A Potential Electrical and Electronic Debris Management Model and Ecological Impact and Awareness Issues in Bangladesh

M. U. Kabir[1], M A Sobhan[2], M. K. A. Khan[3], and M A K Rouf[4]

Abstract

People's life are made easy of ICT advancement, however, unknown to this comes with a silver lining of production of electronic cast-off from electrical and electronic equipment. Accumulating growing amount of electronic debris of our own domestic sources and overseas import has been our scientific community's a main concern nowadays. In the early 1980s, first introduced abandoned productions from mobile phones and computers were foreign issues owing to inaccessibility of electrical and electronic equipment (EEE). Nonetheless, enormously growth in the city inhabitants and the relatively decline in years of electronic device lifetime, number of electronic outcast generating in Bangladesh has arrived at an amazing amount. Practices of inappropriate disposal are affecting our health and the potential ecological problems. In this paper the authors attempt to shed light to the raising trouble of electronic cast-off management and the diverse possibilities mentioned and proposed a potential model of Electronic Cast-off management for Bangladesh that can be functional to a conundrum that is sharply turning out to be a national level concern.

Keywords*:* Electronic Debris, EEE, Pollution, Recycling, WEEE

Introduction

Electronic waste comprises a large and increasing array of electronic equipments ranging from wide household appliances, such as stereo systems, mobile phones, refrigerators, air-conditioners, discarded computers consumable electronic items and so forth. Due to our lifestyle there is an increasing acknowledgement of our impact on the ambience, while the requirement of adoption a more sustainable approach relating to our using habits appears as of particular significance. Affecting industrial sectors, this trend regards the utilization practice and, in particular, electronic industry where the little life cycles and the speedily developing technology have led to increase electronic cast-off volumes. Electronic debris is frequently misinterpreted as allied to old computers or IT appliances in general, while the same term Waste of Electrical and Electronic Equipment (WEEE) is also utilized in the international literature. Chemically and physically electronic wastes are differed from urban or industrial waste. It both valuable material and perilous requiring special recycling practices and treatment to avoid adverse ecological impact and perilous impact on human health contains. Recovering the important and base metals is possible by recycling electronic cast-off, but the huge labour price and the firm

[1] *DPP, Ministry of Public Administration; American World University, USA,* kabiruddin@gmail.com
[2] *Prime University, Mirpur-1, Dhaka, Bangladesh,* sobhan30@gmail.com
[3] *Jagannath University,* kakhan01@yahoo.com
[4] *DoE, Ministry of Environment and Forest, Bangladesh,* arkhan_milon@yahoo.com

ecological legislation have consolidate these activities implementation mostly in Asian countries such as Bangladesh, Pakistan, India, and China by use of obsolete methods and inadequate emphasis on the employees' protection. As a result, the electronic cast-off removal matter has concerned the attention of government as well as autonomous organizations. The greater parts of electronic outcast elements are led to landfills. Their partial recyclability, owing to their material composition together with the obligatory limits in landfills, has led to the growth of recovery techniques for their recycling and reuse, highlighting the importance of electronic outcast recycling, not only from a waste managing aspect but also from an expensive materials' retrieval aspect.

Research Methodology

The nature of this research is explorative, focussing on perplexity social actions in order to understand awareness levels of electronic waste practices. A purposive selection procedure was applied to identify 15 interviewees; the maximum number could be covered, considering time and resources available for this study. The organizations in the ICT sectors, environmentalist, teachers, students and appliances repairing shops were selected on the basis of how long they had been in operation to get some diversity among this small number of interviewees. This study used both primary and secondary data sources to accomplish the research work. In order to have an idea about the current status of electrical and electronic cast-off recycling systems in European and Asian countries in the informal sector, existing literature were reviewed. The authors surveyed two shops at each spot and closely observed rest of the shops to infer on the entire spot.

Results and Discussion

In view of a study, more than 500 thousand computers were in use in 2004 and this number has been dramatically growing at 11.4 percent yearly. Considering the mentioned figure as the base line the PCs contain approximately 20,323 tons of waste in 2014 contains deadly plastics, Pb, mercury and so on. And approximately 50,000 children were involved in the informal electrical and electronic waste collection and recycling process which is awful for the health as well as ecological system. Any ecological benefits of recycling are more than offset if the waste has to be transported long distances due to the negative ambience effects of fossil fuel combustion. However, recycling always has a lower ecological impact than landfilling of incinerated electrical and electronic debris. In Dhaka the areas with the most concentrated disposal and storage of electrical and electronic abandon are in Islampur, Kamrangirchar, Gingira, Mirpur and Mohammadpur. At present, there are no proper electronic abandon management guidelines or regulations in Bangladesh. All the informal recycling systems are being carried out and the process of recycling has the potential to be perilous to the recycler's health and ambience. Also due to their lack of knowledge, the recovery yield of the precious metals is very poor and, thereby, substantial percentage of metals like copper, gold, silver, and other precious metals (palladium, tantalum, platinum etc) are lost. So this process is also unable to provide sufficient support to economy of Bangladesh. The authors recommended a model for recycling of electrical debris in Figure 02, which may ensure proper collection and recycling of its various parts. It would also be favourable for health, ambience, and economy.

The primary data as of questionaries survey rich in our aftermath to get destination of 3:3 matrix of objectives and variables. Electrical debris impact awareness is poor to general people. A few environmentalists anxious of ecological system for-

i. Optical fibres included cabling of Fluorine (F), Zirconium (Zr), Yttrium (Y), Lead (Pb) but exclusion of Copper (Cu),
ii. LCD screens replaced instead of CRT screens where Pb deduction but Hg attendance,
iii. Rechargeable batteries reduce Nickel (Ni), Cadmium (Cd) but increase Lithium (Li) as well.

The organizations of non-governmental and the movements of the citizens press for the abolition of perilous substances in electronic machines, resulting to manufactures competing for a more 'green' profile. Some indicative results are-

i. Bromide combustion replacement retarders with more friendly ambience ones based on phosphorus (P),
ii. Legislative restrictions of the Restriction of Hazards Substances (RoHS) directive on perilous substances are Mercury (Hg), Palladium (Pb), Chromium VI (Cr), Cadmium (Cd), Polybrominated Diphenyl Ethers (PBDE) and Polybrominated Biphenyl (PBBs) up to 1000 mg/kg
iii. "halogen-free" appliances production, not contribution to the fabrication of Printed Circuit Boards (PCBs) and dioxins (contain carbon, hydrogen, oxygen, and chlorine, Polychlorinated Biphenyls (PCBs)), but their production is more expensive environmentally.

Additionally, the production of electronic debris is expected to increase owing to financial growth and the on hand technologies since the growing GDP leads to increase buying of electronic appliances and eventually increased electronic cast-off product. For instance, the figure of PCs for every country is linked to the country's GDP. It is anticipated increasing economic growth to reflect higher electronic debris production. On the contrary, predictable that particular modifications in the technology and the consumption practices are expected to reduce electrical debris production, since customers may favour more portable PC solutions having 1-3 kg in an average weight compared to the stationary computer weighting 25 kg or the stationary computers are expected to be prepared with Liquid Crystal Display (LCD) screens in preference to the older Cathode Ray Tube (CRTs).

The Productions of Electronic Cast-Off

Production of the global electronic outcast is measured at 30-60 Mt/year equivalents to 2-4% of the probable global urban outcast production (2036 Mt). TVs, cell phones and PCs will add 16.5 Mt in 2016 and will sum to 22.8 Mt in 2020. In wealthier countries, electronic abandoned will stand for 18% of the urban outcast amount. Participation of each electronic items in the yearly electronic cast-off production, E (kg/year), figures on the item of electronic average mass, M (kg), its amount in the market and utilization, N, and its average life time, L (year).

$$E = \frac{MN}{L} \text{ ----- (1)}$$

In an average Electronic Computers life time 3-year contribute to a greater extent compared to the total electronic cast-off flow to electrical cook-stoves and refrigerators, getting in an average life time of 10-12 years.

Table 1: *Estimated Electronic Debris Lifespan*

SL	Items	Mass of Items (kg)	Estimated Life Time (Years)
1.	Washing machine	65	8
2.	Electric cooker	60	10
3.	Photocopier	60	8
4.	Air-conditioner	55	12
5.	Dish washer	50	10
6.	Freezer	35	10
7.	Refrigerator	35	10
8.	Tumble dryer	35	10
9.	Television (TV)	30	5
10.	Personal Computer (PC)	25	3
11.	Micro-oven	15	7
12.	Vacuum cleaner	10	10
13.	High-fidelity system	10	10
14.	Video recorder/DVD player	5	5
15.	Electronic games	3	5
16.	Fax machine	3	5
17.	Radio	2	10
18.	Food mixer	1	5
19.	Hair-dryer	1	10
20.	Iron	1	10
21.	Kettle	1	3
22.	Telephone	1	5
23.	Toaster	1	5
24.	Cell phone	0.1	2

The electronic debris quantities, on the whole for the European Union enhance by 4-6% per year, which is three times faster than the city solid waste. The quantities produced in EU in the period of 1990-1999 were approximately 3.3-3.6 kg/resident, while estimated quantities during the 2000-2015 vary between 5.3-6.00 kg/resident. Having used the equation (1) Swiss is estimated to produce 10 kg per year per person, the European people 15 kg per year per person, with the sum EU fabrication amounting to 6.6 Mt/year. China produced 2.5 Mt in 2005, while USA produced approximately 2.6 Mt [1] considering poorer countries there are no available data in this regard, but it was assessed that India, Bangladesh, Pakistan and Thailand generated 0.3, 0.1, 0.1 and 0.2 Mt of electronic abandon in 2007. Based on the equation (1) another calculation, Table 01 and existing data for the total figure of PCs (0.78 billion units), TVs (1.4 billion units), Radios (2.5 billion units), Stationary phones (1.3 billion units), Cell phones (7 billion units), the total manufactured amounts to 12.7 Mt/year. Considering electronic waste production increasing dramatically and the fact that the comparatively enormous mass electrical and electronic devices (air-conditions, refrigerators and so forth) are not included in the aforementioned calculation, it

is expected that the total electronic cast-off amount will be had rather colossal. If approximately 20% of the global increase of GDP in the last 7 years is also regarded, then aforementioned estimate of 30-60 Mt/year is justified.

Potential Ecological Impacts and Problems Related To Electronic Debris

Chemical composition of Electronic outcasts confides on the class and the time of the discarded electronic items. It a number of metal alloys, especially Fe, Cu, and Al attached to, covered with or assorted with several plastics or ceramics is usually predominated. Some of them are used in the production of electronic stuffs such as heavy metals (Zn, Cr, Cu, Pd, Mn, Ni, Sb, Hg, Cd, Be, and As), while others, like Polycyclic Aromatic Hydrocarbons (PAHs) are produced by burning electronic outcast at low temperature. In open barrels combustion, the cable isolating plastic covers produce 100 times more dioxins than domestic debris.

In view of about 30 Mt/year electronic debris productions, the whole amount of the several contaminants hold in the electronic cast-off flow result, significantly, in landfills or recycling centres getting into the ambience or/and public health. For that reason, in spite of significant recycling, electronic cast-off is responsible for 5000 time Cu annually emitted to the milieu [2]. Polybrominated Diphenyl Ethers (PBDEs) are incineration retardants that lastly cause the surroundings and, provided that they are lipophilic amalgamates, are bio-accumulated in living organisms, while the refrigerators and air-conditioners discarded contain CFCs (chlorofluorocarbons) that will finally destroy the Ozone layer when, in the future, CFCs escape from the electronic cast-off dumping site. The perplexities of aforementioned raise larger considering the fact that the greater parts electronic outcast are not recycled, because several electrical and electronic substances are disposed together with household outcast and are subject to no further treatment. The collected quantity for recycling approximately is 80% result in their treatment in every loose ecological frameworks increasing impact on the milieu and the employees in the particular operations.

Electrical and Electronic Abandoned Disposal and Recycling System: Impact on Ecological and Health Issues

The majority electronic debris is led to (sanitary) landfill sites. In this case, the appropriate implementation of Toxicity Characteristic Leaching Procedure (TCLP) test has showed that discarded electronic cast-off at waste dumping of urban sites do not generate leachates with heavy metals concentrations beyond the ecological limits. Notwithstanding, this generated chemical cocktail as leachate using the TCLP assessment from several electronic substances was toxic for aquatic organisms. The general management practice, electronic cast-off compression before or during discarding in landfill may add to the leachate volumes owing to the disturbance of the several electronic circuit parts and, in view of that, it is proposed to do cement solidification on electronic abandoned that enhances P^H and reduces the aqueous solutions' flow in the outcast discarded. Before incineration, remove at landfill site increases heavy metals mobility held in circuits wrapped with a plastic grid and therefore, while not having been

bioavailable following wash-out, they are liberated to the ambience during combustion [3], Figure 01.

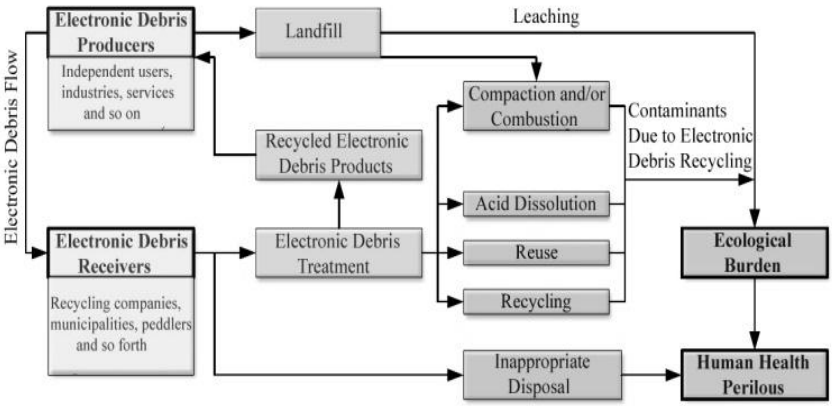

Figure 01: Disposal and Recycling System of Electronic Debris: Impact on Ecological and Health Issues

In contrast, electronic cast-off recycling comprises destroying and disassembling the individual parts to recover several materials. With the help of recycling, 95% useful materials of a computer and 45% materials of a cathode ray tubes can be retrieved. The methods of recycling have minimum ecological impact when the appropriate technology combining with the application, like as in Hong Kong, Taiwan, Japan, while, in contrast, when using the performs followed in developing countries (i.e. child labor, electronic debris burning and release of several contaminants to the atmosphere, leachate seepage in underground and surface aquifers and so forth) the final ecological benefit-impact equilibrium is not always optimistic. It must also be stressed out that any ecological advantage from recycling disappears when the outcast to be recycled is transported to long distance owing to the adverse ecological impact of the energy used for its haulage, while, recycling, besides, has smaller ecological footprint than outcast dumping and incineration.

Selected Countries Electronic Cast-Off Management Systems

A. Switzerland Electronic Debris Management

Regarding electronic debris management legislation through Ordinance on the Return, the Recovery and the Disposal of Electrical and Electronic Appliances (ORDEA) law, an official electronic waste management system where Switzerland was the maiden country in the world in 1998 was established and operated [4]. Two different recycling systems of electronic outcast are active in the country running by the (1) Swiss Association for Information, Communication and Organizational Technology (SWICO) Recycling Guarantee- manages the “brown” electronic equipment (i.e. computers, televisions, radios, and so on), and (2) Stiftung Entsorgung Schweiz System (S.EN.S)- manages the “white” electrical equipment (i.e. washing machines, refrigerators, ovens etc).

In a more convenient way, especially consumers return the electronic waste either through specified collection points of retail companies or carrying the debris directly to the recycling sports. The materials from the collection site as the particular points to the disassembly appliances in order to disassemble and sterilise electronic abandon by dismantling the most toxic factors are transported. Electronic outcast even more detailed disassembly, shredding and sorting, is resulting mostly to the collection of aluminum, copper, steel, glass and plastic pass through in the recycling facilities. The recycled materials of all or mostly then consigned to refineries or foundries for the last material recovery. The remaining materials that can not be recovered are led in incinerators for energy retrieve and a small amount, usually < 2%, consummations up to landfills. In 2004 in Switzerland approximately 75 Kt of electronic waste had been collected, classified, disassembled and then processed while approximately 68 Kt were in 2003.

It is obliged, in the Swiss system, retailers, importers and manufacturers to take back their electronic abandon free of cost and handle them in an "environmentally tolerable way". Producers of the waste, function and operation of the management system, are fully liable for the entire system is funded through a special recycling cost include in the product's price.

B. Electronic Outcast Management in Greece

For the period of 2003-2006 the average annual electronic cast-off production approximately came up to 80 Kt representing 3.9% of the entire amount of domestic solid waste. For the same period the 90% of electronic debris with other urban solid debris had been mixed or recycled with other materials (i.e. metal outcast) with no previous process, a management practice mentioned as "grey recycling". In order to deal both in 2004 with the developing problem of "grey recycling" and the growing amounts of electronic debris, the process of an authorized alternative electronic abandon management system started, having as main responsibilities the collection, haulage and process in special facilities. The system in the first year of operation collected approximately 0.1 Kilotons (Kt) in the year of 2005, 32.5 Kt and 48 Kt in 2008, and 2009 respectively, and 26 Kilotons in the first five months of 2009, overthrow the national target, as termed by the Greek legislation. These targets a separate collection of at least 5 kg per resident per year of electronic debris of domestic origin include 45 Kt/year for Greece in total. Nonetheless, the administration of discarded electronic outcasts is not happened in a systematic way, as a result collecting by street vendors and to their support to metal and alloy recovery units are uncontrolled.

C. Electronic Abandoned Management in Japan

Two laws, the Law for the Promotion of Effective Utilization of Resources (LPUR) and the Law for Recycling Specified Kinds of Home Appliances (LRHA), have been formulated to deal with electronic cast-off situation in Japan. Personal computers and small-sized batteries are covered with the LPUR while LHRA deals with air-conditions, washing machines, televisions, refrigerators, and clothes dryers. The manufacturers voluntarily facilitate electronic outcast recycling to deduct the production of waste on behalf of LPUR, while LRHA imposed more obligatory on the manufacturers and

consumers. Disposal of house appliances for the recycling and haulage cost will be carried out by the consumers. Manufacturers are accountable for ascertaining proper electronic debris recycling facilities and are requested to achieve mandatory recycling rates as 60% for refrigerators, 65% for washing machines, and 70% for air conditions. Manufacturers and importers are necessary to label their goods and provide information on mercury, chromium VI, lead, cadmium, PBDE and PBB. Aside from manufacturers, importers of the substances must be met the Design for Environment (DfE) criteria, which are essential for local manufacturers.

D. Electronic Outcast Management in India

India, one of the fastest developing industry sectors in the world, has a main issue owing to the production of local electronic waste as well as imported appliances. Indian's Central Contamination Control Board developed guidelines in 2005 for environmentally sound management of electronic outcast but not regulated practice as well. Nonetheless, as part of the ecological Production Act of India, the Ministry of Environment and Forest has enacted the "Electronic Waste Management and Handling Rule" of 2011 to mandate producers to be accountable for the anthology and financing the systems in line with an extended produced responsibility concept.

E. Electronic Debris Management in Pakistan

In Pakistan neither has inventory nor government regulation on formal mechanism to manage electronic waste at national level although the National Environment Policy has been formulated since 2005. The informal recycling sector is locally very active where open dumping and combustion of electronic outcast is common practice in Pakistan.

F. Electronic Waste Management in Thailand

Thailand suffers lack of general consciousness, ecological sound management practices and specific rules and regulations on electronic debris. In order to these facts the Thailand government enacted the National Strategic Plan on Integrated Management of WEEE in 2007.

A Proposed Electrical and Electronic Debris Management Model for Bangladesh

Bangladesh National Environmental Policy was adopted in 1992 whereas in 1995 and 2008 the Environmental Conservation Act and Medical Waste Management Rules were formulated consecutively. At present, dealing with electronic waste specifically regulations are in absence [5]. However, giving height priority Bangladesh Government is involved to prepare two rules regarding electrical and electronic waste management, (i) the Perilous Cast-off Management Rule, and (ii) the Solid Waste Management Rule which will contain the concern related to electronic debris. It is cautioned that most of the electronic outcast in Bangladesh is dumping in farming land, open water bodies and open landfills reasoning severe ecological and health impacts.

The government authority of Bangladesh needs to get a target regarding the prevention of ambience contamination for the exploitation of resources as well as the diminution of landfill exercise. The legislation should be developed by the government is depended on three ways, the prevention, recycling and re-use of electronic debris so that the sum of electrical and electronic equipment outcast is reduced. In two relative orders the below are elucidated-

(i) Government orders can the use of perilous substances introducing the necessity for change of substances reasoning the major ecological problems during the setting and recycling of the electrical and electronic equipment cast-off. In connection with this order, the most useful way to make sure the considerable reduction of health and ecological hazards relating to perilous materials is their substitute with other, safer substances. The limited of use of hazardous materials is most likely to raise the potential and the financial benefit from recycling electrical and electronic appliances.

(ii) Government order on electrical and electronic equipment outcast can develop particularly to assist in reducing the electronic waste available in the landfill and promote the more efficient utilize of resources by recycling and reuse. The accurate instruction measures for collection, management, retrieve and recycling of all classes of electrical and electronic goods and attentions on the Extended Producer Responsibility (EPR). The main points are:

a. The electronic cast-off should be collected separately from other structures of debris and their anthology should not burden households.

b. Producers are responsible for financing electronic waste collection and management.

c. The study and production of electronic cast-off should make easy the disassembly and retrieve for posterior utilize and recycling of electronic debris.

d. The aim price to incorporate in the management system is 5 kg per year per resident.

e. Ending of 2018 manufacturers should be able to recover and re-use a certain goal proportion for each of the ten categories of the directive ranging between 50-80%.

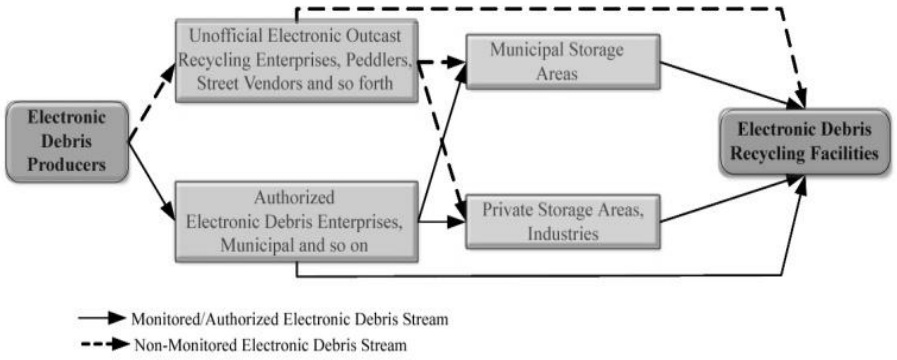

Figure 02: A Proposed Model of Electronic Debris Management for Bangladesh

Considering proposed model, Figure 02, electronic debris withdrawal system should not be free of cost, but consumers shell out an amount of money when they revert exhausted electronic goods to the traders. Electronic abandon recycling facilities should be partially financed by the ministries, municipalities or Bangladesh companies producing electronic products [6]. Producers implement in their trade strategy the electronic abandon administration and have their individual facilities or team up with other producers to generate and operate such facilities. The collected abandon will be haulaged to the intermediate 3380 electronic debris collection point and finally to the facilities in the course of a distribution system. A fundamental characteristic system is to use of the

primary disassemble procedure of large parts initially with a more precise and concise process so that they can handle the residues in a more appropriate approach.

Conclusions

Separation of electronic debris from the rest of solid cast-off and their recycling for valuable recovery raw materials and basic metals is indispensable [7]. According to the given electrical debris management model and the survey's aftermath, government has to be realistically so that the ecological benefits from the anthology, haulage, administration and the economic values from the retrieve are not set-off by the needed resources and energy utilizations for the system operation. In everywhere in our society electronic equipment and therefore electronic waste are characterized by a complex chemical composition and complexity in quantifying their trains at an international and local level. Receiving them for recycling and recovering of their important metals the toxic waste caused by their irregular management significantly degraded the ambience mostly in least developing countries like Bangladesh. As for the aftermaths on human health, ecosystem and ecological restoration of areas loaded by certain contaminationers created by electronic outcast, there are no adequately documented scientific studies. Aggravated by the minimization of ecological effects caused by the produced electronic outcast, abundant technological changings have been effectuated. To ensure better human health and safety of workers involving in the process of debris disposal, effective electronic cast-off recycling management system is needed which is sustainable. This study tried only to unfold a theoretical model for better electronic debris recycling process in Bangladesh. To investigate the possibilities of this model, a complete empirical study in necessary. This study will also prepare the platform for additional study and exploration of electronic debris recycling.

References

1. Elliot,S. 2007. "Environmentally Sustainable ICT: A Critical Topic for IS Research," in *Pacific Asia Conference on Information Systems*, pp. 99-112.
2. Sinha-Khetriwal,D.,Kraeuchi,P. and Widmer,R. 2009. "Producer responsibility for e-waste management: key issues for consideration—learning from the Swiss experience," *Journal of Environmental Management*, vol. 90, no. 1, pp. 153–165.
3. Brigden, K., Labunska, I., Santillo, D. and Allsopp, M. 2005. "Recycling of Electronic Waste in China and India: Workplace and Environmental Contamination", *Greenpeace International*, p 55.
4. Li, J., Duan, H. and Shi, P. 2011. "Heavy Metal Contamination of Surface Soil in Electronic Waste dismantling Area: Site Investigation and Source-Apportionment Analysis", *Waste Manage Res.* Volume 29, Issue 7, pp. 727–738.
5. Department of Environment (DoE).2015. www.doe.gov.bd, accessed on February 4.
6. Watson,R., Boudreau,M. and Chen,A. 2009. "Information System and Environmentally Sustainable Development: Energy Informatics and New Directions for the IS Community", *MIS Quarterly*, Vol. 34, No. 1, pp- 23-38.
7. Agamuthu, P. and Dennis, V. 2013. "Policy Trends of E-waste Management in A.7 6572 Asia" *Journal of Material Cycles and Waste Management*, 15:411-419.