



# Trade-Offs of Improper E-waste Recycling: An Empirical Study

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**Abstract.** The term “E-waste” refers to any electronic equipment that has been abandoned and discarded or reached the end of its service life. As electronics is one of the largest growing industrial sectors, the recycling of E-wastes has evolved into a serious global issue. E-waste contains both metals and chemicals. A growing country like Bangladesh is now estimated to create 2.8 million tons of E-waste every year. Around 15–25% of it gets recycled, while the remaining end up in open soil, farmland, and water. Many hazardous elements from improper E-waste disposal can cause health diseases for workers and their families like breathing problems, skin infections, and stomach problems. Also, improper disposal of E-waste can harm the environment and have a negative impact on our climate. In this paper, we analyze the environmental effects and health issues of electronic waste. We found that there is a significant lack of understanding on how to reuse, rescale, and refurbish electronic equipment. People everywhere may avoid health and environmental problems by managing E-waste effectively, collecting E-waste properly, and raising awareness about the dangers of improper e-waste disposal can save people all over the world from challenges.

**Keywords:** E-waste · Environmental Impacts · Health Impact · Improper Recycling · Disposal

## 1 Introduction

E-waste is a general term for electronic equipment that has achieved the end of its lifespan or has been thrown away because newer and better technology has come out [1]. Improper E-waste disposal is causing a considerable loss of something rare or expensive precious metals and other raw materials like Indium (essential for flat-panel televisions), Nd (used in motor magnets), and Co (for batteries) [2]. It is estimated that E-waste accounts for more than 5% of municipal solid waste across the world. In developing nations,

where E-waste is recovered, it is typical for metals to be extracted and sold in unsafe, inefficient ways [3]. Electronic waste is recognized as a valuable resource on every continent because it can be used to get back precious materials like Fe, Cu, Al, Ag, Au, etc. [4]. Abandoned electronics are considered a global resource since they can be recycled for valuable materials. So, proper E-waste disposal seems to be an important subject to take into consideration.

Personal electronics such as displays, mobiles, PCs, and televisions account for half of all E-waste. The other half comes from large-scale home electronics equipment. Every year 40 million tons of E-waste are thrown away into landfills, fired, or sold cheaply and poorly handled [2]. Though, only 12.5% of electronic trash is recycled currently. E-waste is mainly a problem in developing and emerging countries because they don't have the right infrastructure in place to deal with it or, sometimes, it is not there at all. For this reason, many unauthorized and informal vendors handle most of the E-waste. Nowadays, E-waste is frequently mishandled which harms workers and the health of children, who spend their time near the places where E-waste is disposed [1].

Again, improper E-waste disposal increases global warming. If the materials from electronics garbage are not recycled, these scraps will not be able to substitute primary materials or reduce carbon emissions caused by the extraction and refinement of raw equipment. Also, some temperature exchange equipment uses refrigerants, which are greenhouse gasses. If discarded refrigerators and air conditioners are not properly disposed of, they can release approximately 98 million tons of CO<sub>2</sub> into the atmosphere, which is equivalent to 0.3% of the world's 2019 energy-related emissions (IEA) [1].

In improper E-waste systems, batteries are holding a large portion. Most batteries have at least one of the nine metals listed below: Li, Co, Cd, Pd, Zn, Mg, Ni, Ag, or Hg. The fastest-growing category, lithium-ion batteries, is expected to reach \$100 billion by 2025 [2]. Lithium-ion batteries consist of many harmful materials which are toxic to people and the environment. Li-ion batteries are more frequently found in the environment as E-waste because most electronics are becoming easier to throw away [5]. One electric vehicle lithium battery can contain the same lithium as 1000 smartphones [2].

By 2030, it is assumed that over 11 million tons of old lithium-ion batteries would have been dumped [6]. The absence of necessary information regarding the treatment of this expired electronics equipment, as well as the improper disposal, does not raise concerns about human health only. It can also be harmful to our environment. The study's findings would give us an essential understanding of the increasing crisis of E-waste and assist us in gathering the necessary information.

## 1.1 Background

Electronic products which have concluded their respective time are known as E-waste [7]. E-waste is a toxic brew of metals and other substances. A new item enters the market and quickly replaces older ones, often even before they reach the decline stage [8]. This kind of generated E-waste is increasing quickly, with estimates indicating that 72 billion tons are created globally each year [7]. Economically depressed countries rely on informal electronic waste recycling to generate cash flow. The problem is that in developing countries, it is often handled and disposed of in unsafe ways, resulting in

poll uncontrolled processing methods exposing vulnerable populations, such as women and children, to harmful chemicals [1].

According to the EPA, about 18% of the hazardous and valuable electronic waste can be integrated and properly processed. However, no initiative can achieve its full potential even in the absence of active participation and appropriate lessons for consumers. According to the ITU, E-waste is the most extensive and difficult to manage waste stream in the world. In the year 2019, the globe produced 53.6 metric tons of electronic garbage, of which only 9.3 metric tons or 17% were recycled. Electronic trash comprises both valuable materials and hazardous substances, recycling in a way that is both efficient and safe is becoming more significant for the economy, the environment, and also for human health. The difference between how much E-waste is made and how much is properly recycled shows how important it is for everyone, including young people, to work on this problem [9].

As Bangladesh rapidly moves closer to its goal of being a middle-income nation, IT infrastructure is being constructed and the usage of electronic devices in homes, offices, and several other government and non-government sectors is growing daily. Every year, Bangladesh generates approximately 2.8 Metric Tons of electronic waste. An unknown quantity of electronic garbage is dumped in open soil, farmland, and water. People in Bangladesh are not following the rules for the proper disposal of these products. In Bangladesh, there is no definite amount of E-waste created each year. As technology advances, more new electronic devices are produced, and disposing of old computers, phones, and TVs becomes more common [8].

E-waste is one of the most harmful sources of contamination in the environment [10]. But the lack of awareness and inappropriate electronic garbage disposal may lead to environmental contamination. People can get sick if they don't know how to properly handle or reuse expired products. Electronic trash poses a threat to the health of humans. E-waste contaminants can be inhaled, eaten, or absorbed through the skin. A Bangladeshi study found that over 15% of children die because of improper recycling of E-waste. More than 80% get sick from toxic chemicals and chronic illnesses. Also, the E-waste collecting process in Bangladesh is managed in a harmful way. Because the process of collecting E-waste is mainly dependent on "Vangari" (Local vendors) Shops. They do not follow any rules or regulations while collecting or recycling E-waste. For this reason, the toxic chemical from the E-waste can mix with the environment easily. In illegal E-waste collection and recycling, approximately 50,000 children are involved [8]. The main ideas of our study are to identify, describe, analyze, and assess E-waste damage patterns. Our research will investigate the current state of E-waste in Bangladesh and deliver better ideas for safe and secure E-waste recycling by raising public knowledge about the dangers of improper E-waste recycling.

## 1.2 Problem Statement

The significance of E-waste management is becoming more challenging as technology use increases. In this recent pandemic situation of COVID, people have started online education and work-from-home tasks. For this, the use of electronic devices increased by a large amount among average people. Unfortunately, most of these technologies end up in the trash, resulting in E-waste. The majority of E-waste is still dumped in an open

area, as a result of which valuable resources are lost as well as the release of harmful chemicals and pollutants into the water, soil, and atmosphere. These toxicities can cause harm to the human health system and also can create skin problems.

According to our research, general people are not concerned about the hazardous effects of improper E-waste Handling. In the large or small recycling industry, management and workers do not pay enough attention to hazardous electronics wastes that are imported for reprocessing. In a human sense, the absence of an appearance of hazardous material contained in E-waste leads them to believe that these items are toxic-free. There is a huge knowledge gap between shop owners and workers [11]. As far as the authors' knowledge goes, no scientific paper describing IT waste processing and dealing with its dangerous impact of improper disposal in Bangladesh could be located [9]. In addition, neither a systematic review nor a case study has been conducted in Bangladesh about improper E-waste recycling and its effects on health and the environment.

### 1.3 Aim

This study explores the E-waste scenario, the E-waste recycling system, and industrial actions in Bangladesh, which represent impediments to proper E-waste recycling, and finds solutions to remove the Inappropriate E-waste Management structures.

### 1.4 Objectives

The study's aims are as follows:

- To illustrate the current E-waste management company initiatives in Bangladesh
- To describe the practices of IT waste disposal in Bangladesh.
- To investigate the health consequences of poor E-waste disposal in Bangladesh.
- To analyze the effect of improper electronics waste recycling in Bangladesh.
- To analyze the awareness level of the shop owners and workers and general people in Bangladesh.

### 1.5 Scope of the Study

This research focuses on the trade of inappropriate E-waste treatment in growing nations such as Bangladesh. It has explored and analyzed the situation in Bangladesh and described the health and environmental damages. All other waste management is out of our scope. Also, the study is based in Bangladesh. The research will be focused on observations of the E-waste disposal scenario in Bangladesh.

## 2 Related Work

Apparently, in accordance with the Step Initiative of 2014, "Electronic waste" is a phrase that is used to include objects of all different sorts of EEE and a component of the item that the owner no longer needs and is so disposed of as garbage without any intention of reusing it. Bangladesh purchases roughly 3.2 million electronics items each year, according to the Bangladesh Electrical Merchandise Manufacturers Association (BEMMA) [12].

According to a survey done by ESDO (2016), in Bangladesh, totally broken or unusable electronic devices are 50% disposed of, whereas partially damaged equipment is fixed 90% of the time. The author also suggested that E-waste must be treated carefully since many of these goods include poisonous and dangerous materials, posing a huge environmental concern as well as a major danger to employees' health in the workplace. In order to establish an efficient method for managing electronic trash, it is essential to have a solid understanding of the journey that electronic trash takes from the point at which it is produced until it reaches its final destination [13].

The author conducted a poll of the employees at the recycling center, and the results showed that the average monthly salary for these workers is BDT 3000, even after working twelve-hour per day. When compared to those in other fields, the individuals that are involved in recycling electronic garbage are receiving lesser salaries. A day worker in this town may expect to earn at least BDT 200 for putting in an average of eight to nine hours of work per day [11]. The lower salary rate indicates that there are a lot of infrastructure problems in Bangladesh's E-waste recycling system.

According to the first proposal, The GEA would allow the E-waste industry to be rebranded from its present polluting image to a greener potential that reflects Bangladesh's economic progress. The second proposal is to construct nationwide electronic trash databases alongside a decision-making tool, to gather, maintain, and disseminate information and statistics on electronic waste. The third option is to establish a stepwise national E-waste register for the unorganized sector with the intention of publicly recognizing and observing the unorganized sector [14].

The environment can be protected by recycling, reusing, or rehabilitating electronic trash [1]. Reuse decreases the amount of human- and environmentally harmful chemicals by 71% and 40%, respectively. Refurbishment/Upgrading decreases the number of harmful toxins by 61% for individuals and 31% for the environment. From Recycling/Secondary production, the scientific recycling procedure eliminates human and environmentally harmful pollutants by 11% and 14%, correspondingly [15]. The primary manufacturing of these metals would have created 1.28 million tons of carbon dioxide (or 17.1 tons of carbon dioxide per ton of metal). The comparative analysis demonstrates that secondary production generates less CO<sub>2</sub> [16].

Young people in the country of Bangladesh, numbering in the vicinity of fifty thousand, are actively engaged in the recovery and sorting of electronic waste. About 40%, or 20,000 minors, are employed in shipbreaking yards [8]. In our nation, 15% of child laborers die due to improper E-waste handling. Moreover, 83% of children workers in this industry suffer from illnesses [17, 18]. There are about 120,000 Vangaries (E-waste recycling workers) who will be much more badly affected by their exposure to the chemicals found in E-waste [19].

### 3 Methodology

#### 3.1 Data Collection Methods

This chapter specified the study methods and procedures for achieving its research objective. The design and data sources have been designed here for the study. This study was conducted in a few recycling industries in Bangladesh. We also collect data from various online resources because Bangladesh, as a developing country, is quite new in its E-waste recycling culture.

#### 3.2 Research Process

The study aims at finding the problem that is created by improper E-waste recycling in Bangladesh. The study used qualitative data collected from surveys, case studies, and field observations. The data is about the collection, disassembly, disposal, E-device users, and the generation of E-waste.

- Identifying environmental and health hazards while disposing of the E-wastes in an improper way
- Exploring the current state of the electronics waste recycling practice in Bangladesh.
- Collecting and analyzing data from different places (Experts, industry, vendors, public opinions).
- Designing solutions to recycle E-waste in a non-hazard way.

The following diagram (Fig. 1) is referring to the process flow of the research.

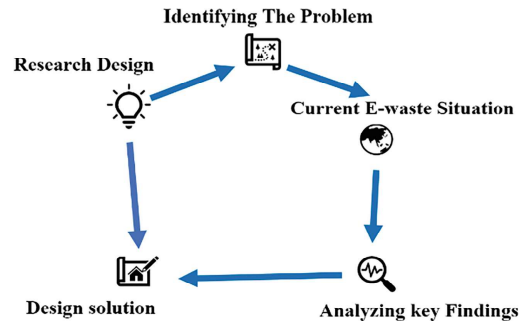


Fig. 1. Research Process

#### 3.3 Research Ethics

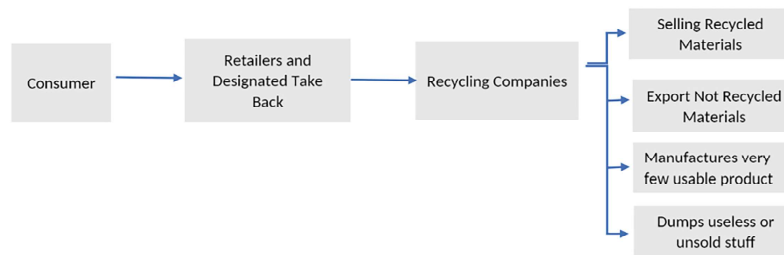
In this study, we visited a few well-known E-Waste recycling companies, and also for research purposes we met with some entrepreneurs and researchers who are doing research on opening a new E-waste recycling industry. For the collection of data from individual interviews, a consent form describing the goal of this study was issued. The anonymity of the participants was maintained. Participants in the offline survey were required to read the informed consent form, and interviews were conducted only if they agreed to the conditions.

## 4 Result and Discussion

### 4.1 Recycling System in Bangladesh

From our research and analysis, we can assume a scenario where very few people in our country are concerned about improper E-waste disposal which has so many hazardous effects. There are some E-waste recyclers that exist in our country, but they are facing many kinds of barriers to collecting e-waste and recycling them in a proper way.

Basically, people are concerned about using good electronic devices, but they are not aware of the situation when the technology becomes E-waste. Some people throw them in the dustbin, and some sell them to second-hand device users or vendors in exchange for a small amount of money. There are very few well-known companies that collect their perished products to reuse or recycle the E-waste in a proper way to reduce its harmful effects. The recycling process of E-waste in general in Bangladesh follows the process which is attached below:



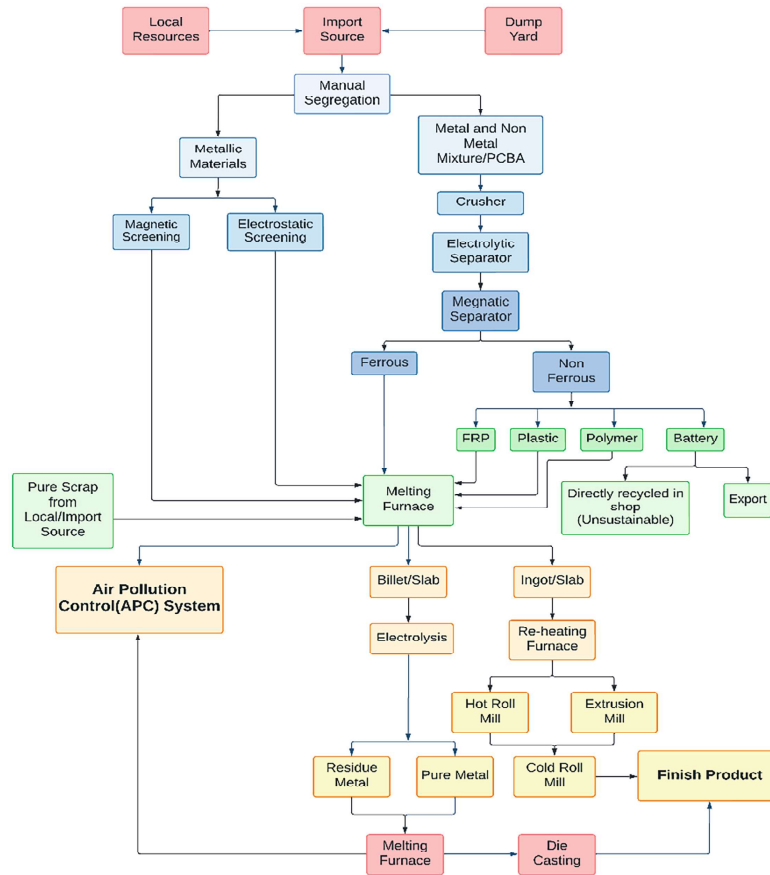
**Fig. 2.** E-Waste Recycling procedure in the Bangladeshi recycling industry.

Thus, from the diagram (Fig. 2), we can see that very few recycling companies collect electronic devices from retailers and designated take back which comes from consumers, and then sorts them and divides them into 4 segments:

- Selling recycled materials.
- Exporting not recycled materials.
- Manufacturing very few usable products.
- Throwing the rest of the parts in an improper way.

Though, the E-waste recycling system of Bangladesh is not maintained in a proper way. But our research finds that there are few well-known E-waste companies in Bangladesh who are aiming to recycle E-waste in an efficient technique. They try to follow the rule and regulations of considering environmental and health issues which strictly follow international standards and satisfy most of the government policies of Bangladesh.

A summary of possible E-waste recycling pathways is provided in Fig. 3. The chain for reusing and recycling electronic scrap has many steps, such as inventorying, assessing, collecting, shipping, reselling, recovering electronic parts, disassembling, shredding/pre-processing, and final processing of the different materials and metals.



**Fig. 3.** Overview of possible E-waste recycling pathways.

Pre-processing is one of the most crucial phases following the collection of electronic waste equipment. Most of the time, E-waste is sorted by type before it is processed. This is because some parts of E-waste, namely batteries, cathode ray tubes, and lamps where mercury is used, need extra steps to be taken to reduce risks. Heating electronic parts above the threshold at which solder (around 250 degrees Celsius) typically used in construction would melt is another method for reducing their size and then hitting, shearing, or vibrating the material. Using this method, it is possible to get the maximum disassembly rate.

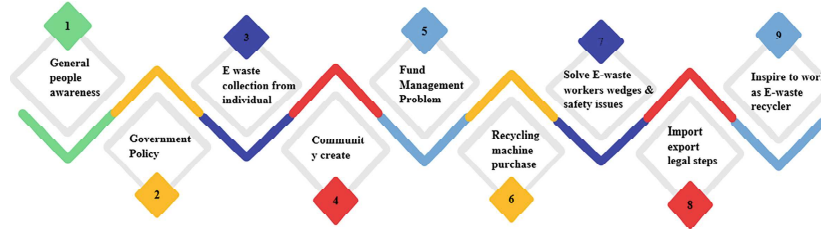
On the other hand, the research found that shipping the waste does not result in the burden that comes with recycling operations and the issues that come with them [20]. However, it benefits the exporter financially. Importers of E-waste are typically from developing countries, and they process the E-waste in informal recycling circumstances, which can cause harm to the environment [21].

As a developing country, the recycling process of batteries is not started since there is no appropriate technology are not available in Bangladesh. For instance, batteries



require pretreatment to control accidental disposal that may result in combustion. More waste is handled wrongly in growing countries, where most companies are informal and there are few health and safety regulations in effect to protect employees.

The existing companies in Bangladesh do not recycle all kinds of E-waste because they face many different types of barriers. The drawbacks should be overcome to establish a recycler company that will be able to recycle all kinds of hazardous products (Fig. 4).



**Fig. 4.** Necessary steps to establish a recycler company to recycle all kinds of hazardous products.

From investigating current barriers, we can summarize that if government policy issues, general people awareness, and fund initiatives are taken seriously and also if the worker community works together to collect E-waste from the district wise and maintain safety measurements and concerns about proper import-export ways then Bangladesh can go forward to go green in IT waste management situation.

#### 4.2 E-waste Generation Scenario

The study investigated and examined the present scenario of E-waste in Bangladesh. Bangladesh is well-known for being one of the leading electronic waste import nations. Aside from that, the country generates 2.81 million metric tons of these scrap materials each year [18]. Dhaka and Chattogram are the two most important stakeholders in the collection and management of electronic scraps [22]. Workers may be exposed to health risks as a result of dermal contact with harmful components in E-waste. Despite the fact that this employment poses several health risks, workers do not receive either health benefits or recompense for the harm done to their health. In Bangladesh, the labor force associated with collecting and dismantling electronic garbage lacks a strict legal framework. The study reveals that the workforce involved in managing E-waste earns only 3,000 takas per month, works 12 h per day, and does extremely dangerous tasks. Moreover, any analysis to analyze this possibility could not be done due to a lack of essential data. Again, no scientific articles or supporting documentation were found to justify the risks posed by toxic element interaction through the skin [13].

### 4.3 Impact of Improper Recycling

The release of dangerous compounds into the surrounding environment is one of the consequences of inefficient management of electronic waste throughout the collecting, sorting, reprocessing, and open dumping processes, including aquatic areas, as well as reservoirs that mix into the atmosphere.

E-waste is the major source of several heavy metals (e.g., Hg, Pd, Cd, Cr, Zn, etc.) [23]. When heavy metals are left untreated and exposed to the elements, they become toxic and cause numerous human diseases like cancer, sight problems, damage to kidneys, and damage to other tissues (Table 1) [24].

If these heavy metals are not cleaned up and are left out in the environment, they can cause many diseases, such as cancer, nerve damage, asthma, hearing problems, infant mortality, kidney problems, birth problems, brain disorders, liver damage, and lung damage. The following table provides a summary of the many elements that are produced by electronic waste and the risk they bring to human health.

Most of the people who are associated with recycling waste in developing nations like Bangladesh are women and children, making them the most vulnerable because they breathe in the dust, eat it, or touch it. The most obvious health problems are related to exposure at work or in a local area. E-waste and associated contaminants can be exposed to people outside of the workplace in a variety of ways. Children who work in E-waste recycling are in danger as well, getting sick from their parents' clothes and skin, and relatively high contamination if recycling is carried out in their houses. We observe that the children who live near recycling sites have health problems like breathing problems, skin infections, and stomach diseases.

Electronic waste has negative consequences for the atmosphere, hydrosphere, lithosphere, and biosphere. Personal computers (PCs), notebook computers (notebooks), and laptop computers (laptops) emit CO<sub>2</sub> during their mining, manufacturing, use, and disposal as E-waste. Cyber Warming refers to CO<sub>2</sub> emissions from the information technology and computer industries. In electronics equipment, one of the most common materials is PVC (Polyvinyl Chloride) also when hydrogen chloride is mixed with water, it produces hydrochloric acid, which causes lung issues when inhaled. Furthermore, as it covers copper wires and plastic computer casings, PVC emits highly toxic dioxins and furans when burned [24].

**Table 1.** Health and Environmental Hazard

E-waste category	Some examples of products	Hazardous Elements	Health and Environmental Hazard	Source
Temperature exchange equipment	Refrigerators, Freezers, Air conditioning equipment	Pb Ba	Pb, Ba, and hazardous phosphors discharge into the soil Damage kidney and digestive system. Cause children's slow mental development	Kaushik (2018) [26]
Display equipment	Screens, Televisions, LCD photo frames, Monitors, Laptops	Hg Cd	Loss of mental ability, annoyance, and IQ drop CH <sub>3</sub> Hg can slow down maturation, and reproduction	Ramachandra and Saira (2004) [27]
Large equipment	Washing machine, Dishwashing machine, Cooker, Electric stove, Musical equipment, Large printing machines, Large medical devices	Sb Be	Loss of sensation and control in the limbs for Se. Respiratory tissue that has aged. Blood pressure elevation, migraines, and diarrhea	Wu & Ikerionwu (2010), ATSDR (2003) [28]

*(continued)*

**Table 1.** (continued)

E-waste category	Some examples of products	Hazardous Elements	Health and Environmental Hazard	Source
Small equipment	Vacuum cleaner, Carpet sweeper, Microwaves, Iron, Toaster, Calculator, Toys, Smoke detectors	Brominated Flame Retardants BPA	Cd accumulates in the kidneys and damages the liver, breathing, and joints From Arsenic Allergic reactions, nausea, vomiting - A decrease in blood cell production, Absurd heart rhythm	Dyrud (2007) [29] Schmidt (2002) [30]
Lamps	Straight fluorescent and Compact fluorescent lamps, Strong density discharge lamps, Na lamps, LED	DPB Phthalas PVC	Br cause vomiting, breathing issues and stomach pain, diarrhea	The US. National Library of Medicine [31]
Small IT equipment	Mobile phones, Routers, Personal computers, Printers, Telephones, IC, switches, cables		PVC produces dioxins which can damage reproductive and immune systems	

By exploring categorizes E-waste by dividing it into six waste categories [25] and other sources, we designed a collective table (Table 1) where health and environmental hazards are pointed focused on category-wise created hazardous elements.

## 5 Conclusion

Bangladesh imports electronic trash from advanced nations and manufactures its own. However, this electronic garbage is gathered, handled, and recycled outside in the open air without proper protection for the workers, resulting in difficulties for both the environment and workers' health. When electronic garbage is burned, it produces smoke containing toxic gasses and heavy metals (lead, cadmium, and mercury).

- These toxic elements can be inhaled by people who work with E-waste, take it apart, and recycle it. This can cause cancer and other health problems.
- Because there is no strong regulatory framework for E-waste disposal, the labor force in Bangladesh involved in collecting and recycling E-waste works for very low salaries and is exposed to health risks.
- When workers eat lead, they put their health at risk because it can cause cancer. Chromium and cadmium, on the other hand, do not pose any health risks when eaten.
- People who work in the informal sector, especially children, recycle without any safety measures or protective gear.
- The environment is at risk when E-waste isn't recycled and thrown away in the right way. Weathering and chemical reactions speed up the release of dangerous elements from electronic waste into the air, water, and soil, which is very bad for the environment.

The recycling of old electronic equipment is very important, but the process must be carried out in a secure and consistent way. However, there should be age-related differences in the allowed limits for children and adults because their bodies are different, and they are more likely to be hurt. It is non-negotiable to improve working conditions for every employee of E-waste companies and eliminate child labor. Every year, tons and tons of E-waste are dumped, and the problem keeps getting worse.

## 6 Recommendations

Recycling, reusing, or refurbishing E-waste can help save the environment. The following recommendations are based on the findings and discussions of the research.

- There must be a distinct infrastructure for gathering, sorting, and disposing of E-waste in order to adequately manage it., recovery, and disposal (at least for chosen goods).
- Workers' health and safety must be protected during recycling processes.
- To stimulate the establishment of collection and disposal facilities, the administration may provide financial incentives to industry and businesses in the nation.
- Harmful objects need to be covered or protected properly so that any harmful chemical or gas cannot mix with their surroundings.
- After recycling all the industrial equipment needs to be cleaned properly.
- One of the simplest methods to reduce electronic waste footprint is to sell or donate your devices to others who can use them.
- Maintaining your gadgets properly to extend their life is also a great way to save money and reduce E-waste.

Therefore, social engagement, events, workshops even curriculum implementation in our education system may raise awareness of the E-waste problem.

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