Magnitude of the Flow of E-waste in Bangladesh

Brief Study Findings 2014

The report shows that the generated e-waste has increased significantly in total number; current amount is over 10 million metric ton/year. The surveyed data displays that there was huge need of awareness about this issue as major part of the population is still unaware about this issue. In Bangladesh every year more than 15% of child workers die as a result of e-waste recycling and more than 83% are exposed by toxics substances and become sick and are forced to live with long term illness.

ESDO Environment & Social Development Organization

Content

List of abbreviations

Cd	Cadmium
CFL	Compact Fluorescence Light
Cr	Chromium
DoE	Department of Environment
ESDO	Environment and Social Development Organization
EEE	Electrical and Electronic Equipment
E-waste	Electronic Waste
Hg	Mercury
IPEN	International POPs Elimination Network
MoEF	Ministry of environment and Forest
Pb	Lead
POPs	Persistent Organic Pollutant
SSNC	Swedish Society for Nature Conservation
UNDP	United Nations Development Program
UNEP	United Nation Environment Program

Introduction

Bangladesh indicates a rapid economic growth with emerging market for consumers of electric, electronic gadgets, home appliances. These demands have created a circumstance of increasing amounts of locally produced electronics products and increasing demand for re-using these products. Equipment is largely refurbished and recycled in semiformal and informal sectors. Reuse or recycling or of equipments and as well as dumping are creating risks to human health and the environment. At present, there is lack of awareness and proper management of e-waste as well as its hazards in Bangladesh.

What is E-waste?

E-waste is a generic term comprising all electrical and electronic equipment (EEE) that have been disposed of by the user, and includes everything from large household appliances, such as microwave ovens, refrigerators, television sets, and computers, to hand-held digital apparatuses, cell phones and toys. When new equipment is procured, the old ones become obsolete. They are eventually discarded, leading to an enormous amount of waste.

E-waste comprises of a multitude of components, some containing toxic substances that can have an adverse impact on human health and the environment if not handled properly[1] (Pandve, 2007).

Electronic waste or e-waste is a rapidly growing problem around the world. Nowadays, end-of-life EEE or e-waste is one of the fastest growing waste streams globally. It is also a major emerging concern for waste management professionals.

Worldwide, e-waste is associated with environmental contamination and significant health issues due to its chemical constituents. In Bangladesh, a large volume of e-waste is managed in the informal sector and recycled without any environmental or public health safeguards.

1.http://www.ijoem.com/article.asp?issn=0019-5278;year=2007;volume=11;issue=3;spage=116;epage=116;aulast=Pandve

Components arise from E-waste Processing: Risk factor

Electrical and electronic equipment is generally loaded with hazardous compounds (e.g. lead, cadmium and mercury) that may be emitted during end-of-life processing. Many of the processes can also result in the formation of new toxic compounds. Risks may thus arise during traditional waste handling processes and incineration, as well as during recycling processes when breaking down the materials. Most risks arise during uncontrolled recycling activities occurring in many developing countries, which result from the rudimentary methods used. These rudimentary methods involve minimal emission control systems or personal protection for the workers. Humans and the environment in these areas are therefore highly exposed to a wide range of toxic compounds originating from these activities. The workers involved in recycling and the local residents are particularly exposed via dust generated during dismantling and shredding processes (including breaking of CRTs), and fumes and smoke generated during acid digestion processes and various high temperature processes, such as open burnings and heating, melting, and extraction processes. Humans in these areas are also indirectly exposed via contaminated food and drinking water.

The environment is mainly contaminated from the open burning processes and through leakage from dumped residues of various recycling activities, e.g. stripped CRTs and PC-boards, spent acids from the digestion processes and residual ashes. The compounds of most concern vary depending on the material being recycled and the recycling methods used. These compounds are all very toxic and may potentially be emitted in large amounts during rudimentary e-waste recycling activities. As a consequence, extremely high levels (in some cases the highest ever measured) of these compounds have been measured in environmental as well as human samples collected in areas where uncontrolled e-waste recycling is taking place.

Other metals that may pose a risk are cadmium, mercury, tin, antimony, nickel, barium, chromium, zinc, beryllium and copper. Some of these, e.g. cadmium and mercury, are generally present in low amounts in e-waste, but may be of concern due to their high toxicity[2]. Others, such as copper, have low toxicity but may be problematic due to very high abundance in the materials. Recycling

[2] http://ewasteguide.info/node/219

under controlled conditions, that is carried out in facilities adapted for this purpose, is much better from a risk perspective point of view, both for the recycling workers, the local residents, and for the environment. However, risks may occur during these activities as well. For the workers, the largest risk is exposure to dust during dismantling, shredding and separation of the e-waste as well as during the subsequent pyrometallurgical processes. In addition, workers may be exposed to volatile compounds, such as mercury, that may be accidentally released during breakage of components in which these compounds are encapsulated.

For the environment and the general population, the largest risks arises during the pyrometallurgical processes and during other high temperature processes, such as those used during plastic recycling and incineration of residual waste (justified in the recycling industry as energy recovery). During these processes, substantial amounts of chlorinated and brominated dioxins as well as other chlorinated and brominated compounds may be emitted, and in the case of the pyrometallurgical processes, a wide range of metals (similar to those emitted from uncontrolled processes) may also be emitted. Even if it is possible to minizmize these emissions, by using optimized processes together with modern dust containment and flue gas treatment systems, existing data regarding emissions indicates that this is not always done satisfactorily. Significant levels of several compounds have been found in and around some of these facilities.

The alternatives to e-waste recycling, i.e. to incinerate the material in waste incineration facilities or to put it in landfill, are less attractive. Incineration will, as previously noted, give rise to a wide variety of toxic compounds, including those that were present in the original waste and those that may be formed during the incineration process. If the e-waste is incinerated in mixed form, the emissions will be even greater than the emissions that arise during incineration of separated combustible fractions, and it will also lead to loss of the valuable materials that are present in the e-waste. The latter will, in turn, lead to increased consumption of virgin materials with further impacts and the consequential pollution of the environment. Evaporation mainly occurs for volatile compounds, of which mercury and its methylated derivatives are of most concern. Due to the long time spans involved, it is difficult to predict and completely prevent emissions from landfill. Conditions may change over time, which may lead to altered behavior of the pollutants.

The discarded products constituting e-waste are made of a wide variety of components and sophisticated materials containing thousands of individual substances. Most are, by weight, bulky materials such as iron, aluminum, plastics and glass but there may also be wood, ceramics and rubber.

In Bangladesh, CFL bulbs were introduced at least as early as 2005 by Transcom Electronics Ltd. Up until 2010 the production of CFL by the Transcom Ltd. was 3,200,000 bulbs. The lifetime of a CFL bulb is rarely greater than 18 months. Therefore, it can be said that in last 5 years the number of disposed bulbs generated by Transcom was 5,253,313. There are also six other companies that produce CFL bulbs in Dhaka city (e.g. Energy Pac, Osaka, Onik, Delta, SKS and Rangs.) Therefore, it can be estimated that till June 2010 the volume of e-waste from CFL bulbs is around 9,455,964. Volume of E-waste by CFL and mercury bulb
According to the census of 2001 the number of household in municipalities was 1,934,000. In the last 10 years, each household used at least 3 mercury bulbs. So in last 10 years the volume of e-waste generated from CFL and Mercury bulbs is 96,485,694 [3]. E-waste contains toxic substances that are harmful to humans and the environment! Figure 1below shows the heavy metals used in different parts of a desktop computer:

Figure 1: Deadly chemicals and heavy metals used in a computer

1. Lead in cathode ray tubes and solder
2. Arsenic in older cathode ray tubes
3. Selenium circuit boards as power supply
4. Polybrominated flame retardants in plastic castings, cables and circuit boards
5. Antimony trioxide as flame retardant
6. Cadmium in circuit boards and semi-conductors
7. Chromium in steel as corrosion protection
8. Cobalt in steel for structure and magnetivity

These metals together make up the major economical incentive for recycling of e-waste, as they may constitute over 95% of its total value (He *et al*., 2006; Cui and Zhang, 2008).

[3] Study on E-waste: Bangladesh Situation 2010, Environment and Social Development Organization-ESDO, Dhaka, Bangladesh

E-waste is much more hazardous than many other municipal wastes because electronic gadgets contain thousands of components made of deadly chemicals and heavy metals like lead, cadmium, chromium, mercury, polyvinyl chlorides (PVC), brominated flame retardants, beryllium, antimony and phthalates (Atsushi *et al.*, 2006).

Objectives

The objectives of this study are to;

- Summarize current knowledge concerning health hazards and environmental impacts associated with the handling and end-of life treatment of electronic waste. This include hazards and risks that may arise during traditional waste handling processes, such as land filling and incineration, as well as those arising during direct recycling processes.

- Review hazardous compounds that have been added to the products thatmay be released during the end-of-life treatment, and compounds that may be formed during the disposal or treatment processes.

Current situation in Bangladesh

E-waste is one of the emerging problems at a global and regional level. It accounts for a significant portion of a country's total waste. Bangladesh works with e-waste, generated both internally and imported from other countries. Environment and Social Development Organization-ESDO conducts annual studies on e-waste and completed an updated study in July 2014.

The study aims at assessing the current situation of e-waste and updating the data of past research reports. The study was done through surveyed data in six selected areas and the sample selected randomly. Some demographic percentages were taken from secondary data sources and assumptions were also made based on field survey and observations. The report shows that Bangladesh is producing a significant amount of e-waste; the production of e-waste has been found to be over 10 million metric ton/year. The surveyed data displays that mass awareness about this issue is needed as the majority of the people are unaware of this issue. The report also underlines the need for more indepth research into the production, consumption and waste management in this field.

E-waste has become the fastest growing waste stream in Bangladesh and has emerged as a lucrative business. According to the recent study by ESDO, Bangladesh generates roughly 10.019 million metric tons of e-waste yearly, the ship breaking industry alone generated 8.8 million metric tons in 2011-12, which was 4.70 million metric tons and 6.47 million metric tons in 2012-13. Bangladesh imports scrap ships from developed countries as it has no legal rules or regulations preventing the import of such highly polluting scrap products and equipment. I According to a UNEP study, developed nations dump e-waste in Asian countries (India, Bangladesh, China and Pakistan) through illegal trade routes (Hossain, 2010).

Internal demand for electronic for ICT knowledge is causing the technology boom in Bangladesh and is also a major contribution to e-waste, a category that barely existed 15 years ago. In fact, e-waste represents the biggest and fastest growing manufacturing waste. Economic activities associated with industry, health services and other service sectors are generating electronic waste and causing serious health and environmental hazards. They threaten public health and endanger the economic sustainability of the country.

In order to enhance the cooperation among Governmental and Non-Governmental organizations, public and private parties and regional cooperation, and to facilitate a common approach to e-waste management, Environment and Social Development Organization-ESDO in association with Swedish Society for Nature Conservation (SSNC) conducted research on the current situation, to review and compare existing practices for dealing with e-waste at the national and regional level and collect information regarding the situation of e-waste in the country.

Bangladesh is developing with increasing technology usage. Sustainable and safe use of technology can drive an economically developed country, but the wastes from these electronic goods can be incredibly damaging. In Bangladesh, EEE's are consumed and then dumped without considering damages to the environment or sustainability. Some electronic waste is reused, some is broken down for parts and others components thrown out completely. Currently this informal practice is not being carried out safely and has become a hazard to human health and the surrounding environment. Currently, there is a general lack of awareness about the e-waste issue within the general population, government and also in the private sector.

Limited safeguards, legislation, policies and enforcement of the safe disposal of imported e-waste and electronic goods have led to serious human and environmental problems in many countries. For instance-waste disposal impacts on human health has become a serious issue, documented in case studies from China[4] (Chan *et al.*, 2007; Huo *et al.*, 2007; Qu *et al.*, 2007).

Facts of E-waste in the World

Due to insufficient legislation and recycling collection systems in many countries, proper management is seldom practiced, especially when seen on a global scale. E-waste problems related to trade off and trans-boundary movement in the developing countries has environmental, social, and economic impacts[5] (Terazono, 2006). A large part of the e-waste generated around the world is sent, mostly illegally, to developing countries such as, China, India, Bangladesh, Nigeria and Ghana, where the e-waste is disassembled by poor people using rudimentary methods, in the hunt for valuable materials.

Most of the older and less ecologically-friendly equipment that is discarded by western countries is exported to developing countries[6]. It is estimated that 80% of all developed countries e-waste is sent to developing countries (Hicks *et al.*, 2005).

With the growing demand and wide use of electrical equipment like cell phones, television and computers, e-waste is growing at an alarming rate. According to US-EPA the generation of e-waste is increasing 5-10% globally, each year. More alarmingly, only 5% of this amount is being recovered. In 2012, 50 million tons of E-waste was generated word-wide according to a report published by StEP (Solving the E-waste Problem), a Germany based organization[7]. The Gurdian says that the annual production of e waste is 50 million tons which is increasing[8].

[4] Chan, J.K.Y., Xing, G.H., Xu, Y., Liang, Y., Chen, L.X., Wu, S.C., Wong, C.K.C., Leung, diphenyl ethers among workers at an electronic waste dismantling region in Guangdong, China. Environment International 33, 1029–1034.

[5] http://link.springer.com/article/10.1007%2Fs10163-005-0147-0

[6] ewasteguide.info/files/Hicks_2005_EIAR.pdf

[7] http://ecowatch.com/2013/12/23/worldwide-electronic-waste-to-reach-65-million-tons/

[8]http://www.theguardian.com/sustainable-business/50m-tonnes-ewaste-designers-manufacturers-recyclers-electronic-junk

It has been estimated that, in the USA alone, over 30 million computers and 100 million cell phones are being discarded every year. Within the EU, every citizen leaves behind 14-24kg of e-waste every year, which in total equates to almost 10 million tons annually and numbers from Japan suggested that by year 2010, 610 million cell phones are to be disposed of in their country[9].

In addition, newly industrialised countries are increasingly contributing to global e-waste generation. In China, for example, at least 4 million computers, 70 million cell phones, 5 million TV sets, 4 million refrigerators and 6 million washing machines are abandoned annually since 2003[10].

What is more concerning is that only little amount >10% of all this e-waste is collected and taken care of in adequate recycling facilities (Cobbing, 2008), despite the well known fact that it contains a wide variety of hazardous components, such as heavy metals and persistent organic pollutants, as well as many valuable materials (including several precious metals like gold and copper) and plastics[11,12]. E-waste can be both a hazardous waste that potentially causes serious pollution and health damage upon disposal and a huge resource that can provide the industry with valuable materials using less energy and fewer natural resources compared to using virgin materials in the production of new products.

Consumers tend to keep obsolete electrical and electronic equipment (EEE) for a while before discarding it, which may be particularly true for computers and cell phones. For example, in USA, it has been estimated that each household has, on average, 4.1 small and 2.4 large obsolete EEE in storage, while previous estimation record the same households having an average of two to three obsolete computers in storage. In Sweden, similar numbers have been estimated for obsolete cell phones stored in homes.[13]

Furthermore, outdated EEE may be resold for re-use to consumers with lower technology demands or lower economical resources. Some are thus traded nationally, while some are shipped to developing countries where old EEE, like

[9] http://greencitizenship.blogspot.com/2008_07_01_archive.html
10 http://www.vctbook.org/doc-289790.htm#.VJILS1BCcA
[11] www.sciencedirect.com/science/article/pii/S0048969709009073
[12] http://www.slideshare.net/victori98pt/recycling-from-ewaste-to-resources
13.http://www.naturvardsverket.se/Nerladdningssida/?fileType=pdf&downloadUrl=/Documents/publikationer6400/978-91-620-6417-4.pdf

computers and cell phones normally can be used for a few more years, extending their useful life. This re-use in developing countries like Bangladesh may be a good way to lengthen the life-span of the products as well as help the poor access technology. At the same time it constitutes a great environmental, social and economical problem. The line between re-usable and charity and waste and dumping is very fine. Even if the equipment is working and possibly will be used a few more years in the developing world, the exports will also transfer the waste problem to the recipient countries.

Besides this, a large fraction of the obsolete EEE in the developed world is also deliberately exported as waste to developing countries, where it is recycled under very primitive conditions. Some of this trading, though deliberate waste export, is still phrased as or hidden under the umbrella of charity (computers for the poor), since e-waste export is banned in most countries today. These bans are in place because the rudimentary recycling methods used in the developing countries are not very effective in terms of recovering the valuable materials, and because the activities also lead to huge emissions of hazardous compounds resulting in sever exposure of the workers as well as pollution of the surrounding environments. Since e-waste export is a very cost-effective option for developed countries, due to the lower labor costs and less stringent environmental regulations in many developing countries, it still occurs regularly[14]. In fact, of all the e-waste generated in the industrial world, between 50-80% is probably exported to countries like China, India, Nigeria and Ghana. Only a small part of the e-waste generated in the world is thus being recycled in adequate facilities [14].

Some of these facilities are very efficient and may recover up to 80% of the materials in the e-waste, while incinerating another 15% for energy production. Only 5% of the material thus finishes as waste in these facilities. It is possible that the fraction of e-waste that is recycled properly will increase in the coming years, as a result of the more stringent legislation that is being established in many countries, although the reverse effect of such legislation has also been suggested[15].

14. www.apc.org/en/system/files/gisw2010_en.pdf
[15] www.erb.umich.edu/Research/Student-Research/.../HolyCrossAbbey.pdf

ESDO's approaches and achievements in E-Waste management:

At present there is a lack of awareness regarding e-waste among the general population in Bangladesh; moreover the Government is not highly concerned about this threat. However, in Bangladesh, Environment and Social Development Organization-ESDO has been working in association with IPEN, Swedish Society for Nature Conservation (SSNC) to increase awareness among the general people about the negative side of undisciplined management of e-waste since 2008.

ESDO's conducted survey to determine the situation of e-waste in Bangladesh shows that generated e-waste has increased significantly in total weight, 10.25 million metric ton/year. Hence, there is a necessity for creating awareness as major part of the population is still unaware of this issue. E- waste is disposed of without understanding the harmful effects of open dumping in landfill, farming land and bodies of water.

ESDO has conducted the research to gather information regarding e-waste and to review and compare existing practices for dealing with e-waste at a regional and national level in Bangladesh. In addition, ESDO initiates a local waste management program with a small community in Dhaka to reduce careless dumping. ESDO in association with IPEN and Swedish Society for Nature Conservation (SSNC) has taken the prior initiative to launch different programs, campaigns & workshops to manage e-waste in a proper way.

ESDO has been conducting a project to determine the effects of electronic waste on the environment and public health in Bangladesh. ESDO is officially working as an E-waste advocate formulating a national policy and management guideline since 2008 for Bangladesh.
In 2010, E-Waste Initiatives were launched successfully by ESDO. ESDO have also successfully completed and published three research-based reports on the country situation on e-waste management.

A study was completed to discover hazards created from the generation of e-waste, current dumping practices and rules for dumping. Finally, this study tried to identify the level of awareness regarding e-waste and to determine a way forward to reduce environmental hazards.

Significant Events by ESDO on E-waste awareness:

- **Press briefing:** ESDO organized a press briefing at the Women Volunteer Association (WVA) Seminar Hall on 8th October, 2010 to launch a study and accompanying report. Journalists from the print and electronic media, like minded organizations and members of the general public attended the briefing.

- **E-waste Education for the next generation:** ESDO launched an e-waste awareness project supported by International POPs Elimination Network (IPEN), under the auspices of the International SAICM Implementation Project (ISIP); entitled: "E-waste Education for the Next Generation" On January 13, 2011. It was the first attempt of educating school students of the ages 10-14 years in Bangladesh.

- **Communication efforts:** ESDO conducted educational session on e-waste at Pallabi M. I. Model High School, Wari High School, Dhanmondi, Ali Hossain Girls High School and Lalmatia High School on the 18 January 2011, 23 March 2011, 31 March 2011 and 24 April 2011 respectively to initiate and demonstrate our E-waste Education program. Students acquired knowledge of the dangers of e-waste and were encouraged to share with other students and other society members.

- **"Chemical Safety" Education for the Next Generation:** ESDO initiated school based education and awareness activities from May 2011 to November 2011 as part of its environmental education & awareness program on Chemical Safety. ESDO has conducted chemical (E-waste, Lead in paint, mercury and POP's) awareness campaigns within 15 schools of 6 different District towns of Bangladesh. Teachers and Parents were also involved in the program.

- **Workshops on E-waste management:** ESDO arranged a "Knowledge Exchange Workshop on E-waste Management and Regulation in Bangladesh" on 19 March 2012 at Dhanmondi Dhaka to share the E-waste study findings. ESDO also shared the findings with experts and professionals towards formulation of an integrated national policy framework on E-waste trade-off and effective management in Bangladesh.

- **Workshop on Environmentally Sound Management of E-waste:** A national workshop on "Environmentally Sound Management of E-waste in Bangladesh" was organized by Environment and Social Development Organization-ESDO at Reporters Unity Conference Hall at Segunbagicha.

- **Environmental Education on E-waste (Electric & Electronics wastes):** ESDO arranged an environmental education program in Chittagong Polytechnic Institute and Basonti Girls High School in 2012. The aim of this program was to create awareness about e-waste among the general population and students.

- **Guideline Submission to the Government:** ESDO formulated practical guidelines for the proper management and disposal of electronic waste in Bangladesh and submitted this to the Bangladesh Government in December, 2012. The guidelines can help the Ministry of Environment and Forest and related authorities mobilize current draft policies and formulate future national E-waste management guidelines.

- **Documentary Film:** In December, 2012 ESDO and SSNC jointly launched a documentary film co-ordinated by Dr. Shahriar Hossain, Secretary General of ESDO on the current status of e-waste management in Bangladesh. There was enough information about the current status of e- waste including regular use rates of electrical and electronic products along with their careless dumping, pollution scenario, opinions of specialists and so on. In addition, ESDO's research activities are also shown in the documentary film that gives an idea at a glance of e-waste management in Bangladesh.

Life-cycle of Electrical and Electronic Equipments and Generated Waste

Produced electrical appliances follow a certain process until end of life which is termed as lifecycle. The conceptual framework of the lifecycle of EEE and generated waste of electrical & electronic equipments is illustrated in figure 2.

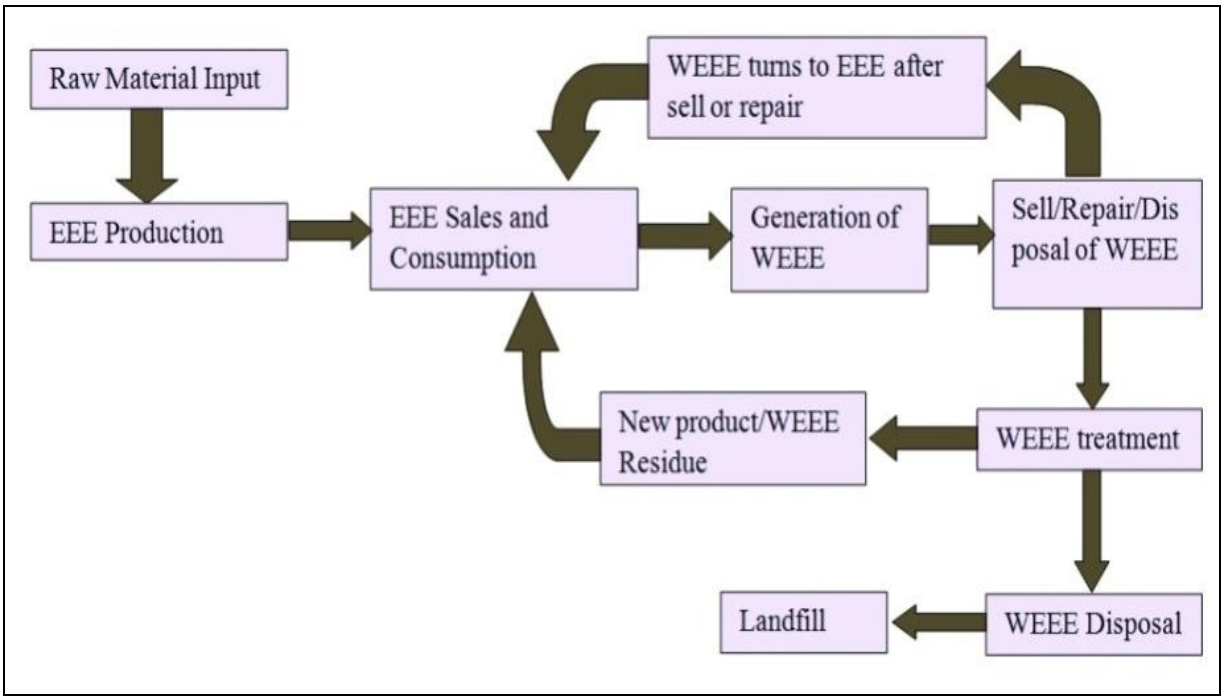


Figure 2: Lifecycle of EEE and WEEE

Rationale of the Study

The increased usage of electrical and electronic equipments in Bangladesh and the illegal import of WEEE have created a need to assess the current situation in Bangladesh. It is especially important due to the lack of safety regulation, framework guidelines, safety equipment and appropriate infrastructure for management of e-waste. The majority of generated and imported e-waste is collected and disintegrated in backyard operations of the non-formal recyclers without following any safety measures. The most alarming aspects are the open burning of the disposed part of the e-waste. Adding to this problem is the untreated contaminants flow in water body and soil, affecting human health and environment of Bangladesh.

Considering these circumstances, it is important to assess the situation of e-waste in Bangladesh. The biggest loophole in the environmental protection sector in Bangladesh is the lack of research and documentation. By identifying

the knowledge gaps, Environment and Social Development Organization-ESDO conducted a research project. This new study was implemented in selected groups and a report was produced.

Target group of the study:

The study was completed in six concerned groups. The target groups of the study were individual households, commercial institutions, importers, retailers, repairers and non-formal recyclers. The total numbers of samples were 997, 143, 7, 512, 120 and 20 respectively.

Methodology

The main methodology was through surveying randomly selected individual groups. The questionnaires of the survey are attached in the annex of this report. The questionnaire included questions regarding the lifespan and the average number of electrical equipments held by the surveyed groups/ individuals.
To calculate the production of e-waste in Bangladesh, the below equation was used for the new surveyed products-

$$E=MN/L$$

Where,

E= produced e-waste (million metric ton/ per year),
M=mass of the product in metric ton,
N=average number of used products and
L= lifespan in years

The previously surveyed products were calculated using the growth rate of 2 years multiplied by the total percentage of generated e-waste.

There were assumptions made while calculating the produced e-waste. They were the percent coverage of electricity in Bangladesh, the percentage of urban population and the exclusion of the percentage of the poverty stricken population.

Results and discussion

Table: Generated e-waste from different sources in Bangladesh (2011-2014)

Sources of E- waste and yearly growth rate (2012-2013 and 2013-2014)	**Estimated e- waste (million metric ton/yr)**		
	2011-2012	2012-2013	2013-2014
Ship breaking yards (37%) a. *Scrap ships (40 – 45%)* *b. Illegal import through other electronics and automobile containers (25-30%)* *c. Smuggled from neighboring countries (mostly India and Myanmar)(30-35%)*	4.7 [a-1.88]	6.47 [a-2.78 (43%)]	8.86 [a-3.98 (45%)]
Television sets (57%)	0.35	0.55	0.86
Computers (31% and 41%)	0.0167	0.0218	0.0307
Mobile phone (87%)	0.006	0.0112	0.0211
CFL bulbs (25% and 29%)	0.002	0.0025	0.0032
Mercury bulbs (21% and 23%)	0.002	0.00242	0.00297
Thermometers (34% and 39%)	0.0007	0.0009	0.0014
Medical and dental waste (67% and 69%)	0.014	0.0233	0.0395
Household electrical appliances & switches (78% &79%)	0.09	0.1602	0.2867
Total	5.1814	7.24232	10.10557

According to ESDO's survey and study it was found that ship breaking yards illegally import e-waste in the ships along with e-waste generated from the scrap ships themselves. Forty to forty-five percent of e-waste is being carried and generated from the ship breaking yards of Bangladesh every year. Approximately, 120 to 200 ships have been imported every year. According to the ship breakers, 260 ships were imported in 2012. [16] Bangladesh has been the top scarp ship buyer from 2000 to 2010 and 2011 to 2013. The size of a scrap ship imports into Bangladesh is average **12 to 18**

[16] Report published in The Financial Express on 13, January 2013.

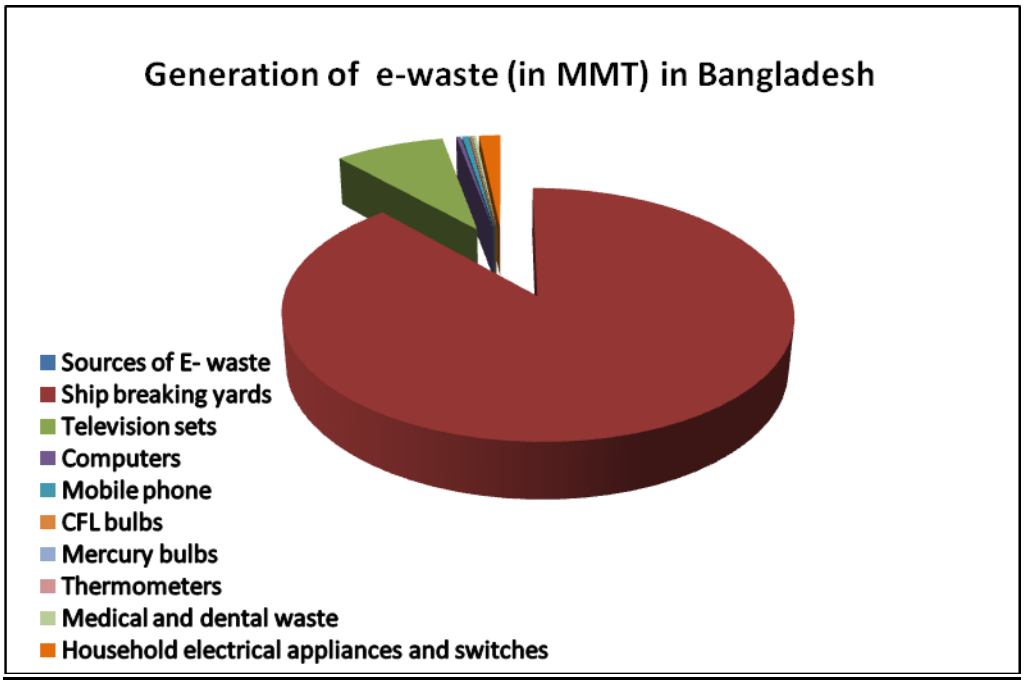
- 1 TEU= 20 Foot=6.1 meter

thousand **TEU (Twenty-foot Equivalent Units)**.* A 20 foot long ISO container equals 1TEU, 40 foot containers stacked on the top of 20 foot containers. These 4 containers represent 6 TEU. Each of these containers contains 800-1500 computers or (CRT) monitors. The scrap ship can provide space for 250 to 2500 containers (according to cargo container, ferry and passengers ship). If it is considered that a ship can contain 500 container spaces in general which can easily contain 300,000 computers or (CRT) monitors. CRT monitor weight average 13 to 15kg according to size. Therefore, a 500 container spaced ship can carry (9000 ton of CRT monitors or computers. If it is considered that these ships carry nothing else but computers or CRT monitors, 200 ships can carry in total 1.8 million ton of these materials. [17]

However, scrap ships entering Bangladeshi coast do not only carry useless computers and monitors; but they carry heavier electronic and electric materials like refrigerator, washing machines and oven. These three weigh for 100 kg, 60 kg, and 50 kg on average respectively. So, in addition to the computers/ monitors and, it is now considered that the scrap ships carry refrigerators. Thus, 150 ships carrying 200 containers can bring 2.7 million metric ton obsolete refrigerators to Bangladesh by the ship breaking yards. Therefore, If this figures, 2.7 million metric ton is roughly added to the 1.8 million tons of monitors, which is 4.5 million metric ton. This figure is even bigger the surveyed figure of the slot for scarp ships (Table 1)[18]

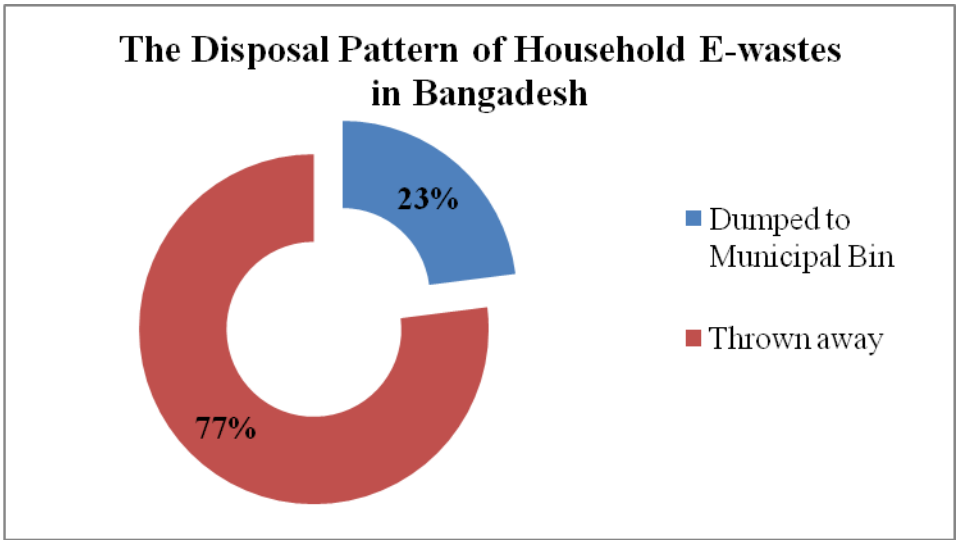
17 If 1 monitor weighs= 15 kg, 1200 monitors in 1 container weigh= 1200x 15 kg= 18,000 kg or 18 ton. Therefore, a scrap ship carrying 500 containers can weigh= 18 tonx500= 9000 ton. Finally, such 200 ships reaching Bangladesh weigh= 200x9000 ton= 1800000 ton or 1.8 million ton

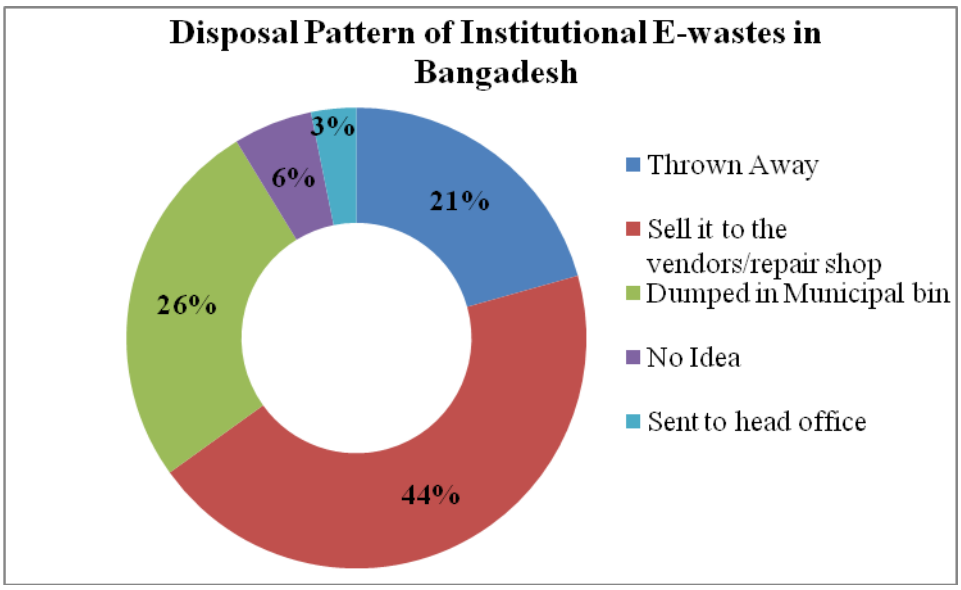
18 If 1 refrigerators weighs= 100 kg, 900 refrigerators in 1 container weigh= 900x100 kg= 90,000kg or 90 ton. Therefore, a scrap ship carrying 200 containers can weigh= 90 tonx200= 18000 ton. Finally, such 150 ships reaching Bangladesh weigh= 150x 18000 ton= 2700000 ton or 2.7 million ton



Disposal Pattern of Household & Institutions

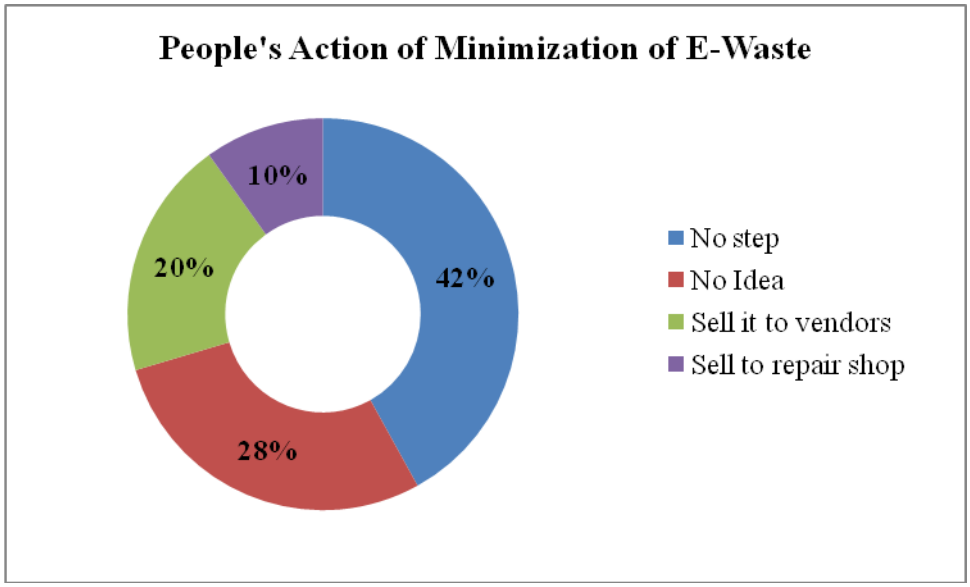
Among the surveyed people 23% throw away to waste dumping sites damaged electrical equipment from their household and 77% dispose of their waste in the municipal bin, where e-waste is not managed properly. For institutions reselling to repair shop/vendors occupies the larger portion (44%), followed by dumping in municipal bins (26%), Open dumping (21%), no idea (6%) and sent to head office (3%).

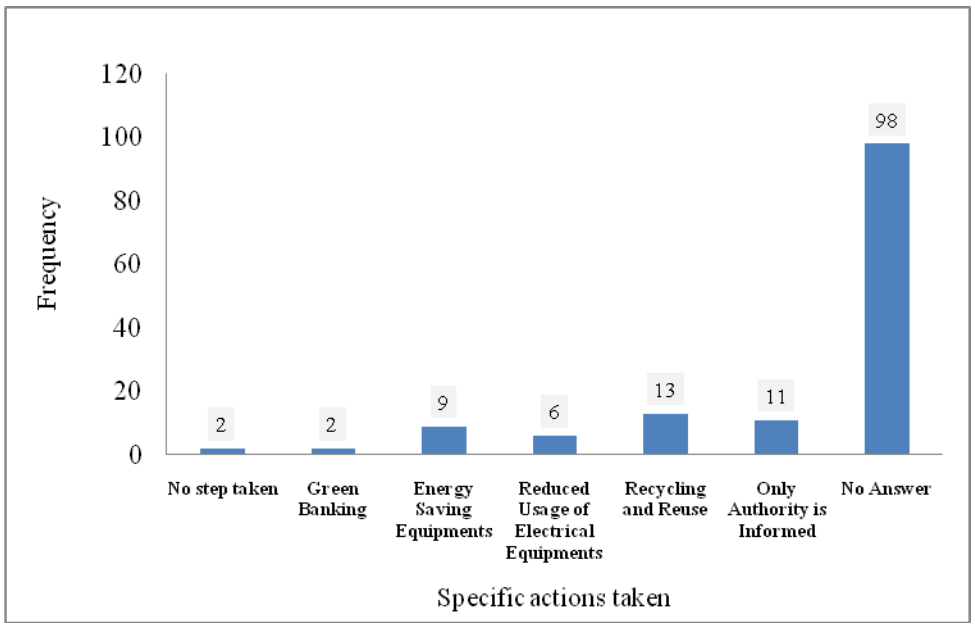




Action to Minimize E-waste

Of the sampled population, 42% do not take any steps needed to minimize e-waste, 28% have no idea about the minimization process, 20% sell on to vendors and 10% sell to repair shops to minimize e-waste. On the other hand, institutions mostly avoided this question (70%); the second popular answer (9%) was re-use and recycling.

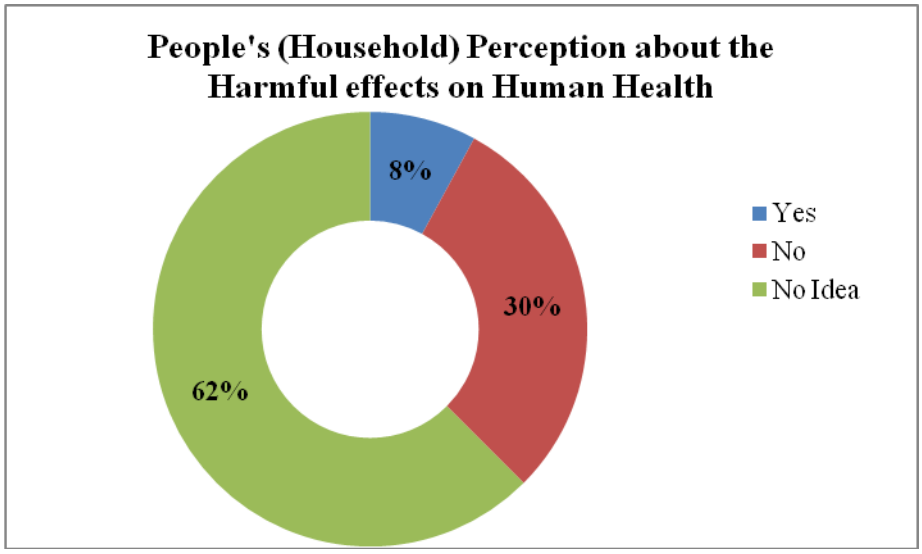




Specific actions to minimize e-waste

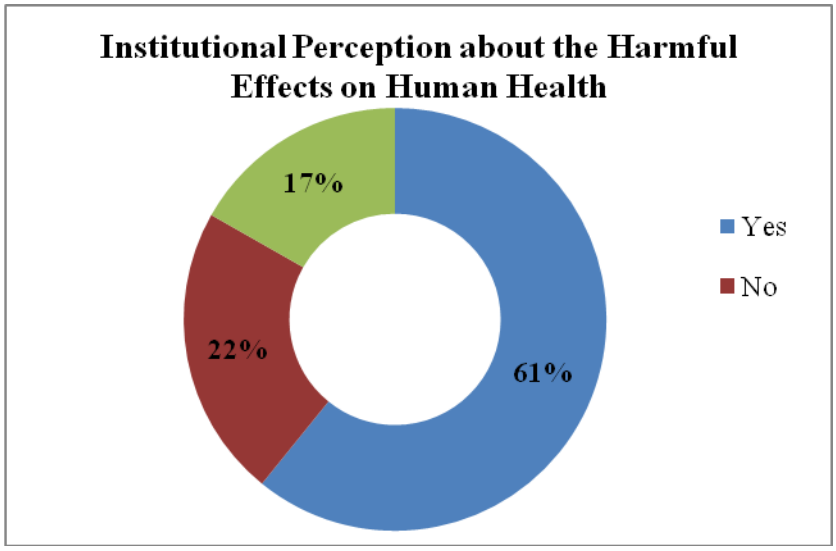
Health Effects

When asked if there are harmful health effects associated with e-waste, the majority of surveyed people, 62% said that they have no idea about its harmful effects, 30% said yes there are harmful effects and 8% said there are no harmful effects.



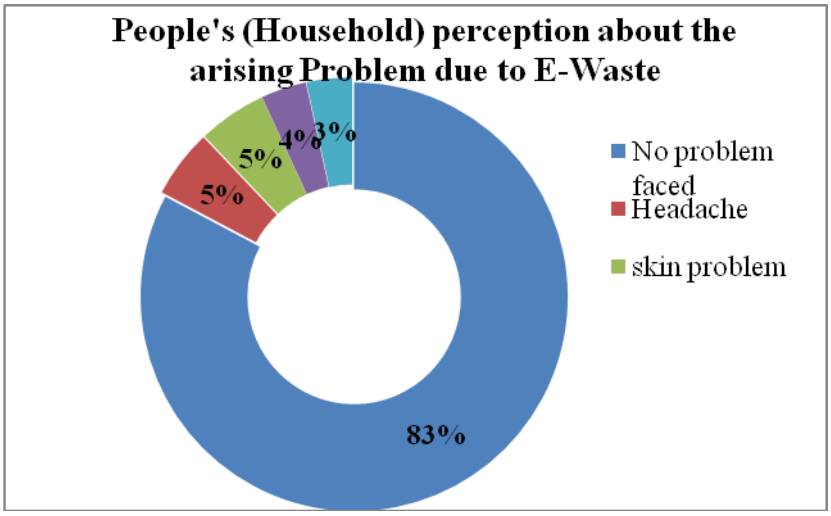
In the surveyed institutions the majority agreed on the harmful effects of chemicals emitted from e-waste which are polluting the environment. The greater part (61%) of the responders from institutions agreed that e-waste

effects human health, 22% said it does not and 17% identified as uninformed about this.



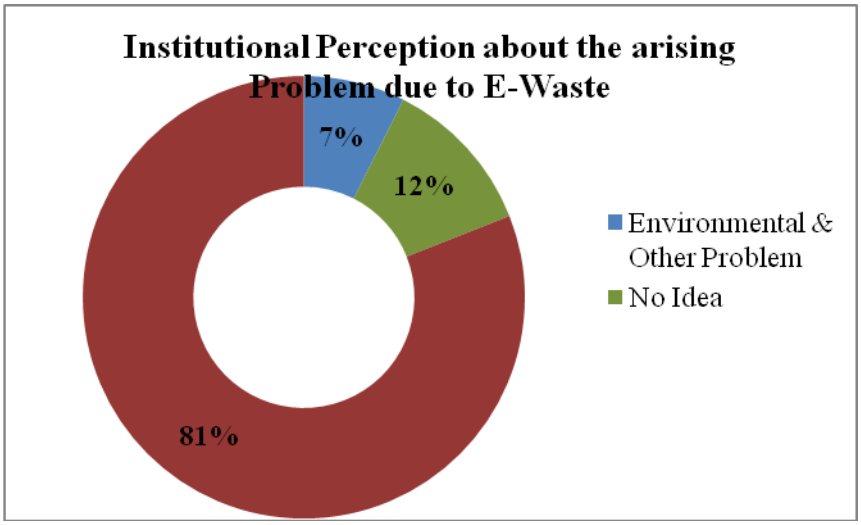
Arising Problem

When asked if they face problems due to e-waste, 83% said they do not face any problems, 3% said they are always facing problem because of e-waste, 5% said they have headaches & again another 5% said they have skin problems, and finally 4% said they have eye problems from e-waste.



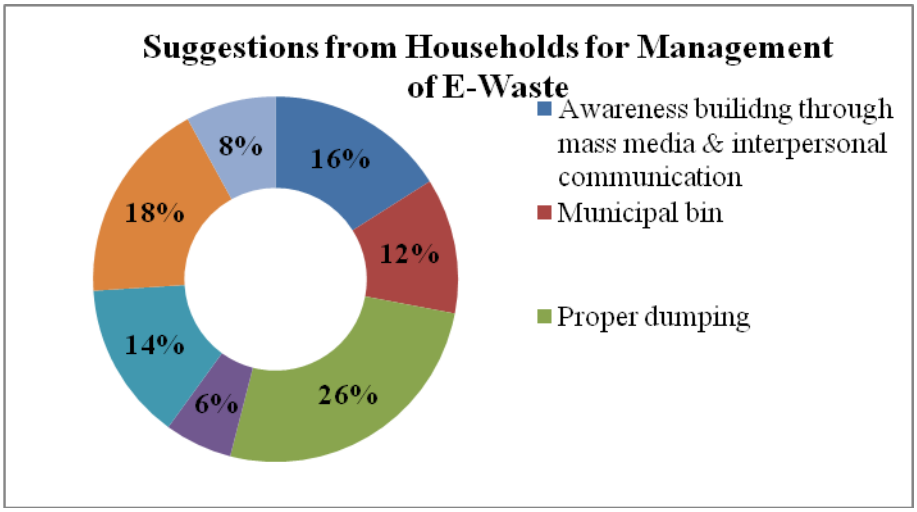
In the case of institutions, the majority (81%) thinks that there is no problem related to e-waste or discarded electrical waste. However, a small portion of

institutions (12%) mentioned about environmental pollution faced due to e-wastes.

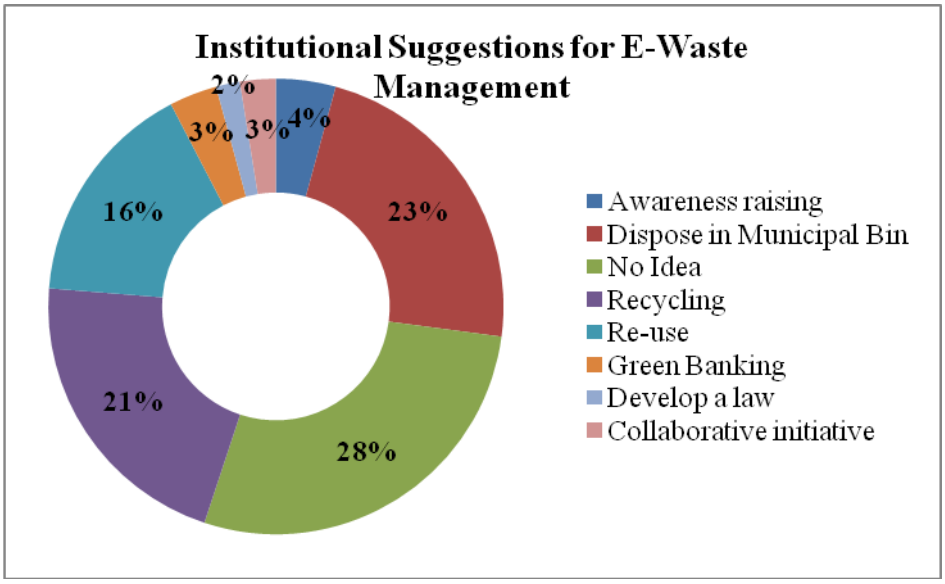


Suggestions

The surveyed population was also asked about ways to minimize e-waste. The majority, 26%, said that proper dumping systems are the solution and 6%, recommended a specific dumping place for the discarded electrical equipment's.

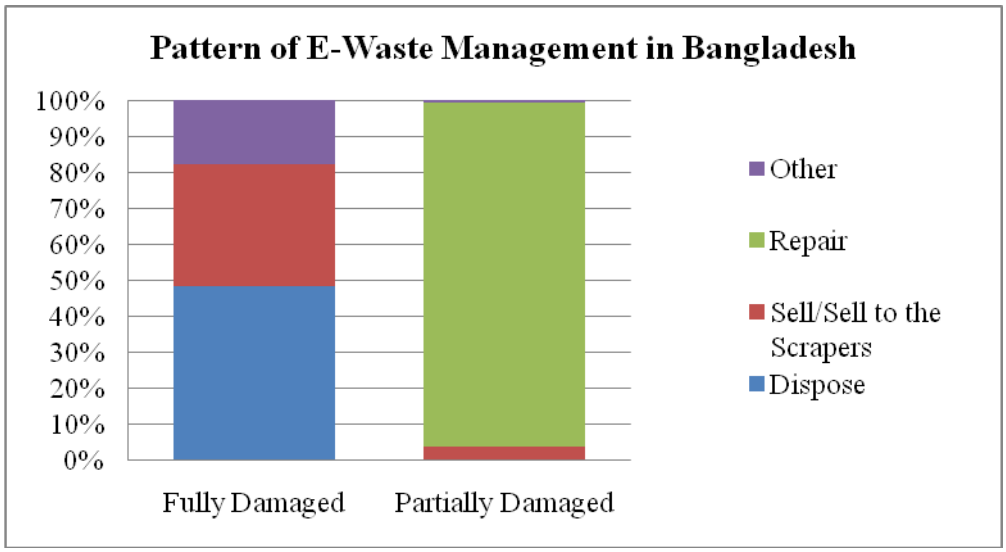


When the same question is asked in the institutions, they gave diverse answers. 28% have no idea about the management of e-waste. New answers from the institutions included starting Green Banking; develop a law and collaborative initiative.



Pattern of E-Waste Management in Bangladesh

When asked about the disposal methods of partially damaged or fully damaged products (both in households and institutions), the majority (almost 90%) responded that they repair the partially damaged products. However, in the case of damaged products almost 50% directly dispose of it, 35% sell to the scrapers and the other 15% have other uses. By other uses they meant that they store it and sell it later, in the case of institutions they send it back to the head office and sometimes, both individuals and institutions sell it.



E-waste handling of Retailer, Repairer and non-formal recyclers

The recycling, disintegration and final deposition is mainly managed through non-formal recyclers & repairers. On the other hand the chief sellers of electrical equipment in Bangladesh are the retailers rather than the importers; the number of importers is quite limited in Bangladesh.

When the survey was completed among these groups, the sample size became very small, especially for importers, only two importers were surveyed, Nokia and Electra international. They are the chain shops of the global industry; therefore they are not actually importers but part of the global chain. Mostly the self-identified importers are retailers. In developing countries like Bangladesh, people rely more on repairing than buying new products.

The sample size of the retailers, repairers, non-formal recyclers and importers were relatively small, therefore it was not included in or portrayed through graphical display. However the survey highlighted that all the sorting, disintegration and other e-waste related works are processed manually without any protective equipment.

Recycling

Vast quantities of e-waste are now being moved around the world for recycling in developing countries using manual processes in backyards of residential properties, resulting in significant contamination of soil, water and air in these countries. Such practices have also resulted in the poisoning of many local people engaged in the recycling process (Peera art, 2013).

Landfill disposal

Irrespective of the current global move towards zero wastes, the number of landfills has been increasing in both developed and developing countries. The presence of thousands of old landfills with no barriers and containing a mixture of putrescible and e-wastes is of great concern. There is sufficient evidence now to demonstrate that landfills accepting electronic devices or old landfills containing e-wastes will cause groundwater contamination (Schmidt, 2002; Yang, 1993). Toxic chemicals in electronics products can leach into the land over time or are released into the atmosphere, impacting nearby communities and the environment.

Incineration

This releases heavy metals such as lead, cadmium and mercury into the air and ashes. Mercury released into the atmosphere can bio accumulates in the food chain, particularly in fish - the major route of exposure for the general public. If the products contain PVC plastic, highly toxic dioxins and furans are also released. Brominated flame retardants generate brominated dioxins and furans when e-waste is burned.

Reuse

Many old products are exported to developing countries. Although the benefits of reusing electronics in this way are clear, the practice is causing serious problems because the old products are dumped after a short period of use in areas that are unlikely to have hazardous waste facilities. Due to transboundary movement it causes a mass generation of e-waste in Bangladesh.

Recycle

Although recycling can be a good way to reuse the raw materials in a product, the hazardous chemicals in e-waste mean that electronics can harm workers in the recycling yards, as well as the environment.

In developed countries, electronic recycling takes place in purpose-built recycling plants under controlled conditions. Here in Bangladesh, recycling process are poorly managed and without consideration for health and environmental safeguards. In many countries, plastics from e-waste are not recycled to avoid brominated furans and dioxins being released into the atmosphere. In Bangladesh however, there are no such controls. Recycling is done by hand in scrap yards, often by children.

Impacts of e-wastes

E-waste containing a wide range of hazardous compounds has turned into a global environmental issue. When the e-waste is not adequately taken care of, either in general waste processes or in recycling processes, these hazardous compounds may be released and thereby become a threat to human health and the environment. Primitive recycling or disposal of e-waste to landfills and incinerators causes irreversible environmental damage by polluting water, soil and air.

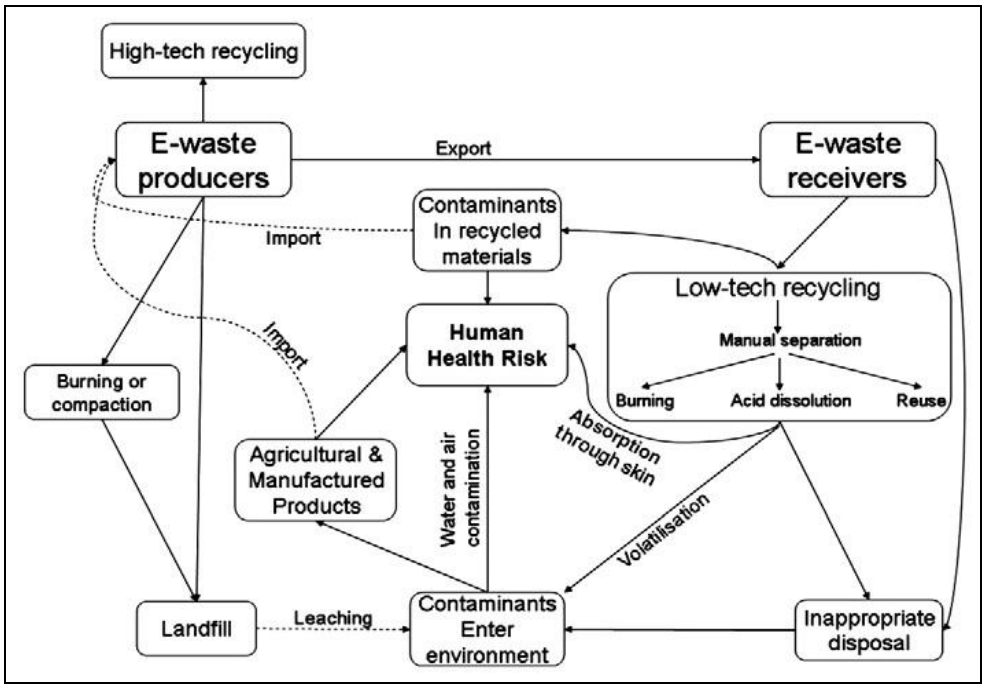


Figure 3: Pathways from different sources that expose humans to e-waste management (Source: Robinson, 2009)

Impact on Health

E-waste takes up space in the communities it invades and can be very harmful to humans and animals. It is of concern mainly due to the toxicity and carcinogenicity of some of the substances if processed improperly.

Long-term exposure to different substances of e-waste damages the nervous system, kidneys and bones, and the reproductive and endocrine systems, and some of them are carcinogenic and neurotoxic. Some of the very common diseases due to e- waste are:

- High blood pressure
- Fragility of bones
- Lung damage
- Mental retardation

A study conducted by ESDO in 2014 on electronic waste management in Dhaka clearly indicates the presence of high levels of hazardous materials including woeful working environment in the areas where this management takes place**.** Workers in the e-waste disposal sector are poorly protected against these risks. Much e-waste recycling occurs in the informal sector, in homes where women

and children are engaged in unsafe recycling practices without the benefit or the knowledge of exposure-minimizing technology or protective equipment. Hence, the workers, children and women (especially pregnant women) are the main victims of e-waste exposure. The negative effects of e- waste on these groups of people are highlighted below:

Impacts on workers

In some processes used, new hazardous compounds such as dioxins may be formed as the original e-waste components are degraded which is widely associated with severe health and safety risks for workers involved in this sector (Brigden *et al.,* 2008).

These risks emerge primarily due to improper and crude recycling techniques used for the recovery of raw materials, as for instance, open incineration of cables and wires to recover copper. Also, fractions, such as low-grade printed wiring boards (PWB) are incinerated to reduce e-waste volumes. Often, insulating foam, primarily polyurethane (PUR), from obsolete refrigerators, and automobile tyres, is used as co-fuels to sustain the fires used for burning the cooling grills of air conditioners.

Occupational hazards associated with e-waste handling

Infections

Skin and blood infections resulting from direct contact with waste, and from infected wounds. Eye and respiratory infections resulting from exposure to different chemicals, especially during metal separation exposure to landfill and incineration operations.

Chronic diseases

Incineration operators are at risk of chronic respiratory diseases, including cancers resulting from exposure to dust and hazardous chemical compounds.

Accidents

- Bone and muscle disorders resulting from the handling of heavy containers
- Infected wounds resulting from contact with sharp objects. Poisoning and chemical burns resulting from contact with hazardous chemical waste.

- Burns and other injuries resulting from occupational accidents at waste disposal sites or from chemical explosions at landfill sites.

Apart from open incineration, inappropriate dismantling techniques to recover metals such as copper, aluminum and iron also represent enormous risks to the workers. For example, breaking of CRT-monitors using stones, hammers, heavy metal rods and chisels, to recover copper, steel and plastic casings, could result in the inhalation of hazardous cadmium dust and other pollutants by the workers. The magnitude of health risks faced by refurbishes and repairers of EEE is much smaller compared to recyclers. Refurbishes and repairers make use of simple tools, such as screwdrivers, pliers, electrical soldering machines, hammer etc. either in order to replace a defective part with a new one or to repair the existing parts to generate a saleable good. Often, refurbishing and repairing activities make use of natural daylight and aeration for the most part of the operation.

Impacts on Children

- Children are especially vulnerable to the health risks that may result from e-waste exposure; therefore, need more specific protection.
- In Bangladesh more than 15% of child workers die yearly as a result of e-waste recycling and more than 83% are exposed to toxic substances and become sick and are forced to live with long term illness, found the survey results by ESDO.
- According to ESDO's recent study and available information, approximately 50,000 (fifty thousand) children are involved in the informal e- waste collection and recycling process, amongst them about 40% are involved in ship breaking yards.
- Body functional systems such as the central nervous, immune, reproductive and digestive system are still developing and exposure to toxic substances hampers further development and may cause irreversible damage.
- Many more children are exposed to e-waste-derived chemicals in their daily life due to unsafe recycling activities that are often conducted in their home- either by family members or by the children themselves. Furthermore, children may be exposed through dump sites located close to their homes, schools and play areas.

Impacts on Pregnant women

After workers and children, pregnant women are greatly at risk when exposed to e-waste. They can face fetal loss, abnormal thyroid function, thyroid development, neurobehavioral disturbances and genetoxicity and the unborn child can face prematurity, low birth weight and congenital malformations.

Diseases due to heavy metals

Workers and residents are likely to be directly exposed to complex mixtures of unknown toxicity and radioactivity. The heavy metals (mercury, lead, cadmium, chromium, zinc and others) from e-waste cause disease in the human body. These include:

Mercury:

- Brain and kidney damage
- Hampers the fetus developing healthily
- Kidney, renal and neurological damage
- In extreme cases, death

Lead:

- Attacks the nervous system of both adults and children
- Learning disabilities
- Mental retardation
- Behavioral problems
- Hearing impairment

Cadmium:

- Damages the lungs and can cause death
- Cancer develops
- Fragility of bones
- High blood pressure
- Nerve and brain damage
- Kidney and liver disease

Chromium:

- Inhaling the hexavalent form of chromium can damage the liver and kidneys
- Causes lung cancer and asthmatic bronchitis

- Chromium easily passes through cell membranes and can cause damage to DNA
- Chromium-6 causes colds, nose bleeding, ulcer and damage to sinuses

Others:

- ❖ Zinc: corrosive to skin and lungs
- ❖ Beryllium: respiratory inflammation known as the beryllium chronic disease
- ❖ Nickel: lung cancer and sinusitis
- ❖ Selenium: selenosis, hair loss, neurological problems
- ❖ Barium: gastrointestinal disorders and muscular weakness
- ❖ Brominated flame retardants: hormonal problems

Impacts on environment

During land filling, hazardous compounds may spread to the surrounding environment including nearby surface water and groundwater reservoirs, and also evaporate to the atmosphere.

Exposure to e-waste might occur directly via recycling or indirectly via ecological exposure, hence, the environment degrades and pollution occurs. The impacts on the environment due to e-waste are given below:

Contamination: High levels of environmental contamination can occur from e-waste recycling, putting residents in surrounding areas at risk of ecological exposure via inhalation or ingestion of contaminated water, air, and food supplies.

Air pollution*:* Burning of e-waste creates smoke which contains poisonous gases and heavy metals. For instance, polyvinyl chloride (PVC), a widely used plastic in electronic appliances, produces large quantities of hydrozen chloride gas while burning. Hydrogen chloride forms hydrochloric acid if it combines with water. This causes respiratory problems when inhaled.[19] PVC which coats copper cables and plastic computer casings also releases highly toxin dioxins and furans when burnt.[20] More interestingly, bacteria can turn into toxic organic mercury

[19] Hazardous Substances in e-Waste;
http://ewasteguide.info/hazardous-substances
[20] Poison PCs and Toxic TVs. http://svtc.org/wp-content/uploads/ppc-ttv1.pdf

compounds while e-waste containing mercury is buried under soil.[21] Lead, cadmium and mercury can release into the air while e-waste is being incinerated[22]. A monitor (14 inch) which has tubes with lead emits toxic fumes into the air when being crushed and burned[23].

Soil pollution: When Brominated flame retardant plastic or cadmium containing plastics are dumped in land fill, both polybrominated dlphenyl ethers (PBDE) and cadmium may leach into the soil and groundwater. It has been found that significant amounts of lead ions are dissolved from broken glass containing lead, such as the cone glass of cathode ray tubes. These get mixed with acid waters, are a common occurrence in landfills, the ground then become infertile to produce crops[22].

Ground water: Bangladesh is blessed with many rivers, rainwater reaches underground sources. If the substances dumped are seeping into the soil our groundwater will be contaminated by arsenic-like poisons.

Blockage: A large proportion of e-waste is shipped to less developed countries for dumping or recycling. Improper management and dumping systems create blockages in water runoff channels.

Degradation of the beach environment: Every year a significant no. of scrap ships are imported to Bangladesh legally. These ships are broken in ship breaking yards. During ship breaking, a large number of heavy metals and toxic pollutants release into the environment, including oil spills on land and in water bodies. As it is legal in Bangladesh to import scrap ships, illegal import and trade off of e-waste is happening by importers to make profits by loading ships with e-waste, increasing the e-waste vulnerability of Bangladesh.

Impacts of e-waste during treatment processes

Management of e-waste by recycling and by disposal to landfills has been shown to pose significant risks to the environment (Puckett and Smith, 2002;

[21] http://www.naturvardsverket.se/Documents/publikationer6400/978-91-620-6417-4.pdf
[22] Where does e-waste end up?
http://www.greenpeace.org/international/en/campaigns/toxics/electronics/the-e-waste-problem/where-does-e-waste-end-up/
[23] Environmentally Sound Options For E-Wastes Management
[22] http://wgbis.ces.iisc.ernet.in/energy/paper/ewaste/ewaste.html

Robinson, 2009; Wong et al., 2007a). The impact of e-waste from recycling and disposal processes is summarized below.

Many old electronic goods gather dust in storage waiting to be reused, recycled or thrown away. The US Environmental Protection Agency (EPA) estimates that as much as three quarters of the computers sold in the US are stockpiled in garages and closets. When thrown away, they end up in landfill or incinerators or, more recently, are exported to Asia.

Limitations of the study

The main limitation of the study is that it is based on surveyed data and limited survey results have influenced the data. The assumptions were made based on observations and from secondary data sources, therefore the study is not purely based on primary data and ESDO was depended on estimations.

Policy regime:

Law

 Bangladesh adopted its National Environment Policy in 1992, highlighting the regulation of all activities that pollute and destroy the environment.

 There are no specific laws or ordinances for e-waste management and recycling. But we have the Bangladesh Environment Conservation Act of 1995, the Environmental Court Act of 2000, and The Environmental Conservation Rules of 1997.

 The Environment Conservation Act of 1995 authorizes the Director General to undertake any activity necessary to conserve and enhance the quality of the environment and to control, prevent and mitigate pollution.

 The Medical Waste Management Rules of 2008 address the waste management issues for the medical sector, including e-waste.

 The Government of Bangladesh has prepared the draft National 3R (Reduce Reuse and Recycle) Strategy and in that draft e-waste issues were addressed.

 The Hazardous Waste Management Rules are under preparation and there is still time to incorporate e-waste management issues for proper management of e-waste.

 The Department of Environment is preparing draft Solid Waste Management rules, which are now in the consultation stage and there is still time to include e-waste management issues within those rules.

 Bangladesh is a signatory to the Basel Convention prohibiting trans-boundary movement of hazardous waste.

 Importing of any kind of waste requires Government permission.

 The High Court of Bangladesh has directed the Department of Environment to ensure that all ship-breaking yards operating without environmental clearance to shut down their operations. The court handed down this ruling in March 2009.

 The High Court also directed the government to ensure that no ship with hazardous waste enter the country without being pre-cleaned at the source or outside the territory of Bangladesh.

The court observed that none of ministries had co-operated to ensure conformity to these environmental laws. The order said the government had to ensure that ships were only broken after guaranteeing safe working conditions for the laborers and having in place appropriate disposal arrangements for hazardous waste and protection of environment.

Conclusion

E-waste is a serious problem at both a local and global scale. E-waste problems appeared initially in developed countries and now extend widely to other countries around the world. The volume of e-waste is growing fast because consumer technology is rapidly changing and the innovation of technology results in rapid obsolescence, thus generating massive amounts of e-waste. E-waste consists of many different materials, some of which contain a variety of toxic substances that can contaminate the environment and threaten human health, if end-of-life processes are not meticulously managed.

There is no completely safe disposal method for e-waste when considered from a health and environmental perspective. Although risks may be greatly reduced in controlled recycling facilities, they cannot be completely avoided. To further reduce the risks, the amounts of hazardous compounds in the EEE have to be reduced, since the very presence of these compounds is one of the primary causes of the risks. At the same time the amount of e-waste generated worldwide has to be reduced in order to solve the e-waste problem on a global scale. This can, at least partly, be achieved through the design of products with greater life-spans that are safer and easier to repair, upgrade and recycle. The ultimate goal must be to ensure that the quantities of e-waste generated are minimized, and that the e-waste that do arise are recycled and disposed of in the best achievable manner to minimize impacts on human health and the environment.

Recommendations and Future Framework

This report will be one of the key components in e-waste management in Bangladesh as this reflects the current situation of e-waste. One of the chief recommendations from this report is that a proper e-waste management system and guidelines should be implemented in Bangladesh, especially to prevent illegal trade of e-waste from developed countries. This report also highlights the future need for research in this field. The future research framework should include contamination in soil, water and its effects on the human body.

The best option, both from an environmental and a recovery efficiency point of view, is unquestionably to recycle e-waste in modern recycling facilities using state-of–the–art technologies with efficient emission control systems.
Legislation needs to be created for active policies, which will pave the way for a brighter, pollution free future in the country. Consequently, to avoid serious impacts on human health and the environment it is crucial to ensure that e-waste is properly

taken care of, all the way from collection and handling through to recycling and disposal.

The most effective solutions of e-waste:

- Minimum standards and improved awareness are needed for recycling in Asia, especially in the receiving countries.
- Develop E-waste policy and guideline with consultation with the relevant stakeholders.
- Monitor e-waste trafficking and shipment.
- Design of products with greater life-spans that are safer and easier to repair, upgrade and recycle.
- Alternatives for recycling technologies and materials must be developed.
- Harmony among governments is needed concerning environmental issues and trade in Asia.
- Enforcement and regulation policies must be included in any discussions.
- The informal sectors that are deeply involved in material cycling must evolve into more formal sectors, especially in developing countries. This is a big issue for all downstream businesses.
- Registration and capacity development of E-waste recyclers
- All costs must be internalized rather than ignored as externalities.
- The generation of E-wastes must be reduced. This could be accompanied by the promotion of appropriate reuse.

In addition to the previous points, on the basis of the experience, the following points were raised as policy options to accelerate formalization:

- Tax reductions/incentives for recycling industries could be provided.
- Low-interest loans for the installation of pollution control equipment would be useful.
- More information concerning the potential for cleaner production could help to implement appropriate technologies.
- Factories can be relocated to industrial parks with upgraded facilities for the reduction of pollution.
- Environmental awareness should be increased.
- Electronics companies can lead the way on clean energy - if they are pushed.
- However, when people do need to purchase a new product, there is some good news to report: many electronic companies have improved, removing toxic chemicals from mobile phones, computers and tablets, an important step in the right direction. This change did not happen by accident or altruism.

Companies changed in large part because of creative peoplewho campaigned these companies.

All of us – companies and individuals alike – have a responsibility to make our planet more sustainable.

Acknowledgement

The research team of ESDO is grateful to the volunteers who have helped in the survey. We are also grateful to the supervisor and survey questionnaire developer Md. Monzer Hossain and the stakeholders who willingly consented to take part in the survey. Lastly, we thank the entire ESDO team who helped in many ways in the completion of this report.

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