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A Review on the environmental and health impacts due to electronic waste disposal in Bangladesh

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Abstract

Bangladesh is one of the main importer countries of e-waste in the world. Moreover, country also generates e-waste about 2.81 million metric tons per year. However, majority of e-waste is being dumped into the open soil, open land, or open water bodies resulting problem on environment (i.e., pollution) and human population (i.e., health). Therefore, present review summarizes the environmental and health impact due to disposal of e-waste. Poorly management of e-waste during the collection, processing, recycling, and land filling causing environmental impact followed by air pollution, soil pollution, water pollution, and degradation of the beach because hazardous compounds spread to the surrounding or environment. Furthermore, e-waste also creates lots of health problems. Humans can be exposed to e-waste contaminants by the inhalation, dietary intake, dust ingestion, and dermic contact. In north eastern part of Bangladesh, about 36.3% women who lives near recycling sites experienced the death of a baby. Again, about 15% child laborers die, and 83% child laborers are affected by long term health problem because of e-waste mismanagement practice. There are about 120,000 Bhangaries who may be exposed to e-waste contaminants more seriously. The result of the study would provide us important insight into the growing concern of e-waste and would help policy maker for designing policy measure to recycle e-waste in a hazard free manner.

Keywords: Bangladesh; E-waste; Environment; Health; Recycle

1. Introduction

Industrial countries started shipping hazardous and e-waste to lower and middle income countries during the 1970 and 1980s [1]. For example, about 250,000 tons to 1.3 million tons of e-waste have been shipped out from Europe mostly to the developing nations of west Africa and Asia [2]. Moreover, per capita of e-waste generation is increased within the lower- and middle-income countries by the rapid development of cellular and internet networks. Sometimes, political agenda (e.g., Digitalization of Bangladesh) can also motivate the generation of e-waste in a country [31]. Therefore, current e-waste generation rate has increased all over the world about 72 million tons, that is 33% more than the last decade [32].

Continuous advancements in the science and technology help us to lead comfortable lives and also create burden on the environment (e.g., pollution) and human populations (e.g., health). For example, electronic and electrical equipment make our life easier but when this e-waste is processed in hazardous and inefficient conditions, that pose environmental and health concern [2]. People who are employed in the e-waste recycling sector had a high incidence of skin damage, headaches, vertigo, nausea, chronic gastritis, and gastroduodenal ulcers [3]. More than 70% of children have blood lead

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levels above 10 µg/dL and neonates had higher levels of toxic chemicals including Pb, Cd, Cr, Ni, PBDEs in blood and placenta [4,5].

E-waste disposal not only raise human health issue but also environmental impact. It can contaminate the agricultural soil with the reduction of annual crop production or can deteriorate the surface and subsurface water ways [6]. Government of Bangladesh has taken a unique case entitled to “Digital Bangladesh” for developing the sector of information and communication technology (ICT). Therefore, e-waste is increasing with the rate of digitalization. Further, the existence of ship breaking industries are also contributing to e-waste generation and recycling problems [31].

Rapid growth of e-waste, lack of proper management and regulation, and the absence of protection of workers causing e-waste derived environmental and health hazards in Bangladesh. However, surprisingly there have been no intensive studies in Bangladesh to calculate the e-waste derived environmental and health hazards. Given this situation, present study gives an overview to estimate environmental and health impact due to disposal of e-waste. This study would be helpful for the policy maker.

2. Definition and categories of e-waste

Electrical and electronic debris popularly known as e-waste (electronic waste). E-waste can be defined as the old, or end of life or discarded appliances, that fail to work or suffer from functional defects during its production [7]. E-waste can be classified into 10 categories based on the directives of 2012/19/EU (https://ec.europa.eu/environment/waste/weee/index_en.htm). It is one of the most widely conventional classifications (Table 1).

3. E-waste generation scenario

3.1. E-waste generation scenario around the world

Currently, the world is experiencing the significant e-waste growth, that is very alarming ecological delinquencies. Around the world, about 20 to 50 million metric tons of e-waste is originated every year and nearly 75 to 80% of that is exported to developing countries predominantly Africa, and Asia for recycling and disposal [9]. China and India are the main importer of e-waste. Besides, Pakistan, Ghana, Bangladesh, Nigeria, and Kenya are another e-waste importer country [10].

According to USEPA, global generation of e-waste is increasing annually with the rate of 5 to 10% [34, 35] because of the frequency of purchasing unnecessary EEE items are high [32], and the short life span of the electrical equipment [11,12]. During the last few decades, e-waste has gained the most alarming concern in both developed and developing countries in the world. E-waste growth has an increasing trend from 2005 to 2017 around the world which is shown in Fig.1.

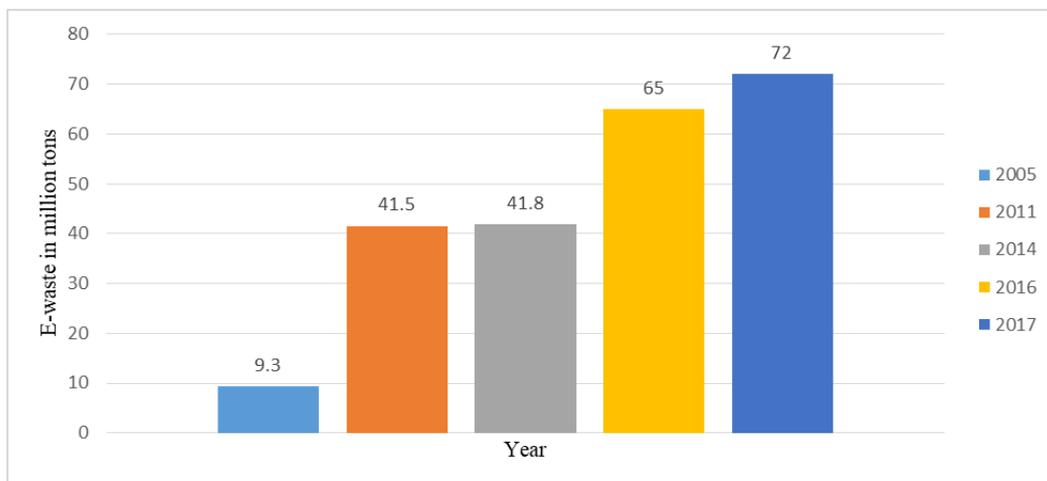


Figure 1 Trend of e-waste around the world [13, 34, 36]

Table 1 Categories of e-waste [8]

Category	Characteristic	Example
Category (C01)	Bulky house hold appliance	Microwaves, refrigerators, freezers, clothes dryers, washing machines, electric cooking stoves, dishwashers and electric fans, hot plates and air conditioners.
Category (C02)	Small house hold appliance	Coffee machines, toasters, tooth brushing, vacuum cleaners, grinders, haircutting appliances, drying and shaving.
Category (C03)	ICT and telecommunication equipment	Minicomputers, mainframes computer, personal computers, notebooks, laptops, printers, telephones, cell phones and IP phone.
Category (C04)	Consumer equipment and photovoltaic panels	Video recorders, video cameras, radios, stereo recorders, televisions, musical instruments, audio amplifiers etc.
Category (C05)	Lighting equipment	Straight and compact fluorescent lamps and high-intensity discharge lamps, LED, solar panel.
Category (C06)	Electrical and electronic tools (with the exception of large scale stationary industrials tools)	Drills, saws, sewing machines, soldering irons, equipment for turning, milling, grinding, drilling, making holes, folding, bending, or similar processing of wood and metal.
Category (C07)	Toys, leisure and sports equipment	Toys, leisure equipment, and sporting goods: electric trains or racing car sets, video games, and sports equipment with electric elements.
Category (C08)	Medical device (with the exceptions of all implanted and infected products)	Ventilators, craniological device, nuclear analyzers, radiotherapy equipment, all types of dialysis equipment.
Category (C09)	Monitoring and control instruments	Smoke detectors and thermostats, heating regulators etc.
Category (C10)	Automatic dispensers	Solid products, food and drinks related electrical device, all electronics device that mechanically deliver various products, cold or hot bottles.

3.2. E-waste generation scenario in Bangladesh

It is very popularly known as Bangladesh is one of the major e-waste import countries. Apart from this, the country also produces about 2.81 million metric ton e-waste annually [14,21]. The total generated e-waste in Bangladesh per year can be summarized in Table 2.

Table 3 reveals the volume of some key sources of e-waste generation from different electrical and electronic product with respect to Bangladesh.

During the last 15 years, Bangladesh is developing in the sector of information and communication technology (ICT) since the declaration of digital Bangladesh as a part of government's "Vision 2021" to rapidly improve the education, health, and the financial situation of the population by infrastructure building and employment of digital technology. Then, ICT sector produces huge number of e-waste. Dhaka and Chottogram are the two largest stake holder for collecting and managing of e-waste respectively [8].

Since our country is becoming digitalized in the near future, the usages of electronic equipment will increase with a great speed [21]. This jumping in electronics consumption will led to e-waste disposal, repair, and recycling. Over and above, Bangladesh is home to the second largest ship breaking industry in the world which generates more e-waste than consumer electronics [15].

Table 2 Sources of e-waste in Bangladesh [14]

Sources of e-waste	Amount of e-waste (Million metric ton/year)
Electric charged vehicle	2.5
Television	0.17
Computer	0.035
Mobile phone	0.005
CFL bulb	0.0005
Mercury bulb	0.0001
Thermometer	0.009
Other medical and dental wastes	0.09
Total	2.81

Table 3 Volume of different e-waste in Bangladesh [14]

Sources of e-waste	Volume of e-waste (pieces)	Time duration
Computer	2,103,687	From 1971 to 2010
Mobile phone	24,932,160	From 1971 to 2010
CFL bulb	5,253,313	From 2006 to 2010
Thermometer	610,295,237	From 1971 to 2010
Medical and dental equipment	167,844 (for each doctor)	From 2001 to 2010
	199,595 (for each government hospital)	From 2001 to 2010
	13,068 (for each private clinic)	From 2001 to 2010

4. Environmental impacts

Poorly management of e-waste during the collection, processing, recycling, and land filling causing environmental impact (Table 4) because hazardous compounds spread to the surrounding environment, for example, nearby surface water and ground water reservoirs, and also evaporate to the atmosphere as well [16]. The impacts on the environment due to mismanagement of e-waste are given below:

4.1. Air pollution

When e-waste burns it generates smoke that contains both poisonous gases and heavy metals. For example, polyvinyl chloride (PVC) produces huge amount of hydrogen chloride gas when it burns. Hydrogen chloride forms hydrochloric acid if it is mixed with water resulting respiratory problems when inhaled. Moreover, PVC releases highly toxin dioxins and furans while burning as it covers copper cables and plastic computer casings (<https://ewasteguide.info/hazardous-substances/>). Incineration of e-waste can release lead, cadmium and mercury into the air [16]. A 14-inch monitor uses a tube which contains about 2.5 to 4 kgs lead. The tube emits toxic fumes into the air if it is crushed and burned [17].

4.2. Soil pollution

More surprisingly, bacteria can even turn into toxic organic mercury compounds when e-waste contains mercury and the mercury is buried under soil. Dumping of brominated flame retardant plastic and cadmium in the land fill may polluted the soil as they leach into the soil and ground water [16]. Further, illegal dumping of e-waste in the landfill threatens the soil contents and affecting the crop production as well [2].

4.3. Water pollution

When the dumped e-waste is seeping into the soil then our groundwater will be contaminated by poisons such as arsenic. It has been observed that a large amount of lead ions is dissolved from broken glass which contains lead. Like many other developing countries, Bangladesh is one of the most common ground for recycling of e-waste. Very often, these e-waste is improperly managed creating blockages in water runoff channels [16]. If discarded e-waste materials are percolating into the soil, then aquifer of water can be polluted with poisonous substances [18]. Different types of plastic elements from computer, mobile, refrigerator are dumped into the river which obstacles the free flow of water and reduce the level of oxygen. This is very common scenario for the rivers of Bangladesh, predominantly in and around the city.

4.4. Degradation of the beach

Every year Bangladesh legally import a significant number of scrap ships. These ships are broken down in the ship breaking yards. At the time of ship breaking, a large number of heavy metals and toxic pollutants are released into the environment, for example, oil spills on land and in water bodies. Besides, illegal import and trade off e-waste is happening in Bangladesh by importers to make profits. Consequently, e-waste vulnerability of Bangladesh is increasing rapidly [16].

Table 4 A potential environmental hazard of e-waste component [2,19]

E-waste component	Process used	Potential environmental hazard
Cathode ray tubes (used in TVs, computer monitors, ATM, video cameras, and more)	Breaking and removal of yoke, then dumping	Lead, barium and other heavy metals leaching into the ground water and release of toxic phosphor
Printed circuit board (image behind table-a thin plate on which chips and other electronic components are placed)	De-soldering and removal of computer chips; open burning and acid baths to remove metals after chips are removed	Air emissions and discharge into rivers of glass dust, tin, lead, brominated dioxin, beryllium cadmium, and mercury
Chips and other gold-plated components	Chemical stripping using nitric and hydrochloride acid and burning of chips	polycyclic aromatic hydrocarbons (PAHs), heavy metals, brominated flame retardants discharged directly into rivers acidifying fish and flora. Tin and lead contamination of surface and groundwater. Air emissions of brominated dioxins, heavy metals and PAHs
Plastics from printers, keyboards, monitors, etc.	Shredding and low temperature melting to be reused	Emissions of brominated dioxins, heavy metals and hydrocarbons
Computer wires	Open burning and stripping to remove copper	PAHs released into air, water, and soil

5. Health impacts

In the previous sections environmental impacts of e-waste such as air pollution, soil pollution, water pollution, and degradation of the beach have been discussed. Besides, these environmental impacts e-waste also creates lots of health problems. Humans can be exposed to e-waste contaminants by the inhalation, dietary intake, dust ingestion, and dermic contact. These contaminants e-waste fluxes from producers to receivers and ultimately to humans (Fig.2).

5.4. Impacts on workers

There are about 120,000 Bhangaries (E-waste recycling workers) who may be exposed to e-waste contaminants more seriously [33]. When original e-waste elements are degraded hazardous compounds e.g. dioxins are formed resulting severe health problems of the workers [37]. Sometimes skin and blood of workers are infected by e-waste or by infected wounds. Contact with sharp objects resulting wounds. During metal separation from landfill and incineration operations different types of chemicals are coming out. These chemicals are responsible for eye and respiratory infections [16].

Incineration operators may exposure to chronic respiratory diseases include cancers. Apart from open incineration, improper dismantling techniques for recovering metals followed by copper, aluminum, and iron also creates great risks to the workers. Likely, breaking of CRT monitors using stones, hammers, heavy metal rods and chisels for recovering copper, steel and plastic casings may result in the inhalation of hazardous cadmium dust and other pollutants by the workers. Handling of heavy containers causing bone and muscle disorders. Moreover, occupational accidents e.g. burns occur at the waste disposal sites or from chemicals explosions [16].

5.5. Diseases due to heavy metals

E-waste is the major source of several heavy metals (e.g. mercury, lead, cadmium, chromium, zinc etc.) When these heavy metals are kept unprocessed and open to the environment causing numerous human diseases including cancer, nerves breakdown, asthma, hearing problem, infant mortality, visual problem, kidney, disable baby birth, brain disorder, liver and lung damage as well [16]. Different E-waste generated metals and their human health risk have been summarized in Table 5.

Table 5 Health risk from e-waste compositions to human [25,26,27,28,29,30]

Compositions of e-waste	Impacts on health
Lead	Damage to central and peripheral nervous systems, blood systems and kidney damage; Affects brain development of children
Chromium	Asthmatic bronchitis; DNA damage; Lung cancer; Kidney and liver damage
Cadmium	Toxic irreversible effects on human health; Accumulates in kidney and liver; Causes neural damage and teratogenic; Bone fracture; Lung damage; DNA damage; Central nervous system damage, Cancer etc.
Mercury	Chronic damage to the brain; Respiratory problems
Plastics including PVC	Burning produces dioxin which evolves reproductive and developmental problems; Interference with regulatory hormones and damage of immune system
Antimony	Annoyance of the creature's skin, eyes, lungs
Bismuth	Skin problems as well as depression
Gallium	Breathing problems; Throat irritation; Pain on chest
Cobalt	Vomiting; Loss of vision; Heart issue; Thyroid damage; Causes of Asthma
Nickel	Lung Cancer; Nose cancer; Heart disorders
Iron	High risk of lung cancer
Silver	Brain damage; Kidney, eye, lung, and liver associated problems
Selenium	Abdominal pain; Fever, heart, and muscle problems; Bronchial asthma; Diarrhoea; Enlarged liver; Burning bronchitis; Sore throat

6. Conclusion

Bangladesh imports e-waste from developed countries and also generates e-waste. However, this e-waste is collecting, processing, and recycling into the open environment without proper safety of the workers causing environmental and health problem. When e-waste burns it generates smoke that contains both poisonous gases and heavy metals (lead, cadmium and mercury). Dumping of brominated flame retardant plastic and cadmium in the land fill may polluted the

soil as they leach into the soil and ground water. These environmental contaminations can result in exposure to residents in the surrounding areas.

In addition to, e-waste contaminants can bio accumulate in human tissues and organs. Higher contaminant levels were found in children's blood and serum samples those who live at or near e-waste recycling sites compared to those children who are living far from the e-waste recycling site.

E-waste contaminants can also be found in placenta, breast milk, indicating that pregnant women, fetuses, and young infants are also vulnerable to e-waste exposure. Health workers may be exposed to e-waste contaminants more seriously. Long term exposure to e-waste contaminants can damages the nervous system, kidneys, bones, and the reproductive systems as well.

So, taking initiatives by importers, recyclers, government and awareness build up among people is crucial to ensure safe handling of e-waste and reduce adverse impact of e-waste on residence. Most of lab based research focused on risk associated with e-waste on health such as new born babies, children and pregnant women. As well as research conducted on e-waste generated material such as lead, chromium, cadmium, mercury, plastics including PVC, antimony, bismuth, gallium, cobalt, nickel, iron, silver, selenium and its' possessed risk on human health has been taken place in developed countries. Authentic research on impact of e-waste on different environmental component such as air, soil, water has been articulated in this paper has also been taken place in developed countries too. So, it is crystal clear that there is significant research gap in developing country regarding impact of e-waste on health and environment. Bangladesh is not an exception. Considering limited resources and scope research focused on e-waste can be conducted in Bangladesh.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest among the authors.

Statement of ethical approval

The Study follows proper ethical procedures.

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