES OF E-WASTE IN 2014*

Electronic devises can be classified into six categories and therefore it was relatively straightforward to classify the e-waste into these same categories. The reasoning behind such a classification system is that the function, weight, size, and material composition of each unique category is different. This, invariably, causes the groups to possess clearly distinguishable environmental and health problems.

TABLE 1.3 E-WASTE CATEGORY AND TYPES OF DEVICES THAT FALL INTO THAT GROUPING [13]

Category	Makeup
Lamps	Straight fluorescent lamps, compact fluorescent lamps, high intensity discharge lamps, and light emitted diode (LED) lamps.
Small IT and Telecommunications device	Mobile phones, Global position systems (GPS) devices, pocket calculators, routers, personal computers, printers, and telephones.
Screens and Monitors	Televisions, monitors, laptops, notebooks, and tablets.
Temperature exchange equipmer	Refrigerators, freezers, air conditioners, and heat pumps.
Small equipment	Vacuum cleaners, microwave ovens, ventilation equipment, toaster, electric kettles, electric shavers, scales, calculators, and radio sets.
Large equipment	Large printing machines, washing machines, clothes dryers, dish washing machines, electric stoves, copying equipment, and photovoltaic panels.

It should also be noted that each category requires a specific recycling system. From the data of Table 1.2 and the Figure 1.12, small IT and telecommunication equipment, including mobile phones, constitute 7% or 3 million tonnes of e-waste generated in 2014**.**

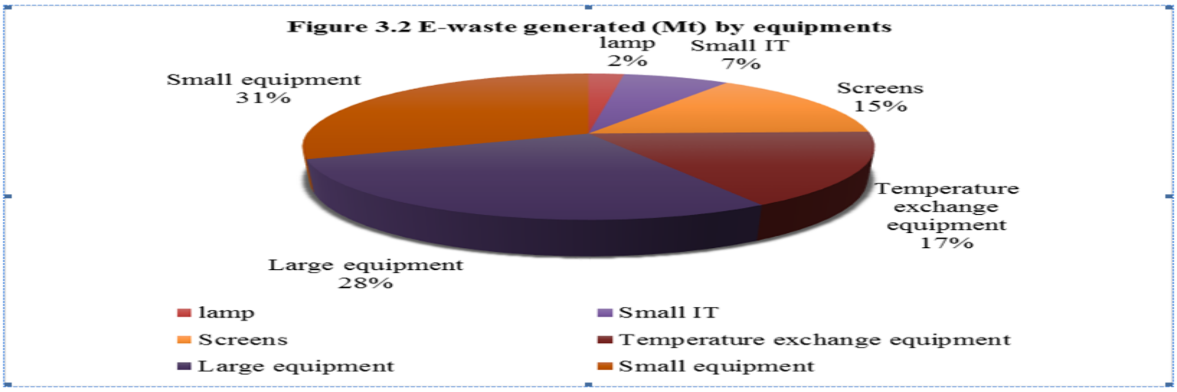

FIGURE 1.2 TOTAL E-WASTE PER CATEGORY

1.4. E-WASTE GENERATION IN THE CONTINENTS

The Americas (North America and South America combined,) generated 11.7 Mt of e-waste including 7.9 Mt for North America, 1.1 Mt for Central America, and 2.7 Mt for South America, which represented a per inhabitant value of 12.2 kg/inhabitant. Oceania generated the lowest quantity of e-waste, about 0.6 MT, and Asia generated the highest quantity of e-waste at about 16 Mt (3.7 kg /inhabitant). Europe (including Russia) generated 11.6 Mt and had the highest per inhabitant e-waste quantity at 15.6 kg/inhabitant. Africa generated 1.9 Mt of e-waste and the lowest amount per inhabitant at 1.7 kg/inhabitant [13].

TABLE 1.4 E-WASTE GENERATION PER CONTINENT PER INHABITANT IN 2014 [13]

Continent	E-Waste Generated (Mt)	E-Waste Generated (Kg/Inhabitant)
Africa	1.9	1.7
Americas	11.7	12.2
Asia	16.0	3.7
Europe	11.6	15.6
Oceania	0.6	15.2

1.5. E-WASTE GENERATION PER CATEGORY, CONTINENT, AND INHABITANT

The two figures below (Figure 1.3 and Figure 1.4) show the ratio of inhabitants that contribute to the rate of e-waste generation. It clearly shows that if the trend continues, it would not be long before there is no more room for where e-waste can be discarded. Even a continent as small as Oceania accounts for a substantially large percentage of the per inhabitant source of e-waste. One possible explanation for this is due to the population density that is present in Oceanic regions. Thus, it is crucial to take a holistic view of the influences of population as well as lifestyle choices of the society during the analysis of such data.

TABLE 1.5 COLLECTIVE E-WASTE GENERATION SHOWING INDIVIDUAL CATEGORIES AS WELL AS TOTALS AND PER INHABITANT VALUES

Equipment	E-waste generated (in Mt)				
	Africa	Americas	Asia	Europe	Oceania
Lamp	0.1	0.2	0.5	0.2	0.01
Small IT	0.1	1.8	1.1	1.9	0.05
Screens	0.3	1.7	2.5	1.7	0.1
Temperature exchange equipment	0.3	2.0	2.7	1.9	0.08
Large equipment	0.5	3.3	4.1	3.6	0.14
Small equipment	0.6	3.6	5.1	3.3	0.19
Total	1.9	11.7	16.0	11.6	0.6
Per kilogram of inhabitant (in kg/inhabitant)	1.7	12.2	3.7	15.6	15.2

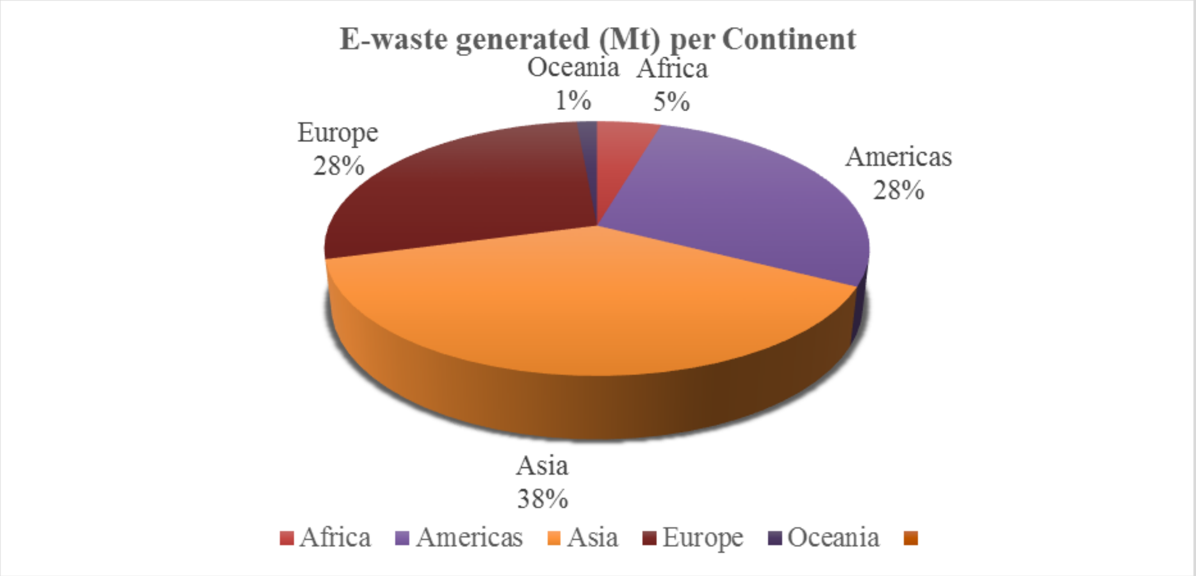

FIGURE 1.3 PERCENTAGE OF E-WASTE PER CONTINENT IN 2014

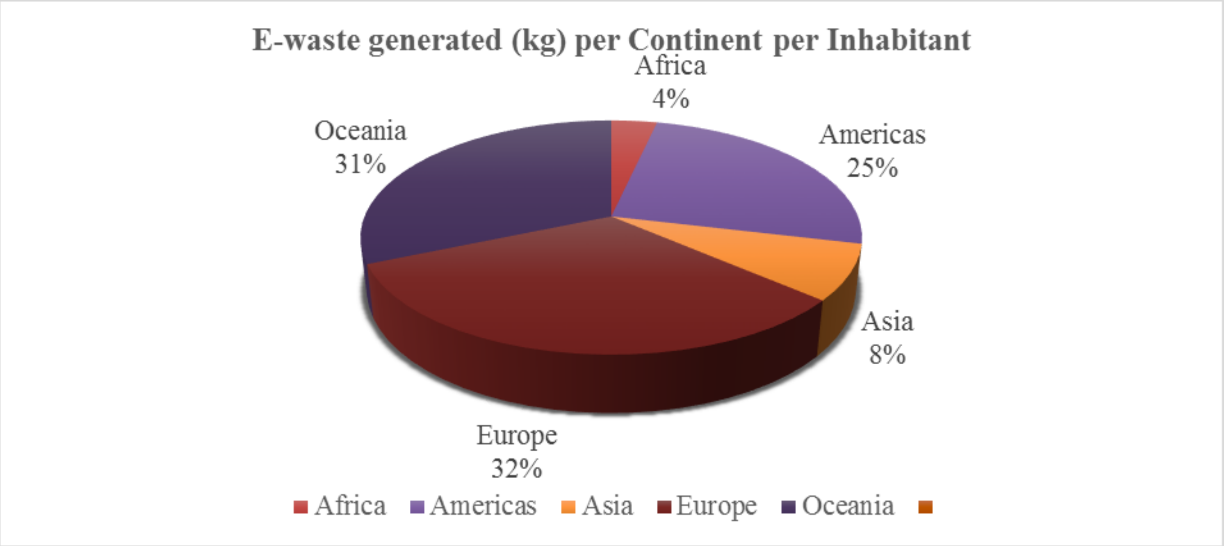

FIGURE 1.4 PERCENTAGE OF E-WASTE GENERATED PER CONTINENT PER INHABITANT IN 2014

III. Legislature Concerning Disposal of E-waste

National e-waste legislations covered about 4 billion people in 2014 and around 6.5 Mt of e-waste was reported as formally treated by national take-back systems [13]. Although, the general consensus is that more needs to be done to protect the physical as well as the socioeconomic environment. To that end, numerous legislations have been implemented with varying degrees of success.

3.1 Federal (E-waste) Laws in the United States of America

Waste in the United States of America (U.S.) is subject to the federal Resource Conservation and Recovery Act (RCRA) [14]. Congress introduced a bill call the Responsible Electronic Recycling Act (RERA) that makes the export of toxic e-waste from the U.S. to developing countries an illegal act. However, the bill was never selected for subcommittee hearing despite bipartisan support in the House, as well as general wide spread support from environmental groups and electronic manufacturers such as (Dell, HP, and Apple).

Coupled with the above, due to the nature of e-waste often being associated with personal data (in digital harddrives), compliance to regulation often exceeds more that just environmentally sound practices [15]. For example:

1. The Fair and Accurate Credit Transaction Act (FACTA)
2. The Red Flags Rule
3. The Health Information Technology for Economic and Clinical Health Act (HITECH)

All of which are designed to protect the privacy and information of the clients of these services.

3.2 State (E-waste) Laws in the United States of America

At the state government level in the U.S., there are currently twenty five states as well as the District of Columbia with e-waste laws. In Figure 1.5, states highlighted in orange have passed some type of e-waste legislation. Table 1.6 shows the states in the United States of America with e-waste laws and the year in which laws were passed [16].

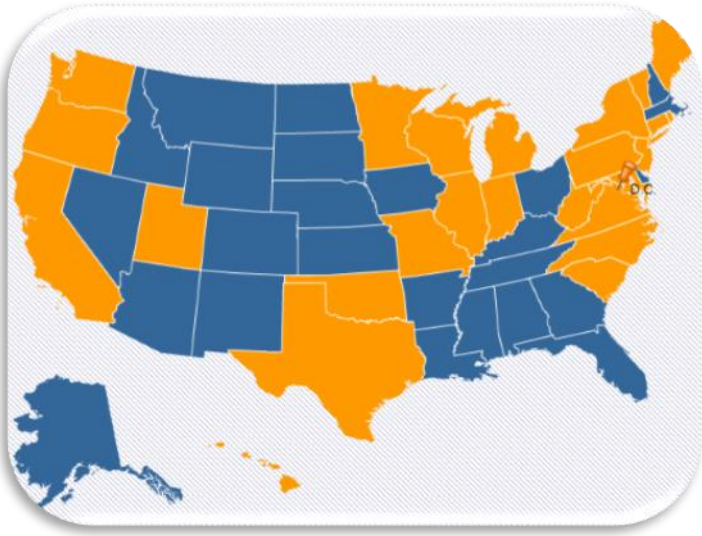

FIGURE 1.5 MAP OF THE UNITED STATES OF AMERICA, SHOWING STATES WITH SOME FORM OF E-WASTE LAW IN ORANGE COLOR (SOURCE: ELECTRONIC RECYCLING COORDINATION CLEARINGHOUSE (ERCC))

TABLE 1.6 STATES THAT HAVE PASSED SOME FORM OF E-WASTE LEGISLATURE

Year	State(s)
2003	California
2004	Maine
2005	Maryland
2006	Washington
2007	Connecticut, Minnesota, Oregon, Texas, North Carolina
2008	New Jersey, Oklahoma, Virginia, West Virginia, Missouri, Hawaii, Rhode Island, Illinois and Michigan
2009	Indiana, Wisconsin
2010	Vermont, South Carolina, New York, Pennsylvania
2011	Utah
2014	District of Columbia

Maryland is the third state that enacted an e-waste recycling program in 2005, and the name of the program is the Statewide Computer Recycling Pilot Program or SCRPP. According to SCRPP, computer manufacturers have been required to register and pay an annual registration fee to Maryland Department of the Environment (MDE) in order to be able to sell their products in Maryland. Upon the success of the Statewide Computer Recycling Pilot Program, the Statewide Electronics Recycling Program or SERP, which expanded the scope of electronics covered and clarification to the definition of manufacturer, was passed in 2007.

3.3 Details of Statewide Electronic Recycling Program (SERP)

The Statewide Electronics Recycling Program (SERP) includes [17]:

- Requiring manufacturers who manufacture an average of more than 1,000 covered electronic devices per year in the immediately preceding three-year period to register with and pay a registration fee to MDE, if they plan to sell or offer for sale to any person in the State a new covered electronic device. A covered electronic device is a computer or video display device with a screen that is greater than 4 inches measured diagonally.
- Payment of an initial annual registration fee of $10,000. The subsequent annual renewal registration fee is $5,000 but the fee can be reduced to $500 provided the manufacturer has an MDE-approved take back program.
- Prohibiting a retailer from selling or offering for sale to any person in the State a new covered electronic device manufactured by a manufacturer that has not registered and paid the required registration fee to MDE.
- Provision for civil and administrative penalties against manufacturers and retailers who fail to comply with the SERP specification.
- Issuance of grants to counties and municipalities to assist with covered electronic device recycling activities.
- Requiring counties to address methods for the separate collection and recycling of covered electronic devices in their recycling plans in order to be eligible for State grants.

Some highlights of electrical waste cycling in Maryland are the special collection events; permanent electronic collection programs; and regularly scheduled electrical waste recycling collection events.

3.4 LEGISLATION AROUND THE WORLD

A similar implementation of an electronic mandate is the one proposed by the Chinese government to curb some of the influx of e-waste. The Chinese government implemented a "Home Appliance Old for New Rebate Program," which was tested from 2009 to 2011. With the help of generous government subsidies, the program collected tens of millions of obsolete home appliances, according to the U.N. Even with the, apparent, success of the (Chinese) government to limit the volume of smuggled supplies of foreign e-waste, the volume of local e-waste has seen a rapidly growth over the last 6 years.

3.5 E-WASTE LAWS IN INDIA

Due to India being both an "importer" of e-waste as well as a local generator, national legislature specifically tackling both e-waste imports as well as those domestically produced were implemented [18]. In April of 2008, Greenpeace organized a meeting with major electronics manufactures in Bangalore in order to initiate dialogue to set the ball rolling for a formal law governing e-waste [19]. After highlighting the problem, Greenpeace continued to work behind the scenes for several years to get companies, industry associations, and government experts to draft legislation that is was binding law to make producers financially liable for the management of e-wastes, in particular, their own e-waste [18].

The Indian Ministry of Environment and Forest (MoEF), with effect from 1st of May 2012, placed a legal liability for reducing and recycling electronic waste on the producers for the first time under the E-waste (Management and Handling) Rules 2011, which forms a part of the Environment Protection Act. According to the rule, manufacturers and importers of computer, mobile phones and white goods will be required to come up with an e-waste collection center or introduce a "take back" system to compensate for the e-waste streams produced by their products. These rules applied to every producer, consumer, and bulk consumer involved in the manufacture, sales, purchase and processing of electronic equipment or components [20]. An amendment to the e-waste rule (E-waste (Management and Handling) Amendment Rules 2011 places some burden on commercial consumers as well as government entities to become responsible for the e-waste they generate. Channeling it to authorized collection centers or ensuring it is taken back by suppliers. They are required to maintain an e-waste records and make these available to State Pollution Control Boards or other authorities. The rules also states that every producer, collection center, dismantler, or recyclers may store e-waste for a period not exceeding one hundred and eighty (180) days and shall maintain a record of collection, sales, transfer, storage and segregation of wastes and make these records available for inspection. In addition, every producer of electrical and electronic equipment shall ensure that new electrical and electronic equipment does not contain Lead, Mercury, Cadmium, Hexavalent Chromium, Polybrominated Biphenyls, or Polybrominated Diphenyl ethers (MoEF).

3.6 THE BASEL CONVENTION

The outcome of this convention has banned the export of hazardous waste to poorer countries since 1992, but the practice continues. Commonly, the term "bridging the digital divide" is used when old waste electrical and electronic equipment (WEEE) are exported to developing countries and they are often labeled as "second-hand goods" since the export of reusable goods is allowed. On the other hand, most WEEE that does work on arrival only has a short second life and/or, generally, suffers damage during transportation. The main objectives of the Basel Convention are: (a) Minimize the generation of hazardous waste, (b) Dispose of hazardous wastes within the country of generation effectively in an environmentally sound manner, (c) Establish enhanced controls on export and import of hazardous waste, (d) Prohibits shipments of hazardous wastes to countries lacking the legal and technical capacity. The incident that led to the creation of the Basel Convention was the Khian Sea waste disposal, in which a ship carrying incinerator ash from the city of Philadelphia in the US, after having dumped half of its load on a beach in Haiti, was forced away, sailed for many months changing its name several times unable to unload its cargo in any port, and ended up dumping much of it, illegally, at sea. The Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal is an International treaty, designed to reduce the movements of hazardous waste between nations. Specifically to prevent dumping of hazardous waste from developed to less developed countries. The Convention was opened for signature on March 22, 1989, and entered into force on May 5, 1992.

IV. Environmental and Human Health Concerns in the Processing of E-waste

Some examples of the toxic materials that are found in computers and other consumer electronics are lead, mercury, cadmium, and chromium, which have been known to cause serious potential environmental and health threats. Rapid growth of the electrical and electronic waste raises concerns about the disposal of these products. E-waste has multiple properties and a great variety of product types and complex material compositions. Some contain base metals (such as iron, steel, aluminum, copper, zinc, magnesium, tin and alloys of these metals), precious metals (such as silver, gold and palladium), and a great variety of plastics. These materials can serve as resources to be recycled but a vast majority of them are too hazardous and toxic which can cause adverse environmental and health impacts when not handled properly with the right tools.

4.1 Content of Hazardous Materials and Human Toxicity Potential of Electronic Waste

Electronic devices usually cause environmental and health issues during the end of life phase of the lifecycle. In addition, sometimes the recycling process itself may cause a significant secondary pollution. For example, using uncontrolled acid leaching to extract the precious metals of circuit boards. The most common toxic materials in electrical and electronic waste comprise halogenated compounds, heavy metals, and other materials such as toner and radioactive substances**.** Plastics and polyvinyl chloride (PVC), which are used in producing flame-retardants and cable insulation, are the most halogenated compound materials. Old models of cooling and freezing equipment, which include chlorofluorocarbons (CFCs), still appear in waste stream and may pose a threat for environment. Batteries, circuit boards, and screens such as CRT and LCD (monitors and TVs), and mercury-containing lamps contain heavy metals, which are considered a potentially toxic material for humans. To summarize the previous conglomeration of information, Table 1.7 has been created, which shows the most common toxic materials in e-waste and their source stream.

TABLE 1.7 THE MOST COMMON TOXIC MATERIALS IN E-WASTE AND THEIR SOURCE STREAM (SOURCE: WANG, F. [18])

Substance	Occurrence in E-waste
Halogenated compounds	
PCB (polychlorinated biphenyls)	Condensers, Transformers, TV enclosures
TBBA (tetrabromo-bisphenol-A); PBB (polybrominated biphenyls); PBDE (polybrominated diphenyl ethers)	Flame retardants for plastics (thermoplastic components, cable insulation, TV enclosures); TBBA is presently the most widely used flame retardant in printed wiring, TV enclosures; Boards and casings, housing of CRT screens
Chlorofluorocarbon (CFC)	Cooling and freezing units, Insulation foam
PVC (polyvinyl chloride)	Cable insulation
Heavy metals and other metals	
Arsenic	Small quantities in the form of gallium arsenide in light emitting diodes
Barium	Getters in CRT
Beryllium	Power supply boxes which contain silicon controlled rectifiers and x-ray lenses
Cadmium	Rechargeable Ni-Cd batteries, fluorescent layers (CRT screens), printer inks and toners, photocopying machines (printer drums)
Chromium VI	Data tapes, floppy-disks
Lead	CRT screens, batteries, printed wiring boards, solders
Lithium	Li-batteries
Mercury	Fluorescent lamps, some alkaline batteries and mercury wetted switches

Nickel	Rechargeable Ni-Cd batteries or Ni-MH batteries, electron gun in CRT
Selenium	Older photocopying-machines (photo drums)
Zinc sulphide	Interior of CRT screens, mixed with rare earth metals
Others	
Toner Dust	Toner cartridges for laser printers / copiers
Radioactive substances Americium	Medical equipment, fire detectors, active sensing Elements in smoke detectors
Asbestos	Older appliances such as electric heaters, coffee pots, toasters a irons

4.2 Classification of E-waste by Potential for Human Toxicity in the End-of-Life Phase

According to the environmental impacts of hazardous materials and effects on human beings, electrical waste can be classified into the following seven categories, under the assumption that all the hazardous materials contained in e-waste are released directly into the environment.

TABLE 1.8 CLASSIFICATION OF E-WASTE BY TOXIC POTENTIAL DURING END-OF-LIFE PHASE (SOURCE: [18])

Category	Products	Average weight	Toxic potential (TP)	
			TP/kg	TP/unit
1	Large household equipment (non-CFCs)	High	Low	Low – Medium
2	Cooling and freezing equipment with CFCs	High	Mediun	Medium – High
3	Small household appliances	Medium	Mediun	Low – Medium
4	Medium-sized IT and consumer equipme	Medium	Mediun	Medium – High
5	Small-sized consumer equipment; Mercury-containing lamps	Low	High	Medium – High
6	Screens (CRT and Flat panel TVs and monitors)	High	High	High
7	Non-mercury lamps Small toys	Low	Low	Low

5.3 Effects of Poor E-waste Management on the Local Population

Electronic devices are bought and kept in the household, offices and locations in which they are used for some time until they are disposed of. The lifetime or residence time of products is the time that the equipment spends at locations in which they are used. After a certain residence time, the product becomes waste. It is the supply of domestically generated e-waste prior to collection and without imports. The e-waste generated can be collected by official take back system, end up in waste bin (in non-separately collected household waste), and collected outside formal take back systems in developed and developing countries. In practice, e-waste is moved from developed to developing countries. Figure 1.6 summarizes the e-waste generation and its phases.

FIGURE 1.6 A SUMMARY OF THE E-WASTE GENERATION AND ITS PHASES

Specific health and safety risks are increased for the local population and involved workers through informal e-waste collection, refurbishing and recycling. During informal collection, these risks primarily grow from handling heavy and broken devices and moving them over large distances or participating in heavy road traffic. In the refurbishing sector, many workers are engaged in hand soldering using lead containing solder paste, so they are exposed to lead fumes over long durations of time, which causes itchy eyes and muscle pain. In the refurbishing of photocopiers and laser printers, toner dust is considered as a significant health risk [19]. Inhaling toner dust can cause respiratory diseases, skin and eye irritation, chronic cough, fatigue, pains, fever, and cancer.

The health and safety risks are more in the recycling of e-waste than the collection and refurbishing. As an example, during the recycling of CRTs, a certain amount of the cadmium-containing internal phosphorous coating is released as dust that can partly be inhaled by the workers.

V. Impact Assessment of E-waste Burning

5.1 Environmental Impact Assessment of E-waste Burning

When e-waste, oil, and other potentially hazardous wastes are burnt they can harm the health of the local population as well as environment. E-waste—such as computers, printers, and cell phones—contain toxic heavy metals such as lead, mercury, and cadmium. When they are thrown away in the trash, they end up in landfills, and these compounds can leach back into the soil and water, polluting lakes and streams. Thus making them unfit for drinking, swimming, fishing, and supporting wildlife. As stated in earlier, the volume of e-waste generated is growing around the world, and, increasingly, it is being disposed of by export from developed to developing countries.

Due to the annual increase of e-waste that is deposed, aquatic environment is at a potential high risk, because the piles of e-waste components that are stored improperly are routinely drenched or flooded by rainfall, producing run-off from storage sites to local waterways. Both water and sediment samples show that e-waste related contaminants have entered local environmental waterways. Our concern is that such exposures have limited and will continue to limit the diversity of aquatic organisms. There have also been changes in the abundance of biodiversity of surviving species, which, ultimately, adversely affect the natural food chain. Heavy metals (e.g. lead, cadmium, copper, and zinc) and organic pollutants (e.g. pCDD/Fs and PBDEs) have been detected in the sediment of local water bodies in quantities that greatly exceed background levels. This fact alone suggests that aquatic organisms that live in the affected water bodies are highly exposed to these toxic, bio-accumulative, and persistent contaminants.

5.2 Health Impact Assessment of E-waste Burning

In developing countries, workers that are either uneducated or improperly equipped to deal with the hazardous nature of the task they are performing routinely disassemble e-waste. Once disassembled, the e-waste components are often stored in large piles outdoors. These processing and storage methods expose workers and local residents to several heavy metals and organic chemicals that exist in e-waste components. Exposure to cadmium dust causes malfunctioning of kidneys and the respiratory system, and possibly to lung cancer and, exposure to lead dust is known to cause multiple disorders including neurological, cardiovascular and gastrointestinal diseases. Exposures to polybrominated diphenyl ethers (PBDEs) have been known to cause endocrine disruptive properties and neurobehavioral disturbances in animals, such as abnormal brain development [22].

Finally, persistent organic pollutants (POPs) such as dioxins are released into the environment by the burning of cables in order to recover copper. Plastics are also burnt but this time to reduce the waste volumes. Soil, dust and air of informal recycling stations have high concentrations of toxic metals such as lead and cadmium, and halogenated chemicals such as phthalates 6 and polybrominated diphenyl ethers (PBDEs) [20], [21]. Studies by the Shantou University Medical College revealed that many children tested in Guiyu, China had higher than average levels of lead in their blood, which can stunt the development of the brain and central nervous system.

TABLE 1.9 SUMMARY TABLE OF SOME OF THE MAJOR COMPONENTS OF E-WASTE AND THEIR EFFECTS

Electrical Component	Major Waste Stream Generatio	Health Impact	Environmental Impact
Printed circuit board (PCB)	Contaminated rinse water (usually contaminated with heavy metals and/or solvents Waste chemicals Effluents which may contain metals such as copper, lead, chromium, antimony, nickel, and gold Waste boards Acidic air emissions VOC emissions	Increases in mortality from cancers of gastrointestinal tract, the liver, the organs and tissues involved in the production of blood, including bone marrow, the spleen, tonsils, and lymph nodes Malignant melanoma	Contaminated rinse water may find its way to a local watershed VOC emissions Acidic air emissions
Gold Plate	Chemical stripping using nitric acid and hydrochloric acid and burning of chips	Soluble compounds, i.e. gold salts such as gold chloride, are toxic to the liver and kidney. Common cyanide salts of gold such as potassium gold cyanide, used in gold electroplating, are toxic by virtue of both their cyanide and gold content. Rare, lethal gold poisoning from potassium gold cyanide. Gold toxicity can be ameliorated chelation therapy with an agent such as dimercaprol.	Hydrocarbons, heavy metals and brominated substances discharged directly into rivers, acidifying fish and flora. Tin and lead contamination of surface and ground water. Air emissions of brominated dioxins, heavy metals and hydrocarbons.
Batteries			Non-hazardous waste since Li-ion contains less toxic chemicals than other types of batteries. Recycling could prevent a future shortage.

VI. CONCLUSION

Environmental and health effects have been confirmed to result from the primitive methods used to recycle and process e-waste within the local environment. Only limited local data exist on the amount and level of threat posed by these e-waste-related contaminants on nearby natural resources, especially aquatic habitat and organisms. In this paper, we have the highlighted the toxicity of selected heavy metals and organic pollutants on the environment. It is confirmed that both heavy metal and organic contaminants are reaching the biota of municipal local watershed; it has been shown that they are producing adverse effects. To be fully confident of the introduced data, more research is strongly recommended to examine, on a large scale and long-term basis, both the contamination levels in biota as well as a longitudinal study on the effects interaction with the physical environment.

Fortunately, there is a stopgap, if not solution per se: returning used electronics for responsible recycling, rather than throwing them in the trash. This has been the selected action that seems to prevent the most amount of e-waste from reaching the dumpsite. Another step in the positive direction is the Indian's e-waste regulation. It is not going to solve India's waste problem right away effective implementation and future strengthening of the regulation is needed. However, the fact that India has adopted such a law also is a positive example for ongoing discussions on regulation of the electronics in places such Argentina and in the EU, which is finalizing a new version of electronic waste regulation, the WEEE directive. Together India, Argentina and the EU can create a global benchmark for responsible and forward looking e-waste treatment.

Ultimately, the environment cannot defend itself. It is the collective responsibility of the inhabitants to properly utilized the natural resources in a sustainable fashion. This aper has highlighted a plethora of health effects as well as environmental effects that are correlated with the burning of e-waste. To offer as potential solution, it has also highlighted some functional legislative oversight, that have proved to be effective in the past. It is our hope that bringing this global problem to light will assist in the exponential increase in awareness, and thus, more sustainable solutions regarding the rapid discard cycle of electronic waste.

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