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Recycling of Electronic Wastes in Dhaka City

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Electronic waste termed as E-waste is one of the fastest growing pollution problems worldwide. According to Bangladesh electrical merchandise manufactures association, in this country, almost 3.2 million metric tons of e-waste is generated every year of which 20 to 30 percent is recycled and the rest of the waste is released to environment. The current practices of e-waste management in Bangladesh are suffering from a number of lacking. This study presents an overview of e-waste management system, including collection and treatment by informal sectors in Dhaka city. The management process may potentially produce an impact on humans and environment due to the presence of hazardous substances. A laboratory test has been performed to identify the presence of some toxic metals present on soil and water sample of Islambag, old Dhaka where a little portion of e-wastes are handled. A questionnaire survey has been performed to predict the awareness among users of electronic products.

Field of Research: Electronic waste; Recycling; Heavy metal; Environmental pollution.

1. Introduction

The exponential growth in the field of information and communication technology resulted not only in a multitude of new electronic products but also reduced their life span. Now-a-days products become obsolete faster than before, thus increasing e-waste. The objectives of this study are to identify e-waste hotspots in Dhaka, to collect information on e-waste management system of formal sector as well as search for authorized sector in Dhaka city, to classify different e-wastes from products, to identify environmental and health risk from poor handling of e-wastes and to identify the awareness level among people. Previous papers on relevant topic include e-waste recycling practices in Bangladesh, issues and challenges faced by developing countries of Asia during e-waste management etc. Herat and Agamuthu (2012) presented a review of challenges and issues faced by Asian countries in managing their e-waste in a sustainable way. Another review inspected the existing systems for recycling e-waste in Bangladesh and also proposed a model for sustainable management of the products which includes collection of e-wastes separately from urban and rural areas through NGOs or factory agents (Riyad et al. 2014). Uddin (2012) explained some techniques of handling e-waste which can be controlled without having an effect to the environment which are yet to be started.

This paper carries some qualitative and quantitative information on e-waste recycling process. A questionnaire survey was done on product users of Dhaka city to predict the awareness level and their willingness to pay for an e-waste free environment.

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The process which is followed here commonly poses as a threat to human health. The study also reveals that land filling is not a common practice in Bangladesh whereas it is one of the major ways of e-waste disposal in other countries. In this paper section 1 deals with introduction and section 2 focuses on literature review and section 3 contains methodology. Results and discussion are provided in section 4 and conclusion is in section 5

2. Literature Review

While there is no generally accepted definition of electronic waste, in most cases electronic waste consists of electronic products that were used for data processing, telecommunications or entertainment in private households and businesses that are now considered obsolete, broken, or irreparable.In short it can be called WEEE (waste electrical and electronic equipment). In WEEE products, there are many types of hazardous heavy metal elements which if dealt by human can be very risky and cause of death.

2.1 Chemical Elements in E- Waste

Chemical elements in e-waste can be classified in three major categories.

Elements in bulk: which include lead, tin, copper, silicon, carbon, iron and aluminium.
Elements in small amounts: includes zinc, chromium, cadmium, mercury.
Elements in trace amounts: contain germanium, gallium, barium, nickel, tantalum, indium, vanadium, terbium, beryllium, gold, europium, titanium, ruthenium, cobalt, palladium, manganese, silver, antimony, bismuth, selenium, niobium, yttrium, rhodium, platinum, arsenic, lithium, boron, and americium. Examples of electronic devices containing these elements are given in Table 1. (Robinson, 2009)

Table 1: Names of Chemical Elements in Different Electronic Devices

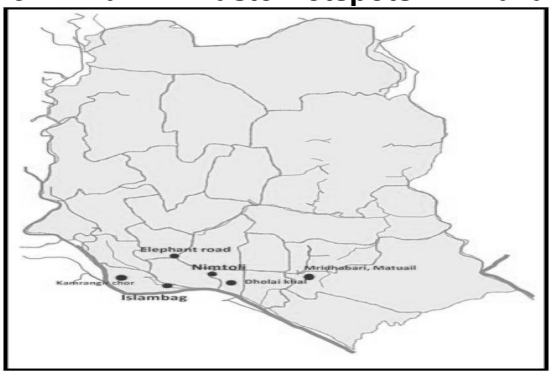
Electronic devices	Chemical elements
Battery, toners, plastics	Cadmium
Data tapes, floppy disks	Chromium
Solder, CRT Monitors (Lead in glass), Lead-acid battery	Lead
Solder	Tin
Copper wire, printed circuit board tracks	Copper
Capacitor, conductor, nearly all electronic goods using more than a few watts of power (heat sinks)	Aluminium
Steel chassis, cases & fixings	Iron
Glass, transistors, ICs, Printed circuit boards	Silicon
Batteries	Nickel
Lithium-ion battery	Lithium
Plating for steel parts	Zinc
1950s & 1960s transistorized electronics (transistors)	Germanium
Lead-acid battery	Sulphur
Steel, plastics, resistors. In almost all electronic equipment	Carbon
Fluorescent lamps, tilt switches (pinball games, mechanical doorbells)	Mercury
CRT screens	Rare earth materials

3. Methodology

Currently in Bangladesh, recycling of disposed electronic products is mainly being handled by the informal sector. Electronic waste or E-waste is collected, segregated, dismantled and recycled in the informal sector based in Dhaka's urban slums. The first stage of the value chain includes the generators of electrical waste, which are the households and offices. The next players of the trade value chain are the informal scrap collectors or vangariwala, who buys e-waste directly from the generators. Here the vangariwala either sells it to the second hand market, repairs and sells it again to consumers or secondhand shops, or sells them to the bulk collectors and manual dismantlers. Once they are dismantled, the different components are sent to different places around Dhaka for further processing, recycling and smelting activities. The final step of the value chain is recycling, where precious and special metals are extracted from the component. The manual dismantling and recycling stages include processes like open burning and acid treatment. E-waste contains around 1000 different chemicals, many of which contain high levels of toxins and hazardous elements. If e-waste is not recycled and disposed of in an environmentally prudent manner, it can pose serious threats to both human health and the environment.

According to the study findings the E-waste hotspots are found mainly in old Dhaka including Islambag, DholaiKhal, Elephant Road, Nimtali, Kamrangirchor, Mridhabari, Matuail etc. Some of the hotspots are indicated in red in figure 1.

Figure 1: Main E-Waste Hotspots in Dhaka City



3.1 Recycling Practice of Informal Sectors

The first step was spot selection as well as field visit to shops regarding recycling system of e-waste. Then next step was to collect information on present electronic waste management trends in formal or informal sectors.

Figure 2: Shredding Machine (Left); Workers are Washing Shredded Plastic Pieces in Buriganga River (Right)

The steps of recycling practice in the area of Islambag near Buriganga river includes separating according to color, shredding by cutting machine, washing and drying, storing the dried pieces, melting and reshaping and finally manufacturing usable products with those.

Recycling reclaims material streams useful for application in the products. Separation of material fractions increases the value of the materials recycled by removing material contaminants, hazardous materials or high-value components. The components are separated by manual disassembly methods. The purpose of shredding is to reduce material size to facilitate the next steps. Washing and drying is mainly for cleaning off other materials from the body. Melting and reshaping into semisolid state gives the privilege to easily manufacture usable products.The products include any type of daily use product such as mug, jug, balti etc. these are delivered to markets in different places.

3.2 Estimation of E-Products Generation

Total population in year 2000 = 13 crore (estimated)
Household with electricity is 31.2% in year 2000 according to BBS, 2006.
Household 25.3 million in year 2000 according to BBS, 2006.

Consumption expenditure is 4537 taka per person per month, (Ahmed, 2004)
Expenditure for household electronic products is 4% per capita income (estimated)
No. of person in each household=5 (BBS, 2006)

Amount of money, which is available to purchase household electronic products in year 2000

= (25.3*1000000*31.2*4537*12*5*4)/(100*100)
=8.595 x 10^{10} taka

A survey on price of Computer, refrigerator and television has been performed. The average prices of the products found from the survey are given below for performing an analysis.

Price of Refrigerator= 20000tk, Television= 16000 tk, Computer= 24000 tk
Total= 60000 Tk

In 60 households,

38 households want Television, 13 households want refrigerator, 9 households want Computer.

If all available money is used to purchase these three categories of products then:

Number of TV sold in market = $(8.595 \times 10^{10} * 38)/(60000*60)$
= 907,250unit

Number of refrigerator sold in market = $(8.595 \times 10^{10} * 13)/(60000*60)$
= 310,375 unit

Number of Computer sold in market = $(8.595 \times 10^{10} * 9)/(60000*60)$
= 214,875 unit

Total= 1,432,500 unit (equivalent)

Consider all these units have sold in year 2000. So 2000 is the base year.

3.3 Impacts on Environment & Health

According to medical and environmental experts, the hazardous chemicals and metals contained in E-waste can cause various diseases and disorders in the human body as well as are disastrous to the environment. For example, contamination of lead, mercury etc, from E-waste can cause skin disease, breathing problem, kidney ailment, high blood pressure, hormone related disorder, asthma, TB, complications with lunge and even may cause cancer. Again, lithium which is widely used in mobile phone and Laptop battery can not only create disease such as heart problem, weakness, weight loss, and eyesight problem but also can diminish the fertility of soil. Apart from these, harmful chemicals from e-waste can also seep into water bodies leading destruction to fish and aquatic resources.

This study performs a test to identify presence of toxic metals and the severity of their quantity present in both soil and water. For this purpose, sample from Buriganga near Islambag was collected. Then samples were prepared before performing heavy metal test.

3.4 Sample Collection and Test Result

Water and soil samples were collected from nearby places where waste plastics are recycled and tests for heavy metals were conducted in laboratory. Sample preparation procedure is given below.

3.5 Water Sample Preparation

Take 250ml of water in a beaker. Mix 7.5ml of HCl and 2.5ml of HNO_3 with it. Heat it in a water bath until the sample volume comes down to less than 25ml. Cool it and make the sample volume to 25ml with distilled water. After that filter the test sample and keep it in a beaker.

3.6 Soil Sample Preparation

Take 20-25 ml of soil sample in an aluminium pot and heat it in oven at 105^0 for 24 hours. After the heating is done, take 5g of sample and mix 7.5ml of HCl and 2.5ml HNO_3 with it. Keep it for 24 hours. After that, boil it for 2.5 hours in a volumetric flask with 300-350 ml of distilled water. Cool it down and add distilled water to make the volume upto 500 ml. Filter the sample and it is ready for metal test.

Laboratory test has been done on Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Mercury (Hg), Arsenic (As) and Iron (Fe). These are very toxic in case of exposure to health and environment. The resulting values are shown in table 2. Also a comparison between various standard values is presented in table 3. (Gebrekidan and Samuel 2011)

Table 2: Laboratory Test Result for Metal Test

Name of Metals Tested	Water in ppm (parts per million)	Water in µg/L	Soil (mg/kg)
Lead (Pb)	0.063	63	2.684
Cadmium (Cd)	0.00	0	0.02
Chromium (Cr)	0.015	15	0.559
Nickel (Ni)	0.013	13	0.649
Mercury (Hg)	0.00048	0.48	0.00284
Arsenic (As)	0.00085	0.85	0.0635
Iron (Fe)	3	3000	300

Table 3: Comparison between Different Standard Values and Toxic Metals Test Values of Water Sample

Heavy Metals	Test sample (µg/L)	USEPA standard (µg/L)	WHO standard (µg/L)	EU standard (µg/L)	Bangladesh standard (µg/L)
Lead (Pb)	63	15	10	10	50
Cadmium (Cd)	0	5	3	5	5
Chromium (Cr)	15	100	50	50	50
Nickel (Ni)	13	100	70	20	100
Mercury (Hg)	0.48	N/A	6	N/A	1
Arsenic (As)	0.85	10	10	10	50
Iron (Fe)	3000	300	N/A	200	300-1000

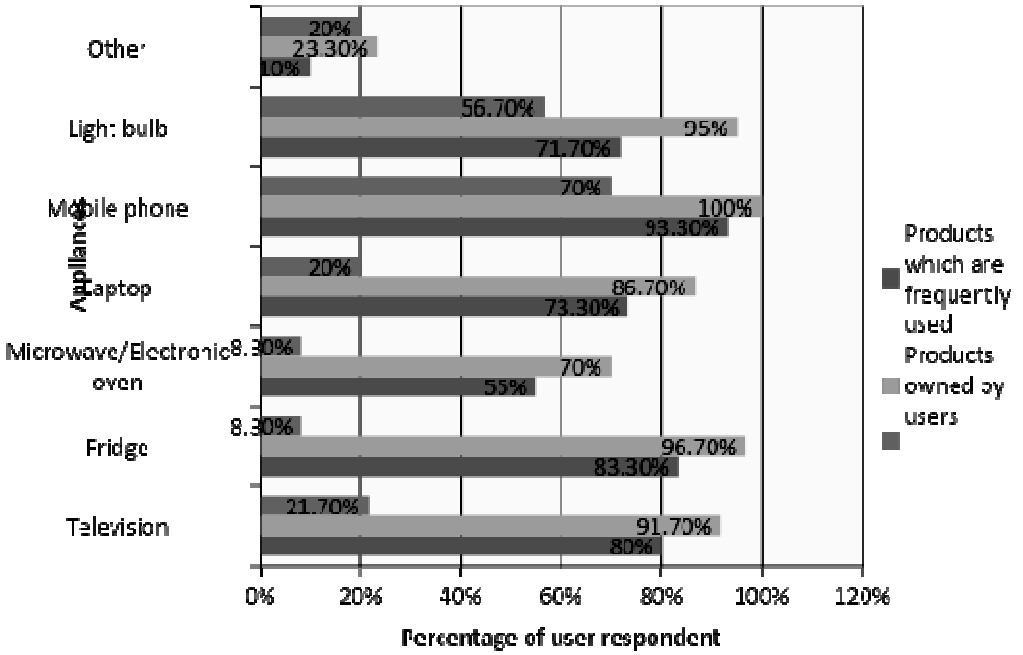
3.7 Awareness Level among Product Users

An online questionnaire survey has been conducted on electrical and electronic (EE) product users. Response of 60 persons has been recorded. According to the survey the following conclusions can be made.

- The study reveals that of the 60 respondents 63.3% are male and the rest 36.7% are female.

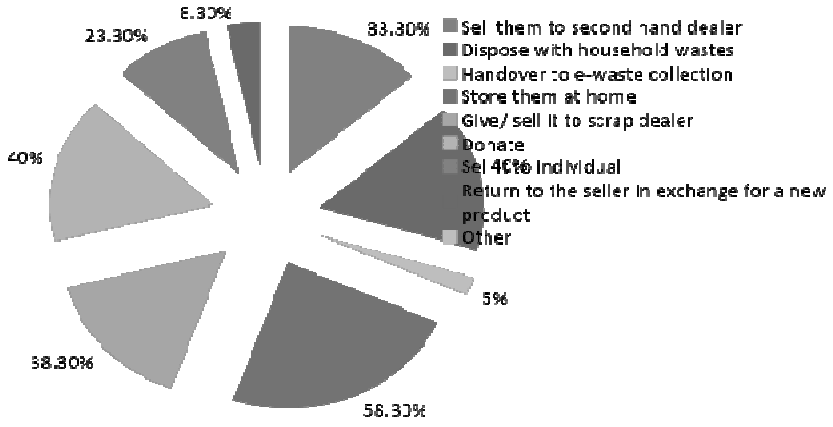
- Average number of members per family is found to be near 4.5.
- Respondent location are found to be all over Dhaka city including Dhanmondi, Mogbazar, Shantibag, Khilgaon, Motijheel, Jurain, Uttara, Siddheswari, Kamalapur, Poribag, Farmgate, Tikatuli, Rampura, Mohammadpur, Pallabi, Paltan, Khilkhet, Mirpur, Modhubag, Kalabagan, Kathalbagan, Adabor, Azimpur and Lalmatia.
- Survey included queries including the products possessed by users, frequently used products and the waste products in their possession. A bar chart is presented (Figure 3) to show a comparison among these. For example, from chart we can see that 100% users have mobile phone in their possession and it is frequently used by 93.3% of 60 respondents, while 70% says they have wasted phones at home.
- 61.7% of them are aware of the environmental impacts of discarded gadgets.
- 73.3% of them are aware of the presence of harmful chemicals in e-wastes.

Figure 3: Comparison among Product Possession, Product Usage and Number of WEEE



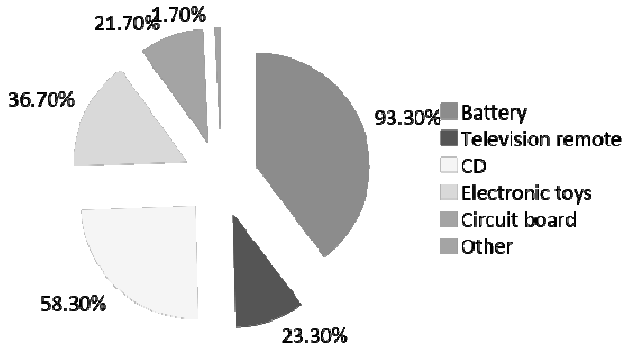
- 78.3% are aware of the fact that these toxic chemicals may cause harmful impacts on human health.
- Only 16.7% of them know about e-waste recycling initiatives around the country.
- While 45.7% are willing to pay for any type of waste management practices, 18.3% are not. The rest are not sure of it.
- Respondents use different methods to dispose of their EE products which include selling to second hand dealers, disposing with household wastes, handover to e-waste collector, storing at home, donating to others, selling to scrap dealers etc. The following pie chart (Figure 4) shows the percentage of people using different methods.

Figure 4: A Pie Chart Showing the Percentage of Users Adopting Different Methods for E-Waste Disposal



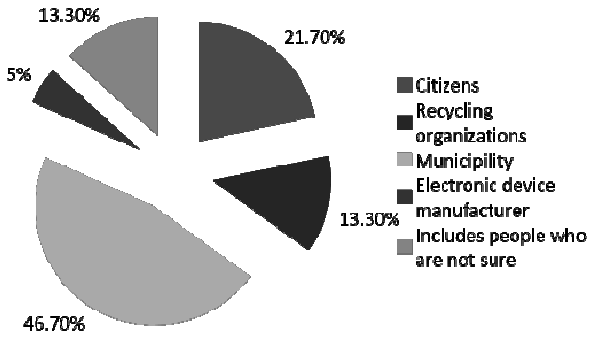
- Batteries, CDs, electronic toys, TV remote and circuit boards are disposed along with household wastes often. Figure 5 shows percentage of respondents that do the same with these products.

Figure 5: A Pie Chart Showing Percentages of People Disposing Specific E-Wastes along with Household Wastes



- Majority of the portion of people think that the financial responsibility for e-waste management should be adopted by municipality. From Figure 6 we can see that 46.7% of respondents think municipality should take e-waste management responsibility first of all.

Figure 6: A Pie Chart Showing the Percentages of People's Responses on Financial Responsibility for E-Waste Management Issue



- Proper management of e-waste is a huge task for any individual. So proper integration of efforts provided by government, people and recycling companies must be ensured. Moreover government rules and regulations about this should be imposed strictly.
- Specialized facilities such as e-waste recycling factories can be constructed which will be dealing with e-wastes in particular. Collection, transferring to facilities, segregation, recycling and selling to users all should be maintained by these facilities.
- Awareness can be raised through television advertisement & social networking sites. Several years ago, a separate bin was provided to each home from government to collect electronic waste. But no measure was taken to continue the program. If it is implemented and maintained a lot of efforts to handle these wastes can be saved.
- Manufacturer should enlist a method in their products to recycle them.
- Awareness seminars can be conducted to create consciousness among people about their reuse.
- A dedicated street-team could be possible. Voluntary work by interested individuals like school children, college/university students in a form of monthly campaign could be very much beneficial in this matter.
- A particular place should be provided for e-waste disposal.

3.8 Authorized Recycler in Bangladesh

Azizu Trading Co., Bangladeshi's largest licensed & authorized electronic waste recycler started operations since 2008, is engaged in handling, recycling and reusing of WEEE in friendly way. The initiative is to aim at reducing the accumulation of used and discarded electronic and electrical equipments, which most end up in landfills or partly recycled in unhygienic conditions by backyard recyclers and then partly thrown into waste streams damaging the environment. The objective of Azizu is to create an opportunity to transfer waste into socially and industrially beneficial raw materials like valuable metals, plastics and glass using simple, cost efficient, home grown, environmental friendly technologies suitable to conditions for south Asian regions. Materials collected from e-waste for processing by this company includes metal, glass, mercury, batteries, printed circuit boards (PCBs), hard drives, CD ROMs etc.

4. Results and Discussion

According to the survey 73.3% of the respondents are aware of the presence of harmful chemicals in e-wastes. 61.7% are aware of environmental impacts and 78.3% are aware of human health impacts. Test results of heavy metal content of water samples collected shows the existence of large amount of Iron and Lead due to washing off plastic materials with Buriganga River water. The presence of toxic metals in soil sample is not much significant.

5. Conclusion

While handling, breaking, melting of e-waste and performing cleaning process, a large portion of water body is affected thus creating environmental pollution. The portion of people handling e-waste manually, is at serious health risk. As they do not take any precautions while performing all manual labors such as dealing with toxic wastes in bare hand, performing shredding operation without goggles etc, they might face any type of health hazards. There are certain limitations of this research findings. Though it is difficult to say that the value of those parameters found in laboratory test is only due to the presence of the pollutants from e-waste, it is certain that e-waste do play a significant role in deteriorating river water quality. Exposure to such contaminated water poses health risk. Also it is to be added that a rough calculation of e-product generation is shown which does not represent value from any real survey of population or products rather represents assumed value.

Further recommendation for future study is considered as below:

- Number of establishment of e-waste collection facilities or factories can be considered.
- Water sample can be collected from both upstream and downstream point of water bodies to determine the extent of hazardous element flow.
- Since there is a possibility of Bangladesh to be used as a dumping site by developed countries, the statistics of imported or used or donated electronic products legally or illegally is important.
- Number of electronic products used by mass people as well as their demand has to be calculated in an accurate way. For this further research can be done to develop an effective way.
- E-waste policy development may require a more customized approach where instead of addressing e-waste in isolation it should be addressed as part of the national developed agendas.

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