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E-waste recycling practices in Bangladesh

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Abstract: The electrical and electronics industry is one of the world's fastest growing manufacturing sectors. As a result of this rise in production, as well as the increasing rate of product obsolescence, waste from electrical and electronic equipment, or e-waste, has become the fastest-growing waste stream in the (post-) industrialized world. Sustainable management for e-waste recycling is a concerning fact in bangladesh to lessen environment pollution and health problems, which are attracting growing public interest. This study helps to scrutiny the existing e-waste management process and introduces proposals for the sustainable management of e-waste products including the potentials of best possible recycling in the existing system. A structured questionnaire has been processed in dhaka and chittagong and existing literature were reviewed. Around 1,20,000 urban poor from the informal sector have been found to be involved in the e-waste recycling trade chain in dhaka city area where only children (under 10 year of age) accounted for approximately 50,000; amongst them about 40% were involved in ship breaking yards. Workers in the recycle shops were found to be less paid with monthly wages approximately bdt 3000 while a day labourer earns almost double approximately bdt 200 per day. The results of the study would provide us important insight into the growing concern of e-waste and would help us to gather input for designing policy measure to recycle e-wastes in a hazard-free manner.

Keywords: *E-Waste, Environmental Impacts, Health Impact, Hotspot, Recycling*

1. Introduction:

Rapid population growth with rapid discarded product due to the increased access of modern technology with increased purchasing power resulted the generation of electronic waste (e-waste).Also the production of electrical and electronic equipment is increasing worldwide and the life span of some of the equipment is very short. For example computers in the early 1980s were used on average for about ten years but their life span has since reduced to an average of about three years. Mobile phones too become outdated and are replaced on average after about two years (Bogue, 2001). As a consequence of the increasing market expansion in electrical and electronic equipments and their short life span, the waste stream of these products, commonly called "e-waste", is fast growing. This is a significant problem that e-waste contain different toxic materials which are hazardous, and are consequently a threat to the environment and to the human health (Sinha *et al.*, 2007). More than 1,000 hazardous and non-hazardous components like ferrous material (38%), non-ferrous material (28%), plastic (19%), glass (4%) and others (including wood, rubber, ceramic) (11%) contain in the electric and electronic waste (Wath *et al.*, 2011). Some heavy metals like lead, mercury, cadmium, chromium (VI), halogenated constituents (e.g., CFCs), polychlorinated biphenyls, brominated flame retardants (BFRs) can also be found as a substance in those compounds. All these may react as catalyst for the formation of dioxins (DEFRA, 2004) and in turn act as a harmful ingredient for both environment and human health (Wath *et al.*, 2011). According to BEMMA (Bangladesh Electric Manufacturer and Merchandiser Association); Bangladesh consumes around 3.2 million tones of electronic products each year (ESDO, 2010). Of this amount, only 20 to 30 percent each recycled and the rest is released in to landfills, rivers, ponds, drains, lakes, channels and open spaces which are very hazardous. Presently, there is no specific law or ordinance for e-waste management and recycling in Bangladesh. Also there is no formal plant to recycle e-waste in a hazard-free manner. Most of these electronic products are recycled by the informal sector located mainly in Dhaka and Chittagong (Ahmed, 2010). When handled improperly, e-waste presents significant human health and environmental risks due to the toxicity of materials used in many electronic products (Environment Canada, 2004; Dayaneni & Doucette, 2005; Leung *et al.*, 2006 ; Huo *et al.*, 2007; Wong *et al.*, 2007; Fu *et al.*, 2008).

The lack of available information regarding the handling of the expired electronics appliances and improper monitoring system relating to dumping does not raise the human health issue only. It can also contaminate the agricultural soil contents with the reduction of annual crop production or can deteriorate the surface and subsurface water ways. Atmospheric pollution due to burning and dismantling activities seems to be the main cause of occupational and secondary exposure (Sepúlveda, 2010). Informal sector e-waste activities are also a

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crucial source of environment-to food-chain contamination, as contaminants may accumulate in agricultural lands and be available for uptake by grazing livestock. In addition, most chemicals of concern have a slow metabolic rate in animals, and may bio accumulate in tissues and be excreted in edible products such as eggs and milk. E-waste-related toxic effects can be exacerbated throughout a person's lifetime and across generations (Frazzoli *et al.*, 2010).

As electronic products become increasingly part of our daily lives and of our waste stream, it is important to consider the potential health risks associated with the materials contained in these products. The following are some of the potentially hazardous materials contained in various electronic products or associated either with electronics manufacturing or e-waste processing. Antimony (found in CRTs, printed circuit boards, etc.) is very hazardous in event of ingestion, hazardous in event of skin and eye contact, and inhalation. It also causes damage to the blood, kidneys, lungs nervous system, liver and mucous membranes (MSDS, 2005). Soluble inorganic arsenic (for making transistors) is acutely toxic and intake of inorganic arsenic over a long period can lead to chronic arsenic poisoning. Effects, which can take years to develop, include skin lesions, peripheral neuropathy, gastro- intestinal symptoms, diabetes, renal system effects, cardiovascular disease and cancer (WHO, 2010a). Short-term exposure of barium (found in front panel of CRTs) causes muscle weakness and damage to heart, liver and spleen. It also produces brain swelling after short exposure (Osuagwu & Ikerionwu, 2010). Cadmium (found in Chip resistors and semiconductors) has toxic, irreversible effects on human health and accumulates in kidney and liver (op. cit.). Has toxic effects on the kidney, the skeletal system and the respiratory system, and is classified as a human carcinogen (WHO, 2010b). Chlorofluorocarbon, CFCs (found in older fridges and coolers) destroy the ozone layer and is a potent greenhouse gas. Direct exposure can cause unconsciousness, shortness of breath and irregular heartbeat. Can also cause confusion, drowsiness, coughing, sore throat, difficulty in breathing, and eye redness and pain. Direct skin contact with some types of CFCs can cause frostbite or dry skin (USNLM, 2011). Cobalt (found in Rechargeable batteries and coatings for hard disk drives) is hazardous in case of inhalation and ingestion, and is an irritant of the skin. Has carcinogenic effects and is toxic to lungs. Repeated or prolonged exposure can produce target organs damage (MSDS, 2005). Copper (in conductor) is very hazardous in case of ingestion, in contact with the eyes and when inhaled. An irritant of the skin and toxic to lungs and mucous membranes. Repeated or prolonged exposure can produce target organs damage (MSDS, 2005). Lead (found in solder of printed circuit boards, glass panels and gaskets in computer monitors) causes damage to central and peripheral nervous systems, blood systems and kidneys, and affects the brain development of children (Osuagwu & Ikerionwu, 2010). A cumulative toxicant that affects multiple body systems, including the neurological, hematological, gastrointestinal, cardio vascular and renal systems (WHO, 2010c). Elemental and methyl-mercury (found in relays, switches and printed circuit boards) are toxic to the central and peripheral nervous system. Inhalation of mercury vapour can produce harmful effects on the nervous, digestive and immune systems, lungs and kidneys, and may be fatal. The inorganic salts of mercury are corrosive to the skin, eyes and gastrointestinal tract, and may induce kidney toxicity if ingested (WHO, 2007). Nickel (found in rechargeable batteries) is slightly hazardous in case of skin contact, ingestion and inhalation. May be toxic to kidneys, lungs, liver and upper respiratory tract. Also has a carcinogenic effect (MSDS, 2005). This study aims at preparing a comprehensive inventory of the level of e-waste management practice in the perspective of large cities in Bangladesh and finally a general physical model was proposed in consultation with the relevant stakeholders for its long-term sustainability.

2. Methodology:

Recycling is clearly a waste-management strategy, but it can also be seen as one current example of implementing the concept of industrial ecology, whereas in a natural ecosystem there are no wastes but only products (Frosch & Gallopoulos, 1989; McDonough & Braungart, 2002). Some of the major stakeholders in the life cycle of e-waste include producers/manufacturers, retailers (businesses/government/others), consumers (individual households/businesses/government/others), traders, exporters and importers, scrap dealers, disassemblers/dismantlers, smelters and recyclers (UNEP, DTIE, 2007). The recyclers are often specialized in recovering specific materials. The e-waste recycling sector in developing countries is largely unregulated and the process of recovering valuable materials takes place in small workshops using simple recycling methods. The practices used in developing countries often exacerbate pollution by creating hazardous chemicals and additional pollution.

This study used both primary and secondary information sources. In order to have an idea about the current status of e-waste recycling in the informal sector, existing literature were reviewed. In addition to this a primary survey has been conducted in Dhaka and Chittagong (Figure 1) with structured questionnaires to collect information from recycles shop owners and workers regarding the recycling process. However the scope of the study was limited to Dhaka and Chittagong. The interviewers surveyed two shops at each spot and closely observed rest of

the shops to infer on the entire spot. Although no definite official data exist on how much waste is generated in Bangladesh or how much is disposed of, there are estimations based on independent studies conducted by the NGOs or government agencies.

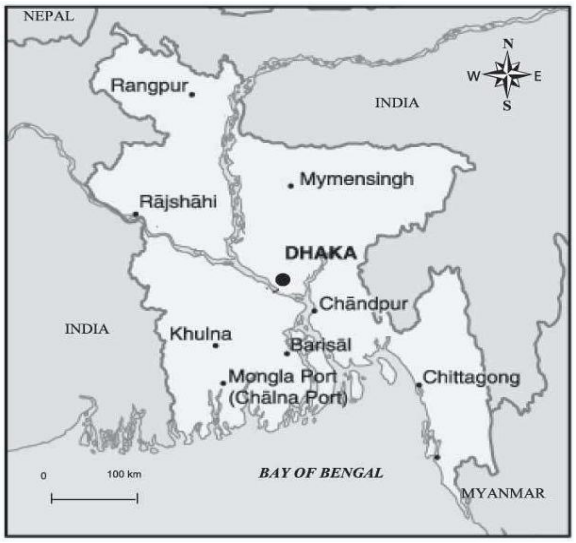
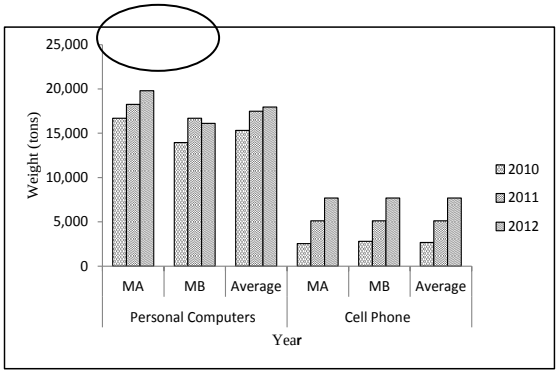


Figure 1: Location of the Survey area

3. Results and discussion:

3.1 Quantity of E-Waste :

According to an estimate, more than 500 thousand computers were in use in 2004 and this number has been growing at 11.4 percent annually (Hossain, 2004). Even if the figure of 500 thousand were taken as the base line, that many PCs would contain approximately 15,323tonnes of waste (@ 27.2 kg/PC for 5 year obsolescence) in 2010 contains deadly plastics, lead, mercury etc. The quantity of e-waste (PC and Cell phone) to be generated has been estimated by following two methods suggested in (Sinha et al., 2007). The first method, Market Supply Method A (MA) assumes that the average life time of an electronic product is approximately five years and after that these are discarded and come to the waste stream. The second method, Market Supply Method B (MB) assumes that all the products are not disposed at the same time, rather they are disposed in varying quantities over successive years. Here weighted average method is used to show the product disposal trend. For PCs the growth rate is considered to be 11.4 percent (Hossain, 2004) and for cell phones a 100% growth rate is considered annually (Pervez et al., 2007). The quantity of e-waste to be generated from these two types of electronic products is shown in Figure 2. According to 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 (ESDO, 2012).



(Source: Ahmed, 2011)

Figure 2: Estimation of PC and Cell Phone Waste in Dhaka City Area

Note: 1.Weight of PCs is derived 27.2 kg/PC
2. Weight of Cell Phones derived 0.079 kg/Cell Phone

Deriving date from all sources, we estimate that e-waste generated in Bangladesh each year can be summarized like this (Table 1):

Table 1: Generated E-Waste from individual sectors per year in Bangladesh

Source of E-Waste	Estimated E-Waste
Ship Breaking Yards	2.5 million metric ton/yr (2500000 metric ton/yr)
Television Sets	0.182 million metric ton/yr (181896 metric ton/yr)
Computers	0.0084 million metric ton/yr (25244.24 metric ton/30yrs)
Mobile Phones	0.0006 million metric ton/yr (6233.04 metric ton/10yrs)
CFL Bulbs	0.0001 million metric ton/yr (566.90 metric ton/6yrs)
Mercury Bulbs	0.0018 million metric ton/yr (1861.32 metric ton/10yrs)
Thermometers	0.0002 million metric ton/yr (8513.59 metric ton/50yrs)
Other Medical & Dental Waste.	0.009 million metric ton/yr (93478.25 metric ton/10yrs)
Total	2.702 million metric tons/yr

(Source: ESDO, 2012)

3.2 E-waste Recycling Areas:

E-waste recycling involves the disassembly and destruction of the equipment to recover new materials (Cui and Zhang, 2008). Recycling can recover 95% of the useful materials from a computer and 45% of materials from cathode ray tube monitors (Ladou and Lovegrove, 2008). Modern techniques can recover high-Pb glass from discarded CRT with minimal environmental impact (Andreola *et al.,* 2007). Any ecological benefits of recycling are more than offset if the waste has to be transported long distances due to the negative environmental effects of fossil fuel combustion (Barba-Gutierrez *et al.,* 2008). However, recycling always has a lower ecological impact than landfilling of incinerated E-waste (Hischier *et al.,* 2005).



Figure 3: E-Waste Recycling in Dhaka



Figure 4: E-Waste Recycling in Chittagong

There are different areas in Dhaka & Chittagong city (Figures 3& 4) that handles second hand electronic products. Among them following are the key areas dealing with e- waste recycling. In Dhaka the areas with the most concentrated disposal and storage of e - waste are in Islampur, Kamrangirchar, Gingira, Mirpur and Mohammadpur (ESDO, 2010). Nimtali, in chankhar pool, is the largest computer vangari spot in Dhaka. There are few Vangari spots in other places beside Nimtali of Dhaka thes are DolaiKhal, Elephant road, Kazipara, Shewrapara, Gulshan 1, 2. There are different areas in Chittagong that handles second hand electronic products. Among them following are the key areas dealing with e-waste recycling: CDA market, Coxy market, Ice Factory Road, Vatiary, Kadamtali (Ahmed, 2011).

3.3 Hotspot Characteristics:

Most of the shops in different recycling markets of Dhaka opened during the last 3-4 years and they are handling mainly PC and related materials. Thus PC is the main source of e-waste in Dhaka. The main source of e-waste in Chittagong is the ship breakage industry. Almost 95% of the e-waste generated in Chittagong is from this particular sector. Thus it can be commented that, without this particular ship breakage industry, Chittagong would have been less burdened with toxic e-waste problem. Workers in the recycle shops in Dhaka are receiving monthly wages of approximately BDT 3000 working for 8-12 hours daily. This is lower than the wages earned by day laborers. Thus the recycle workers are getting less payment for hazardous job. The survey on the recycle shop workers revealed that, on an average they earn BDT 3000 monthly working 12 hours a day. Compared to other professions, the workers engaged in e-waste recycling are getting lower wages. A day labourer in this city earns minimum BDT 200 for working 8 to 9 hours a day. Hence recycling as a profession is less financially rewarding in spite of being hazardous. Most of these shops in Dhaka are using pliers, hammer, chisel, screwdriver as a tool to break those things. From most of the items they could not recover important parts which they could have if used modern technology. This inefficiency is resulting into higher quantity of wastage and scraps. Although the recycle shop owners in Chittagong commented during the survey that, they employ skilled people to recycle the electronic products. However, the discharging of scraps up to 50% of the purchased quantity suggests that, their recycling process is elementary and less efficient. They have reported only the use of hammers, screw-drivers and chisels in recycling, which indicates their low level of operational efficiency. Workers and the owners in both cities do not think that recycling electronic products are hazardous. The lack of visibility of toxic material contained in e-waste by naked eyes making them believes that these are toxic free. There is huge knowledge gap among the shop owners and workers. The owners of the recycling shops in Chittagong are selling their electronic products at 20 to 100 percent markup. Thus the shop owners are extracting a higher profit margin. Also their net gain becomes even higher because of the opportunity to get at a cheap rate. From survey, in Dhaka PC parts like mother boards are exported to China and India. After repairing these are again imported in Bangladesh. There are illegal import and export channels of e-products in Bangladesh. During the survey most of the shop owners reported that they are in the business for 3 to 4 years. Thus the growth of this e-product recycling is relatively new in Dhaka (Ahmed, 2011).

3.4 Recycling Flow:

The recycling flow of the informal sector in Dhaka & Chittagong is shown in Figures 5 & 6. Vangari shops buy pc form various organization through auction. They also buy from hawkers, personal users, retail shops (old parts) and internal buying among the vangari shops.

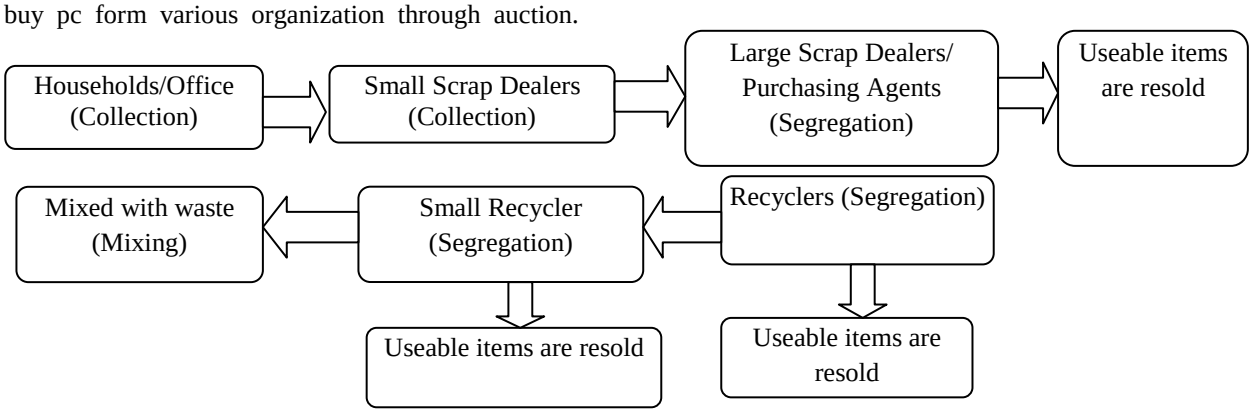


Figure 5: Informal sector recycling process in Dhaka (Ahmed, 2011)

According to the shop owners there are 200-250 purchasing agents of these types of products who bring pc parts as wastage to them. After purchasing a waste product they first run a check to see whether the product is functioning or not. If the product is functioning then they sell it to a purchaser who looks for second hand parts. Otherwise they break the product into pieces to separate iron, lead, copper, silver, plastic etc. and sell this to a purchaser of this thinks. They disassemble these products without any protection which can be injurious to their health and surrounding environment.

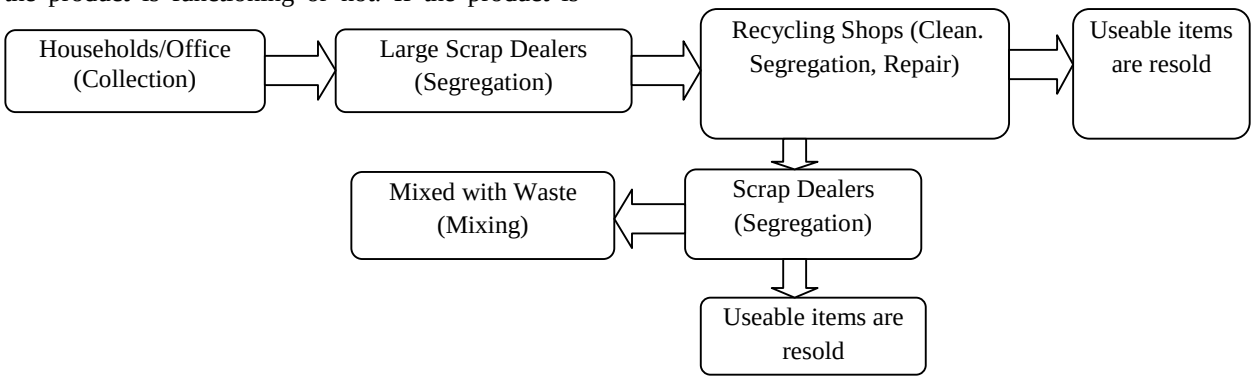


Figure 6: Informal sector recycling process in Chittagong (Ahmed, 2011)

It is estimated that 120,000 urban poor from the informal sector are involved in the recycling trade chain in Dhaka city. 15% of the total waste generated in Dhaka (mainly inorganic) equates to 475 tons recycled daily. Of this amount, only 20% to 35% is recycled, while the remainder is disposed of in landfills, rivers, ponds, drains, lakes and open spaces (ESDO 2010).

4. Proposed model for Bangladesh:

Currently, there are no proper waste management guidelines or regulations in place. Reuse of e-equipment is a common practice in Bangladesh. All the recycling is being carried out by the informal sector only in Dhaka and Chittagong. In the informal sector, the process of recycling in Bangladesh has the potential to be hazardous to the recycler's health and environment. Also due to their lack of knowledge, the recovery yield of the precious metals is very poor and, thereby, substantial percentage of the 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. Here a model is recommended for recycling of e-waste (Figure 7), which may ensure proper collection and recycling of its various parts. It would also be favourable for health, environment and economy.

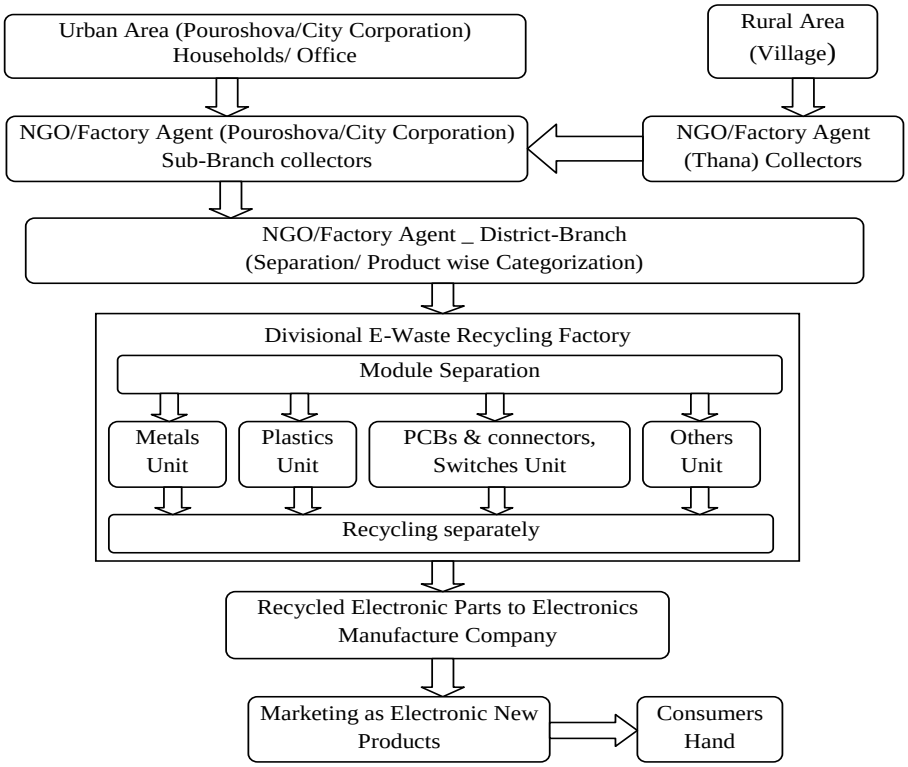


Figure 7: Proposed model for Sustainable Recycling of E-Wastes

In this process, recycling factory should have one divisional factory in every district. NGO/ Recycling Factory agent of Pouroshova/City Corporation in urban area collect electronic waste from household/office. In rural area, thana collectors collect the waste and transfer these to pouroshova/city corporation. District branch collectors collect the waste and separate it according to types such as parts of computer, circuits, cables etc. The parts of different electronic equipment then send to the divisional recycling factory. In divisional recycling factory, workers of different units separate the module and then recycle separately. After proper recycling process, the recycled parts send to the manufacturers. Manufacture company produce electronic new products by different process such as CRT monitors are converted into low cost television sets and video game monitors etc. Refurbishers engage in activities that bring non-working rubbish electronics back into working condition. The total volume of material derived from rubbish electronics moved into new rounds of production. New products go to the consumer hand and reuse it.

5. Conclusions:

This paper has provided some qualitative and quantitative information on e-waste recycling sector in Bangladesh. Estimated e-waste was found the highest (2.5 million metric ton/yr) in ship breaking yards followed by 0.182 million metric ton/yr for television sets and so on in individual sectors in Bangladesh. All the recycling is being carried out by the informal sector only in Dhaka and Chittagong in Bangladesh. It is estimated that 120,000 urban poor from the informal sector are involved in the recycling trade chain in Dhaka city. To ensure better human health and safety of workers involving in the process of waste disposal, effective e-waste recycling management system is needed which is sustainable. The formulated general physical model suggests that the large number of waste wholesale shops in the urban and rural area should be properly adjusted with their upper and lower chains in order to improve the overall reuse and recycling scheme. Furthermore, a comprehensive training program on personal hygiene was deemed imperative for the workers in all recycling schemes. In acclaimed management process, generated EW is collected by NGO who are the affiliates of existing social system. They can go from door to door and can attract the people about the proposed model. This model is selected for divisional recycling and so burden is released from the capital city. This study tried only to unfold a theoretical model for better e-waste recycling process in Bangladesh. To investigate the possibility of this model, a complete empirical study is necessary. This study will also prepare the platform for additional study and exploration of the e-waste recycling.

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