

E-WASTE: QUANTITATIVE ANALYSIS AND MANAGEMENT IN KHULNA CITY

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ABSTRACT

Evolution in the high-tech industry and an escalation in the per capita income of Bangladesh have increased people's interest in owning different electronic items. This encourages users to replace their old electronics more frequently, which is alarmingly increasing the quantity of e-waste. This study presents an evaluation of e-waste generation in Khulna city, where the use and consumption approach has been used to calculate the amount of produced e-waste from 222 households in 12 different areas. According to both online and offline inspections, it is ascertained that the amount of e-waste generated in Khulna city annually is 16,473.722 tons. The television is the largest contributor of e-waste, generating 3787.056 tons/year. Out of the 28 different electronic appliances, the wireless router creates the least amount of e-waste, which is 19.861 tons/year. Among 222 families, 57.66% of them give their electronic garbage to a waste collector whereas only 17 families recycle them.

Keywords: *Electronic Appliances, Electronic Waste, Dispose, Per Capita Generation, Recycle.*

INTRODUCTION

In this flourishing world of automation and real-time communication, innovative and interactive gadgets are being manufactured every day by the electronic industry with an aspiration to make people's lives more hassle-free. Today, electronic devices have become part and parcel in people's lives. The current generation is totally enamored with electronic gadgets, and, for these reasons, mass production and importation of electronic appliances are now on an upswing. Nowadays some astounding home appliances are available in market which has simplified people's lives. People are being accustomed to do house chores using a machine which can be simply done manually. Electronic gadgets are being upgraded and modified every day to outperform the competition, and this encourages the gadget enthusiasts to purchase the developed product as soon as they get launched. Instead of using just a normal television, people are purchasing smart televisions. People promptly quit using their old mobile phones and purchases the new ones when a smart phone firm introduces an improved model. Hence, devices that are time-saving and are filled with exhilarating features has made people dependent and addicted towards technology. However, there is a substantial amount of electronic waste (e-waste) because of the pervasive use of technology. Electronic waste, or E-waste, is generated when a user stops using an appliance or when a product reaches the end of its useful lifespan (Sajid M. et al., 2019). Electronic wastes are extremely detrimental to human health. Perilous substances such as mercury, beryllium, lithium, cadmium and etc. are contained by e-wastes (Gaidajis et al., 2010). These materials are not only deleterious to health but also damage the environment. In 2019 e-waste of 53.6 Mt was generated worldwide, with Asia contributing 24.9 Mt (Forti et al., 2020). According to a survey conducted by the Environment and Social Development Organization from 2009 to 2010, nearly 2.8 million metric tons of e-waste was generated every year (Hossain, 2010). The focal intent of this paper is to ascertain the estimated value of e-waste generation in Khulna city. Amid different types of home appliances which type of device generates the most amount of e-waste has been also determined. This survey contains a graphical representation of e-waste disposal methods used by the citizens of Khulna city.

METHODOLOGY

Field of Study

The area of Khulna City Corporation is about 40.79 square km (Banglapedia, 2021). The survey was conducted in 12 areas of the city. The Bangladesh government revealed at its '6th Population and Housing Census 2022' that Khulna has an estimated population of 2613385 (Daily-sun, 27th July 2022). Total 222 houses of 12 locations were covered for attaining required information.

Table 1: List of survey conducted areas in Khulna city and No. of surveyed households

No. of Areas	Areas in Khulna City	Number of Households
01	Fulbarigate	16
02	Khalishpur	16
03	Daulatpur	22
04	Boyra	12
05	Sonadanga	14
06	Sheikhpara	21
07	Basupara	09
08	Gollamari	15
09	Nirala	34
10	Purbo Bania Khamar	27
11	Tootpara	19
12	Rupsha	18
Total Households		222

Data Collection Procedure

For gathering required information various questionnaires were prepared. The total quantity of devices and home appliances people use at their homes was ascertained through paper survey and by online survey using Google form. Information about the methods people prefer for discarding the e-waste generated at their house was also collected.

Method

a) E-waste generation:

The "Consumption and Use Method" Has been used in this study for estimating the amount of total e-waste or WEEE in Khulna city. In order to employ this method, the product's useful life, weight, and quantity of the electronic appliance must all be met. If the weight of the product is, W (kg), the useful life is, S (year), and the quantity is, Q , then the amount of e-waste produced by that specific type of appliance can be symbolized by, E (kg/year), which can be represented as (Robinson, 2009):

$$E = \frac{WQ}{S} \quad (1)$$

b) E-waste generation per capita:

For determining the e-waste generation per capita, the amount of generated e-waste has been divided by the total number of residents of the 222 surveyed houses. If the total number of residents of the surveyed houses is symbolized by R , then the e-waste generation per capita, E_p (kg/person) can be written as:

$$E_p = \frac{E}{R} \quad (2)$$

Here the total number of residents of the 222 surveyed houses was 944.

c) Total e-waste generation:

The amount of total e-waste generation from a specific electronic device is based on the total population of Khulna. If the total population of Khulna is, P , then the total e-waste generation in tons/year can be symbolized by E_T . Here, the equation for estimating the total e-waste generation in Khulna can be expressed as:

$$E_T = \frac{E_p P}{1000} \quad (3)$$

The overall amount of the generated e-waste in Khulna city has been estimated in tons/year.

RESULT AND DISCUSSION

Total 222 households from 12 different locations of Khulna city were surveyed and from the collected information the total quantity of e-waste generation per annum has been estimated using the 'Consumption and Use' method. The survey was

conducted based on the usage of 28 different electrical and electronic devices. Among these devices which appliances are mostly used and which devices are least popular has been identified. Also, how people of Khulna discard these electronic goods when they are damaged or no longer in use has been identified.

Evaluation of Demand of Electronic Products

The pie chart of figure 1. provides information about which electronic appliances are mostly used in households of Khulna. It is very evident that, among 28 types of appliances light bulbs are used in huge quantity in every house. The second most used item is fan and third in line is smart phone.

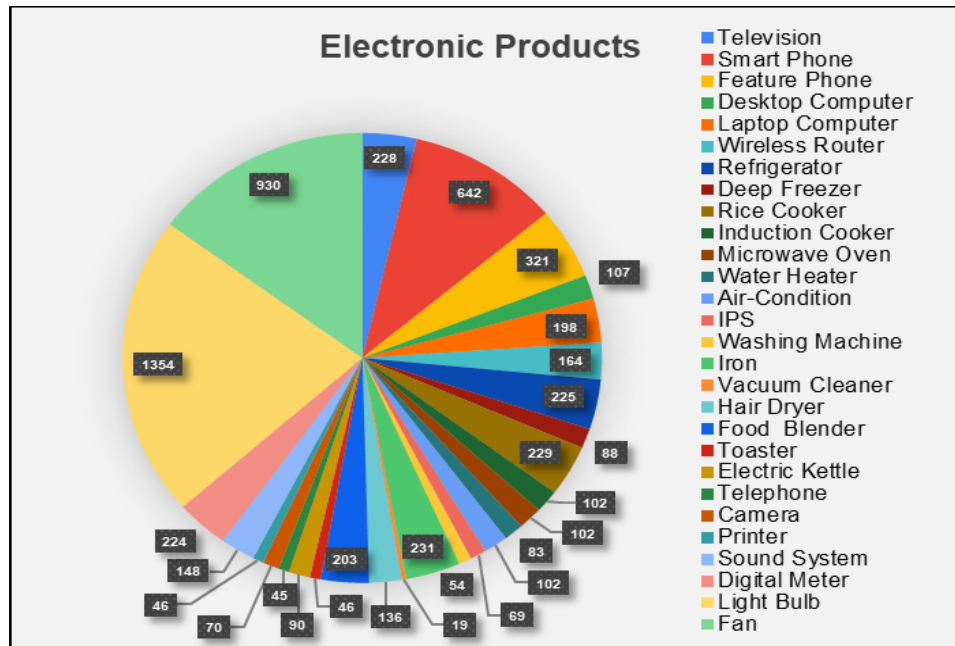


Figure 1: Evaluation of demand of electronic products.

There is no doubt that light bulbs and fans are extremely necessary items, however smart phones have also become a very important part of people's lives. Smart phones became more necessary during the pandemic as people couldn't went outside their homes and had to do a lot of important tasks virtually and it was convenient to use a smart phone with internet facilities. Among the 28 types of devices, vacuum cleaner is the least popular home appliance amid the people of Khulna city. Some other electronic products that are not used mostly are toaster, sandwich maker, telephone. Due to the invention of feature phones and smart phones, telephones have lost its popularity. According to the chart some moderately used items are air condition, wireless router, microwave oven, induction cooker, etc.

Evaluation of E-Waste Generation

Table 2. exhibits information about how much e-waste is expected to be generated in Khulna in 2022. According to the survey and calculations, the total amount of e-waste produced in Khulna in 2022 is 16,473.722 tons. Among the 28 types of electronic appliances, televisions reign supreme and are responsible for 3787.056 tons of e-waste, whereas wireless routers generate only 19.861 tons. Desktop computers are responsible for generating 2468.342 tons of e-waste in a year, which covers almost 15% of the total e-waste produced in 2022. Electronic devices that generate significant amounts of e-waste are the refrigerator, air conditioner, and washing machine, where the amounts of e-waste generated by them are 2180.085 tons per year, 1294.148 tons per year, and 1214.440 tons per year, respectively.

In spite of having the most weight, washing machines generate less e-waste than televisions because the period of efficacy of a washing machine is greater than that of a television, and also because the quantity of washing machines found in the survey is less than that of a television. This substantiates that the amounts of e-waste generation are highly dependent on equipment lifespan. If the longevity of a product is high, it may produce less e-waste. However, laptops and microwave ovens have similar lifespans, but a microwave oven produces more e-waste than a laptop due to its higher weight. In the comparison of food mixers and sandwich makers, food mixers produce more e-waste than sandwich makers, because the number of sandwich makers is less than food mixers, whereas the lifespan and weight of both the equipment are the same. Thus, the weight, lifespan, and number of electronic appliances play an essential role in ascertaining the amount of generated e-waste. It could be plainly seen that the most widely used appliances are light bulbs, fans, and smart phones, where the amounts of e-waste generated by them are 42.336 tons per year, 901.095 tons per year, and 50.176 tons per year, respectively.

Table 2: Determination of total e-waste generation.

Electronic Products	Total Quantity, Q	Weight of Product, W	Typical Life, S	Total Weight of Product	E-Waste Generation (kg/year), E	E-Waste Generation per Capita (kg/person), E_p	Total E-Waste Generation in Khulna (ton/year), E_T
Television ^c	228	30	5	6840	1368	1.44915254	3787.056
Smart Phone ^d	642	0.113	4	72.546	18.137	0.01921239	50.176
Feature Phone ^d	321	0.113	4	36.273	9.068	0.0096062	25.088
Desktop Computer ^a	107	25	3	2675	891.667	0.94456215	2468.342
Laptop Computer ^d	198	5	7	990	141.429	0.1498184	391.485
Wireless Router ^e	164	0.22	5	36.08	7.216	0.00764407	19.861
Refrigerator ^c	225	35	10	7875	787.5	0.8342161	2180.085
Deep Freezer ^c	88	35	10	3080	308	0.32627119	852.486
Rice Cooker ^e	229	3.5	6	801.5	133.583	0.14150777	369.7939
Induction Cooker ^e	102	2.5	8	255	31.875	0.03376589	88.071
Microwave Oven ^c	102	15	7	1530	218.571	0.23153753	604.998
Water Heater (Geyser) ^e	83	45	12	3735	311.25	0.32971398	861.633
Air-Condition ^b	102	55	12	5610	467.5	0.49523305	1294.148
IPS ^e	69	20	10	1380	138	0.14618644	381.815
Washing Machine ^c	54	65	8	3510	438.75	0.46477754	1214.440
Iron ^c	231	1	10	231	23.1	0.02447034	63.766
Vacuum Cleaner ^c	19	10	10	190	19	0.02012712	52.529
Hair Dryer/ Hair Straightener ^c	136	1	10	136	13.6	0.01440678	37.632
Food Mixer/ Blender ^c	203	1	5	203	40.6	0.04300847	112.375
Toaster/Sandwich Maker ^c	46	1	5	46	9.2	0.00974576	25.349
Electric Kettle ^c	90	1	3	90	30	0.03177966	82.844
Telephone ^c	45	1	5	45	9	0.00953339	24.827
Camera ^e	70	0.6	5	42	8.4	0.00889831	22.997
Printer ^e	46	2.5	4	115	28.75	0.03045551	79.446
Sound System ^c	148	10	10	1480	148	0.15677966	409.517
Digital Meter ^e	224	1.2	25	268.8	10.752	0.01138983	29.531
Light Bulb ^e	1354	0.034	3	46.036	15.345	0.01625565	42.336
Fan ^e	930	3.5	10	3255	325.5	0.34480932	901.095
						Total	16473.722

^a (Betts, 2008).

^b (Cobbing, 2008).

^c (Li et al., 2009).

^d (Easin et al., 2022).

^e (Internet sources).

E-Waste Generation

Figure 2. explains the variance in e-waste generation by 28 types of different electronic products of table 2. more clearly. According to the graph it is obvious that the most of e-waste is produced due to televisions. Other devices which also contribute significantly in the total e-waste generation are desktop computers and refrigerators. On the other hand, the gadgets which rarely produce any e-waste are wireless router, camera, telephone, toaster, hair dryer, feature phone, etc.

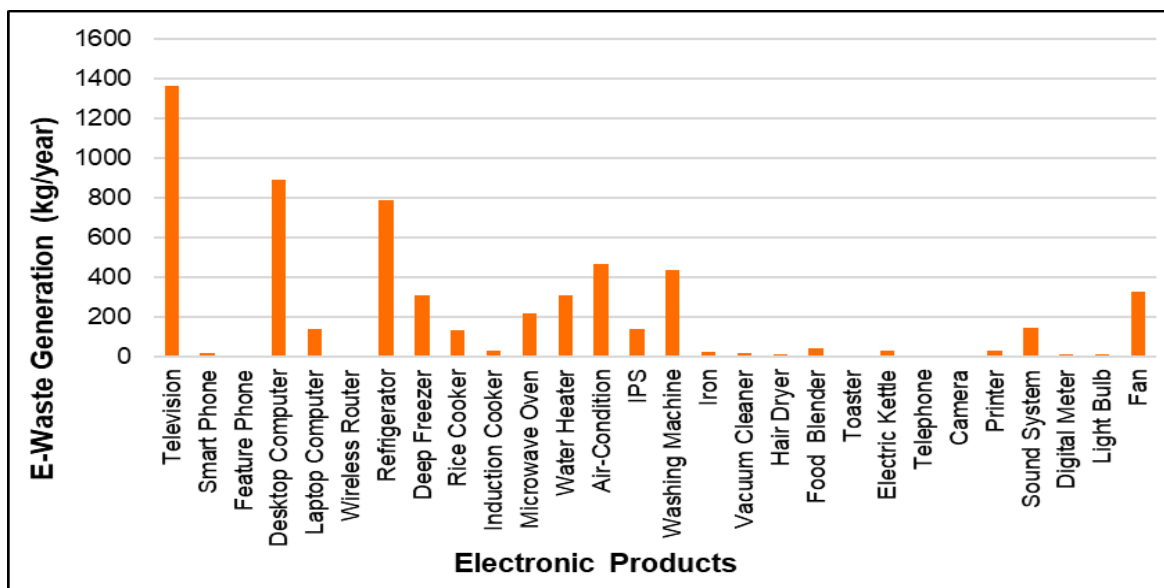


Figure 2: Graph of e-waste generation by different electronic appliances.

Waste Disposal Methods

Figure 3. delineates comparative data about how people in Khulna dispose their e-waste. Among 222 households in different city corporation areas, 128 families give their e-waste to a specific waste collector, which is 57.66%. Whereas 52.25

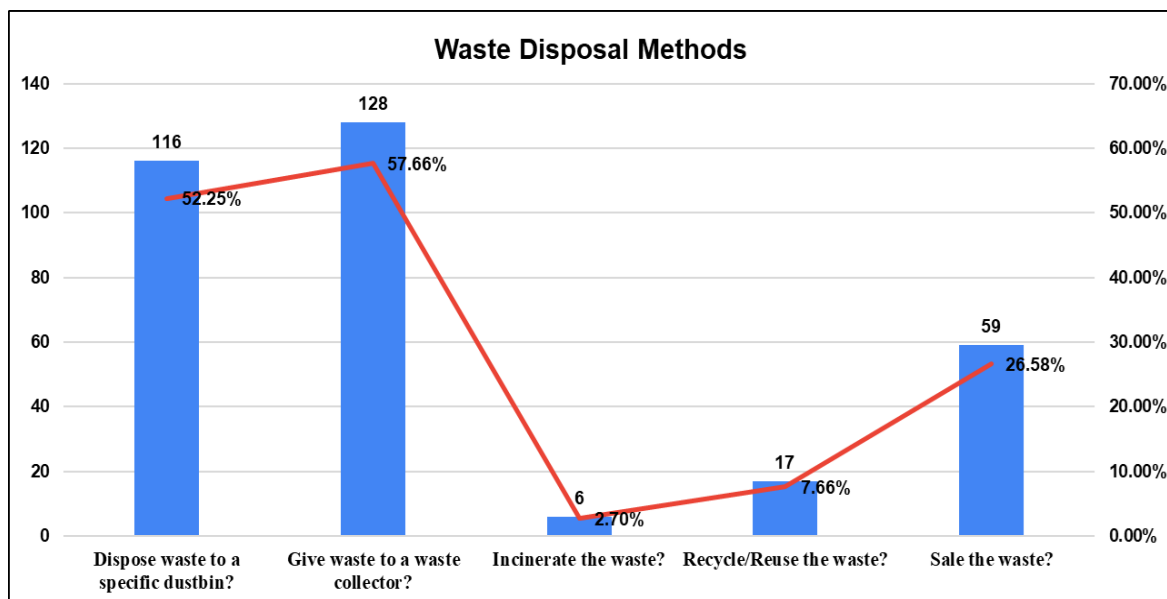


Figure 3: Evaluation of waste disposal methods

percent of families discard the e-waste generated at their house in a particular dumpster, only 59 families vend their e-waste. On the contrary, only 17 families recycle the e-waste produced at their house, and 2.70% of the families incinerate their e-waste. This graph elucidates that collecting the e-waste from people's houses by a waste collector is the most prevalent way of disposing e-waste.

CONCLUSION

As Khulna is the central city of Khulna division, the individuals here are enjoying a tremendous rise in living conditions. People here are becoming more capable of purchasing different types of gadgets day by day. But all electronic appliances stop working after several years, and then these unusable devices turn into e-waste. This paper explicates the scenario of e-waste production and how people deal with the e-waste generated at their home in Khulna city. The survey depicts that, devices which are heavier and has less life expectancy generate higher amount of e-waste. In total of 16,473.722 tons e-waste generated annually, heavy home appliances, such as televisions, washing machines, and air conditioners, are significantly responsible for producing a large amount of e-waste. Nowadays, it is difficult to find a home that does not have these appliances. Even though smart phones are the most widely used gadget and have a short duration of life, they are responsible for only 50.176 tons of e-waste per year because of their lightweight characteristics. Whether the amount is less or more,

these types of wastes are extremely deleterious to our environment. So, recycling these wastes is one strategy to mitigate their potentially harmful impact on the environment. But only 7.66% families among 222 households recycle the e-waste that is generated at their home. As the percentage of e-waste recycling is extremely low, a huge portion of e-waste remains in the environment. Thus, in order for e-waste to be transported to a suitable recycling procedure, the city corporation must take the required measures to collect it from people's houses.

REFERENCE

- Betts, Kellyn (2008). Producing usable materials from e-waste. *Environmental Science & Technology*, 42(18), 6782–6783. doi:10.1021/es801954d.
- Cobbing M. Toxic Tech: Not in Our Backyard. Uncovering the Hidden Flows of e-waste. Report from Greenpeace International. <http://www.greenpeace.org/raw/content/belgium/fr/press/reports/toxic-tech.pdf>, Amsterdam, 2008.
- Easin E. I., Tabassum N., Islam A., and Hossain M. A. (2022). Quantitative Analysis of E-Waste in Dhaka City, Bangladesh. 6th International Conference on Civil Engineering for Sustainable Development (ICCESD 2022), 10~12 February 2022, KUET, Khulna, Bangladesh (ISBN-978-984-35-1972-6).
- Forti V., Balde C.P., Kuehr R., Bel G. The Global E-waste Monitor 2020: Quantities, flows and the circular economy potential. United Nations University (UNU)/United Nations Institute for Training and Research (UNITAR) - co-hosted SCYCLE Programme, International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Rotterdam. ISBN: 978-92-808-9114-0.
- Gaidajis G., Angelakoglou K., and Aktsoylou D., 2010. E-waste: Environmental Problems and Current Management. *Journal of Engineering Science and Technology Review* 3 (1) (2010) 193-199.
- Hossain S, 2010. E-waste: Bangladesh Situation. Environment and Social Development Organization-ESDO. Dhaka, Bangladesh.
- "Khulna City Corporation". Retrieved from Banglapedia, National Encyclopedia of Bangladesh, last edited on 18 June 2021.
- Li J, Gao S, Duan H, Liu L. Recovery of valuable materials from waste liquid crystal display panel. *Waste Manag.* 2009 Jul;29(7):2033-9. Doi: 10.1016/j.wasman.2008.12.013. E-pub 2009 Jan 20. PMID: 19157837.
- M. Sajid, J. H. Syed, M. Iqbal et al., Assessing the generation, recycling, and disposal practices of electronic/electrical waste (E-waste) from major cities in Pakistan, *Waste Management*. Volume 84, 2019, Pages 394-401, ISSN 0956-053X, <https://doi.org/10.1016/j.wasman.2018.11.026>.
- "Population Census 2022: How many people live in your district?", 27th July 2022. Retrieved from Daily sun.
- Robinson B. H., 2009. E-waste: An assessment of global production and environmental impacts. *Science of The Total Environment*, Volume 408, Issue 2, 2009, Pages 183-191, ISSN 0048-9697, <https://doi.org/10.1016/j.scitotenv.2009.09.044>.