

A Study on Present E-waste Scenario in Chattogram City, Bangladesh

Mohammad Iqbal¹, Abdullah-Al-Nadim¹, Hasin Ahmed¹ and Shahrin Iqbal²

¹Department of Industrial and Production Engineering

²Department of Electrical and Electronics Engineering

Shahjalal University of Science and Technology

Sylhet-3114, Bangladesh

iqbalm_ipe@yahoo.com, aalnadim2305@gmail.com, hasinahmed.ipe@gmail.com

shahrin19emma@gmail.com

Abstract

Sales of electronic devices have been increasing in recent years resulting in increased e-waste in Bangladesh. Although Bangladesh is a developing country, it has no infrastructure to handle e-waste properly. At present, there exists no formal e-waste dismantling facility for environmentally sound management of e-waste. Therefore, the estimation of e-waste generation in Bangladesh is crucial to policymakers. Considering the limited available data, this study describes the current and future estimation of e-waste generated from cellphones and PC in Chattogram City, Bangladesh. Modified Consumption and Use methods were applied to estimate the e-waste volume in Chattogram City in the research work. In 2019, the calculated amount of e-waste generated from cellphones in Chattogram City was approximately 401.98 tons. And from PC the amount was approximately 3924.98 tons by applying Modified Method 1. Using Linear Trend Forecasting, it is predicted that the amount of e-waste generated from cellphones will reach approximately 739.18 tons and e-waste generated from PC will reach approximately 5851.80 tons by 2025. This study also discusses the present scenario of e-waste management in Chattogram city, Bangladesh.

Keywords

E-waste, Cellphone, PC, C&U method, and Chattogram.

1. Introduction

The production and consumption of electrical and electronic equipment (EEE) have been ascending significantly in the last two decades. This augmentation is due to significant advances in the electronics and ICT (Information and Communication Technology) industries, short product life spans, economic development and changes in consumption patterns and consumers' lifestyles (Terazono et al., 2006). Accordingly, the disposal rate has been rising, more disposable units are being tossed away, and the quantity of e-waste has been increasing considerably. Electronic waste, or e-waste, is a generalized term used to describe old, end-of-life, or discarded electronic appliances containing electrically powered components. Shagun et al. (2013) defined e-waste as discarded computers, office electronic equipment, entertainment device electronics, mobile phones, television sets, and refrigerators. This definition includes used electronic devices that are meant to be reused, resold, recycled, or disposed of. Kottapalle et al. (2015) defined e-waste as electrical and electronic equipment, whole or in part or rejects from their manufacturing and repair process, which are intended to be discarded. Products that are working or repairable but are dumped or disposed of or discarded by the owner rather than recycled can be termed as e-waste. Increasing e-waste volume pose detrimental consequences to the environment and public health because of inadequate recycling and disposal techniques (Ikhlayel, 2018). As technology grows quickly and electronics reach the end of their life span faster, there is an urgent need for end-of-life management options (also known as e-waste management). The increasing amount of e-waste and inappropriate management approaches are the major concern of most developing countries. Due to population growth and waste generation along with inappropriate waste management practices, Bangladesh is one of the most affected countries. To effectively manage e-waste, the amount of e-waste generation must first be estimated. This study aims at estimating the volume of e-waste in Chattogram city, Bangladesh. In this study, only personal computers and cellphones are considered as e-waste, because these e-products contribute a major share of the e-waste volume.

General objectives of this study are:

- i. To study the present scenario of the e-waste management system in Chattogram City, Bangladesh.
- ii. To estimate the volume of e-waste generation in Chattogram City, Bangladesh.

2. Literature Review

A thorough literature review was conducted in this study by assessing different articles about e-waste and solid waste management related issues and topics. Estimating the amount of e-waste generated in any region is the initial step towards proper planning for e-waste management. Alavi et al. (2015) in their paper titled “Waste electrical and electronic equipment (WEEE) estimation: A case study of Ahvaz City, Iran” estimated the amount of e-waste generated by different electrical and electronics products and investigated the current status of e-waste management in Ahvaz city. They found the trend line of e-waste generation to be increasing. Sajid et al. (2018) in their paper titled “Assessing the generation, recycling and disposal practices of electronic/electrical-waste (E-Waste) from major cities in Pakistan” quantified the e-waste inventory and its processing from major cities of Pakistan. According to Yoheeswaran (2013), the increasing rate of e-waste generation in India which is around 15% and the amount of generated e-waste crossed approximately 800,000 tons in 2012. The majority of that e-waste is handled by the informal sector which is harmful to the human and environment. The author also reviewed the current e-waste legislation and regulation.

Ikhlayel (2016) examined the advantages and disadvantages of five methods of estimating the generation of waste from electrical and electronic equipment. The study considered e-waste generated from the household sector and aimed at discussing the applicability of the methods to developing countries. The study showed that most of the compared methods provide similar estimates of the total amount of e-waste but dissimilar results for each appliance. The methods for estimating e-waste are as follows: (i) Consumption and Use method (C&U), (ii) Time Step method, (iii) Simple Delay method, (iv) Mass Balance method and (v) Approximation 2 method. The author discussed the data required for these methods and also their applicability to different market conditions. Shan-Shan Chung (2011) described four different methodologies for the estimation of e-waste along with their pros and cons. The methodologies are as follows: (i) Market Supply/Material Flow, (ii) Waste Facility Record Compilation, (iii) Direct Waste Analysis, (iv) Consumption and Use.

2.1. Research Gap

Issues related to e-waste has become a major concern all over the world. A lot of research works have been carried out by many authors regarding e-waste. But very few researches have been conducted in Bangladesh. Summary of a few studies on e-waste volume estimation is shown in Table 1.

Table 1. Summary of few studies on E-waste Volume Estimation in different geographical locations.

Sources	Geographical Locations	Methodology
Ikhlayel (2016)	Jordan	Consumption and Use Method, Time Step Method, Simple Delay Method, Mass Balance Method, Approximation 2 Method
Alavi et al. (2015)	Ahvaz city, Iran	Consumption and Use Method
Fraige et al. (2012)	Jordan	Consumption and Use Method
Araújo et al. (2012)	Brazil	Consumption and Use Method
Chung et al. (2011)	Hong Kong	Consumption and Use Method
Ahmed (2011)	Dhaka and Chattogram city, Bangladesh	Market Supply Method
Gorauskiene and Stasiskiene (2011)	Lithuania	Consumption and Use Method
Muñller et al. (2009)	China	Market Supply Method
Yang et al. (2008)	China	Market Supply Method
Laissaou and Rochat (2008)	Morocco	Consumption and Use Method

Different approaches have been used to estimate e-waste volume. However, there has been a lack of comparison among the methods. Very few authors have estimated e-waste volume applying more than one method and compared them. Also, no estimation was done in Bangladesh in recent years and none of these research works predicted the future volume of e-waste. Estimation of e-waste volume in Chattogram city was done several years ago. So, this work will be useful for further analysis of e-waste in Bangladesh.

3. Methodology

Before exploring the research methodology option, the type of research should be identified since the choice of methodology for the research follows on naturally for the clear definition of the research. To establish a credible and reliable methodology, relevant research works were reviewed. Also, the methodology includes some steps such as action plan and tools and techniques that were used during the study.

3.1 Methodology

An action plan has been constructed so that logical and sequential progress can be made throughout the study. Action plan shown in figure.1 describes the stages involved in this study.

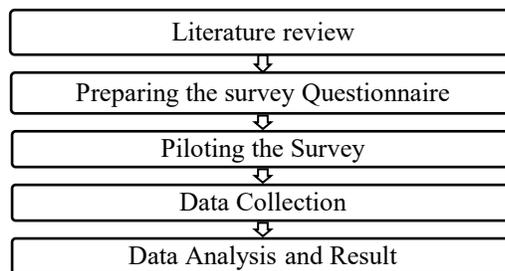


Figure 1. Action plan of this research.

The literature review aims at gathering information on the research topic. Some important publications, reports, and articles were collected from the respective centers. These articles were helpful in having an overview of the topic. The review helped the authors to find out if specific research question(s) has already been answered. And by analyzing and evaluating existing information the authors made necessary revision and update on the methods followed in the study. A survey questionnaire was prepared for the collection of data. During its preparations, the questions that would create anonymity to the respondent were carefully avoided and wordings were kept simple to make it easily understandable. Before going to the fieldwork, a pilot survey was conducted using a small sample to test the questionnaire. In this study, few students from Shahjalal University of Science Technology, Sylhet-3114, Bangladesh helped to conduct the pilot test. After the necessary update and fine-tuning to the questionnaire were made, the authors commenced the fieldwork. Finally, the collected data were arranged and analyzed using the necessary tools.

3.2 Tools and Techniques Used

A. Consumption and Use (C&U) method

Choosing a method for properly estimating the volume of e-waste is very important for the research work. There are several methods for estimating the generation of e-waste. Each of them has its own advantages and requirements. Below factors have played a crucial role in choosing the Consumption and Use (C&U) method for this research work.

- Availability of consumer data
- Scarcity of proper sales data and rarity of e-waste inventory
- The time required for gathering and analyzing the data
- The C&U method requires only stock quantities in the current evaluation year and average lifespan.

The method's formula is presented in the following equation (Ikhlayel, 2016):

$$e - waste (t) = \frac{H(t) Nh(t) W}{L}$$

where, $H(t)$ = Number of households, $N_h(t)$ = Saturation level per household, W = Average electronic product weight and, and L = Average lifespan. The saturation level is defined as the percentage of households that owns at least one electronic product, and its maximum value is one.

B. Slovin’s Formula

If nothing is known about the attributes to be experimented of a population, Slovin’s formula is used to determine a sample size. Slovin’s formula is a random sampling technique formula to estimate sample size. It is used to calculate the sample size from given the population size and a margin of error (“Slovin’s Formula Sampling Techniques”, 2018)

$$n = \frac{N}{(1 + Ne^2)}$$

Where,

n = Sample size, N = Total Population, e = Error tolerance level.

Let, the confidence level of this study be 95 percent. Which gives $e = 0.05$. The population of Chattogram city is approximately 3,920,222 (“Bangladesh Population”, 2019). So, by calculating and rounding to a whole number, we get the sample size to be 400. It means that, 400 respondents need to be selected for data collection from survey questionnaire.

C. Linear Trend Forecasting Technique

Linear trend forecasting is used to impose a line of best fit to time series historical data. It is a simplistic forecasting technique that can be used to predict demand and is an example of a time series forecasting model. A linear trend equation has the form (“Linear trend forecasting”, 2018):

$$F_t = a + b t$$

Where,

F_t = Forecast for period t , a = Intercept of the line, b = Slope of the line, t = Specified no. of time periods from $t = 0$

3.3 Data Collection

Both primary and secondary data were collected for this research work. Secondary data were collected from newspapers, articles, journals, magazines, etc. Primary data were collected from 400 respondents of Chattogram city through a survey questionnaire. The respondents were selected randomly. Collected data were sorted and prepared for analysis using software like Microsoft Excel. Junk data generates wrong information and misleads the research work. In order to avoid this, missing data was handled, and unwanted information was removed.

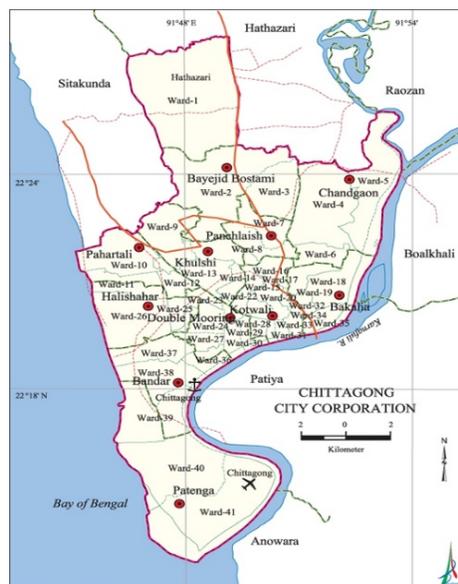


Figure 2. The map of Chattogram City Corporation (“Chittagong City Corporation”, 2014).

4. Data Analysis

In this research, only mobile and PC were considered because of the shortage of time and resources. These products are owned by almost every person aged greater than fifteen. That's why saturation level of less than or equal to one per household will result in significant error. So, a modified version of C&U method (Modified Method 1) has been applied in this research. To address the C&U method's drawback for its down estimation of e-waste, its parameters were modified, and it was used in the study for potential e-waste estimation in Chattogram city. The modified method is represented by the following equation (Ikhlayel, 2016):

$$e - waste (t) = \frac{P(t) Np(t) W}{L}$$

Where, $Np(t)$ is the number of Electrical and Electronic Equipment (EEE) owned by a person, which comprises a value lesser or greater than one. It is also known as penetration rate. Multiplying the population, $P(t)$, by the penetration rate per person, gives the yearly stock (Ikhlayel, 2016).

To include secondhand products in the estimation, further modifications to the method (Modified Method 2) were applied by introducing multiple parameters. Following equation was applied to estimate e-waste of PCs and mobile phones.

$$e - waste (t) = P(t) Np(t) W \left[\left(\frac{\omega}{L_n} + \frac{1-\omega}{L_o} \right) \right]$$

Here,

$Np(t)$ is the average number of EEE owned by a person,

ω is the market share of a new EEE item,

$1 - \omega$ is the market share of an old EEE item,

L_n is the average lifespan of a new EEE item, and

L_o is the average lifespan of an old EEE item

It was important to distinguish between personal computers and the other EEE items in Modified Method 2. For personal computers, the amounts of waste laptops and waste desktops were calculated from the following equation (Ikhlayel, 2016):

$$e - waste (t) = P(t) Np'(t) \left[Wd \left(\frac{\alpha}{L_{nd}} + \frac{\beta}{L_{od}} \right) + Wl \left(\frac{\gamma}{L_{nl}} + \frac{\delta}{L_{ol}} \right) \right]$$

Where,

α is the market share of new desktop computers,

β is the market share of old desktop computers,

γ is the market share of new laptop computers,

δ is the market share of old laptop computers,

L_{nd} is the average lifespan of new desktop computers,

L_{od} is the average lifespan of old desktop computers,

L_{nl} is the average lifespan of new laptop computers,

L_{ol} is the average lifespan of old laptop computers,

Wd is the average weight of desktop computers, and

Wl is the average weight of laptop computers.

A survey was conducted to find the penetration rate and average lifespan of cellphone and PC. Collected data were organized and analyzed using Microsoft Excel 2016. Data were tested for normality and mean values were considered for putting into equations. The average weight was taken as 1 set of PC equal to 12 kg and 1 set of cellphone equal to 250 g. The estimated amount from cellphones, PC and the total amount (both cellphones and PC) in different years using both Modified Method 1 and Modified Method 2 can be shown as in Table 2 and Figure 3. From these, it can be seen that the amount of e-waste generated from both cellphones and PC is increasing gradually. The reason can be the fact that technology is becoming more available to mass people which results in an increase in penetration rate. Also, rapid updates in technology encourage customers to purchase even before the existing one gets damaged which results in a decrease in the average lifetime of products. Furthermore, the population is also increasing. As a result, e-waste is always increasing. Both estimation methods show almost similar e-waste volume. For both cellphones and PC, the e-waste volume estimated by using Modified Method 2 is slightly higher than the volume estimated by using Modified Method 1.

Table 2. Estimated amount of e-waste in Chattogram City.

Year	Cellphone		PC		Total	
	Modified method 1	Modified method 2	Modified method 1	Modified method 2	Modified method 1	Modified method 2
2017	288.97	298.69	3262.73	4124.24	3551.70	4422.93
2018	339.98	351.42	3414.06	4315.53	3754.04	4666.95
2019	401.98	415.50	3924.98	4961.36	4326.96	5376.86

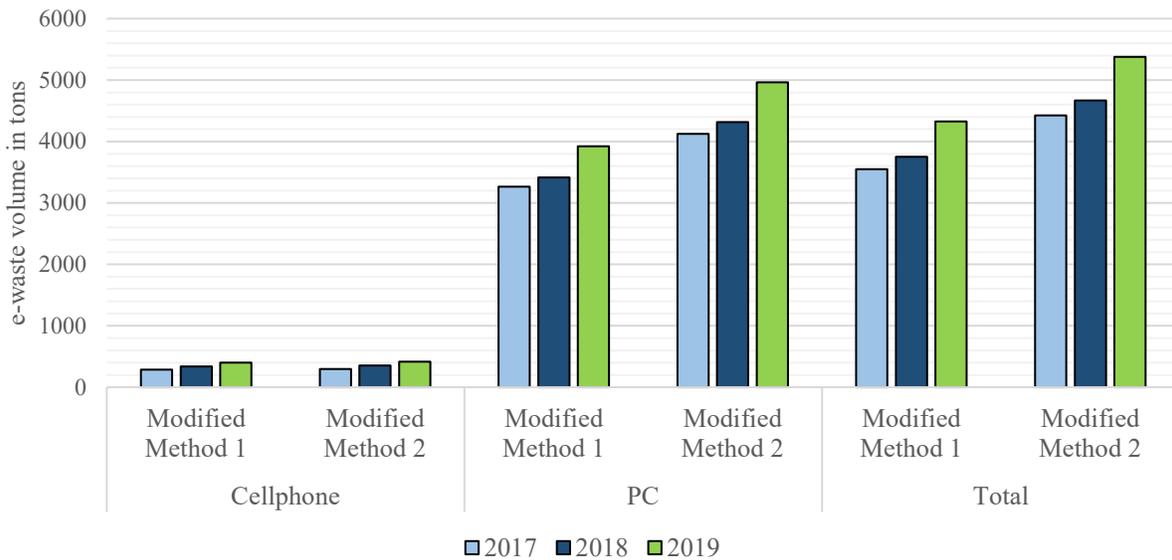


Figure 3. Estimated e-waste by Modified Method 1.

The C&U method assumes that an EEE will be replaced with new products once it reaches its EoL (End-of-Life). Modified Method 1 addresses the C&U method in which it underestimates the e-waste generation drawback. Both the modified methods consider the population change and the possibility that a single person may own more than one EEE. In the Modified Method 2, the introduced parameters allow to include the secondhand products in the estimations as they represent a significant portion in developing countries like Bangladesh. Modified Method 2 also distinguishes between desktop and laptop computers and hence these are put in different equations as both have different weights and lifespans.

Trend projection gives the best accuracy for long-term forecasting. As the estimated volume showed an almost linear upward trend, the Linear Trend Forecasting technique was used to predict the amount of e-waste generation in Chattogram City. The e-waste volumes in different years estimated using Modified Method 1 were put in the equations and the slope and the intercept were calculated using Microsoft Excel 2016. From the slope and the intercept, the volume of e-waste was predicted until the year 2025. Table 3 shows the actual estimated amount and the forecasted amount of e-waste generated from cellphone and PC.

Table 3. Forecasted e-waste amount from cellphone and PC.

t	Year	E-waste from Cellphone		E-waste from PC	
		Actual amount (in tons)	Forecasted amount (in tons)	Actual amount (in tons)	Forecasted amount (in tons)
1	2017	288.97	287.14	3262.73	3202.80
2	2018	339.98	343.64	3414.06	3533.92
3	2019	401.98	400.15	3924.98	3865.05
4	2020		456.65		4196.17
5	2021		513.16		4527.30
6	2022		569.66		4858.42
7	2023		626.17		5189.55
8	2024		682.67		5520.67
9	2025		739.18		5851.80

5. Findings

- i. One of the major findings of the research is that the amount of e-waste is increasing in Chattogram city. It was found from the research that the penetration rate is increasing and the average life of EEE is decreasing, resulting in an increase of e-waste generated from both cellphones and PC.
- ii. Both the modified versions of the Consumption and Use method “Modified C&U method 1” and “Modified C&U method 2” were used to estimate e-waste volume in Chattogram city in the study. In 2019, e-waste generated from Cellphone in Chattogram city was approximately 401.978 tons. This amount was found from Modified method 1, while in Modified method 2 the amount was approximately 415.50 tons. The estimated volumes of e-waste for both methods were nearly similar. E-waste generated from PC in Chattogram city was approximately 3924.979 tons in 2019 through Modified method 1. While in Modified method 2 the amount was approximately 4961.356 tons.
- iii. It can be predicted from the linear trend forecasting that if the volume of e-waste increases at the rate it is increasing now, in the next few years potential e-waste generation per year will be double of e-waste volume generated per year now.
- iv. The amount may seem less for starting a recycling facility only in Chattogram city. But if necessary steps are not taken for managing e-waste, cumulative volume around the country will be much higher, which will have detrimental effects on human health and the environment. So, it is high time an e-waste recovery and recycling facility should be established in Bangladesh.

6. Current Scenario of E-waste Management Practices

During the last decade, technological developments in electronic data management and communications have stimulated economic growth and improved people's lives. But at the same time, it has produced an environmental problem called e-waste. The side effect of this economic improvement is the growing number of electronic wastes in the municipal waste stream. Present status of e-waste management in Chattogram city is depicted below in brief (Rahman et al., 2011):

- No inventory has been made to assess the extent of e-waste problem in Chattogram city.
- Reuse of electronic appliances is a common practice.
- Electronic equipment recycling and dismantling is a growing business in Bangladesh.
- No e-waste dismantling facility is in the formal sector. All the recycling is being carried out by the informal sector.
- No safety regulation is maintained in informal dismantling.

According to Riyad et al. (2014), the main source of e-waste in Chattogram is the ship breakage industry. Almost 95% of the e-waste generated in Chattogram is from this particular sector. Thus, it can be commented that, without this particular ship breakage industry, Chattogram would have been less burdened with toxic e-waste problem. The authors also mentioned that there are 200-250 purchasing agents of these types of products who bring PC parts as wastage to the shop owners. After purchasing a waste product, they first test the product's functionality. If the product is functioning then they sell it to a customer who looks for second-hand parts and products. Otherwise, they break the products into pieces to separate iron, lead, copper, silver, plastic, etc. and sell these to buyers of these things. They disassemble these products without any protection which can be injurious to their health and the surrounding environment. The recycling flow of the informal sector in Chattogram city is shown in Figure 4.

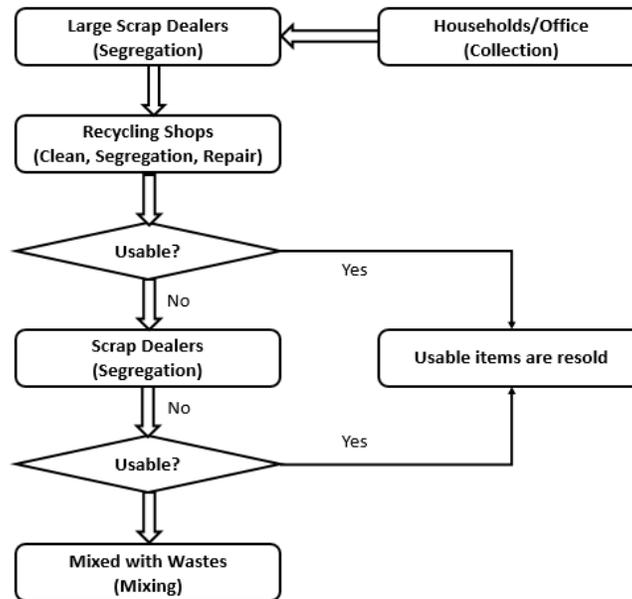


Figure 4. Informal sector recycling process in Chattogram city (Ahmed, 2011).

7. Conclusion

This paper has provided some qualitative and quantitative information about e-waste in Chattogram city. As shown in the findings, the amount of e-waste is increasing in Chattogram city. In 2019, the calculated amount of e-waste generated from Cellphone in Chattogram city was approximately 401.978 tons. And from PC the amount was approximately 3924.979 tons by applying Modified Method 1. The amount found by applying Modified Method 2 was nearly similar to that of Modified Method 1. Due to the high generation of e-waste and the lack of proper managing systems, it is predicted that such waste would have some adverse effects on the health of citizens and the environment as well. Therefore, it is necessary to provide necessary infrastructures for separation, collection, recycling, and management of such waste. Before establishing any proper e-waste recovery and recycling system a complete empirical study is necessary. This study will prepare the platform for additional study and exploration of e-waste recycling. While this study focused only on cellphone and personal computers, other electronic equipment can also be taken into consideration using a similar methodology. This study estimated the e-waste volume in Chattogram city. For estimating the volume of e-waste in other major cities, the adoption of this methodology will constitute an effective approach.

References

- Ahmed, S.U., *Informal Sector E-waste Recycling Practices in Bangladesh*. First edition, Dhaka, Bangladesh, 2011.
 Alavi, N., Shirmardi, M., Babaei, A., Takdastan, A., and Bagheri, N., Waste electrical and electronic equipment (WEEE) estimation: A case study of Ahvaz City, Iran, *Journal of the Air & Waste Management Association*, 65:3, pp. 298-305, DOI: 10.1080/10962247.2014.976297, 2015.

- Araújo, M.G., Magrini, A., Mahler, C.F. and Bilitewski, B., A model for estimation of potential generation of waste electrical and electronic equipment in Brazil. *Waste Manage.* 32, pp. 335–342, 2012.
- Bangladesh Population. (2019-07-12), Available: <http://worldpopulationreview.com/countries/bangladesh/>, August 25, 2019.
- Chittagong City Corporation, Available: http://en.banglapedia.org/index.php?title=Chittagong_City_Corporation&fbclid=IwAR39C0vBmmEWUniyQ06x-tDZFMvHvO8AYHhfoiZwzG3iMjeWepbs32Equ-o, October 12, 2014.
- Chung, S. S., Projection of waste quantities: The case of e-waste of the People's Republic of China, *Journal of Waste Management and Research*, 30(11), pp. 1130–1137, 2012.
- Ellen, S., Slovin's Formula Sampling Techniques, Available: https://sciencing.com/slovin-s-formula-sampling-techniques-5475547.html?fbclid=IwAR2W2gjKUIIG-4MUUpI3XM_DLIUB7xxeBL8Ik3Jy57n47lIU3HBsZ_HYvoso, May 29, 2018.
- Fraig, F. Y., Al-khatib, L.A., Alnawafleh, H.M, Dweirj, M.K. and Langston, P.A., Waste electric and electronic equipment in Jordan: willingness and generation rates, *Journal of Environmental Planning and Management, Taylor & Francis Journals*, vol. 55(2), pp. 161-175, 2012.
- Gorauskiene, I., Stasiskiene, Z., Application of material flow analysis to estimate the efficiency of e-waste management systems: the case of Lithuania. *Waste Manage. Res.* 29, 763–777, 2011.
- Hossain, S., Sultana, S., Shahnaz, S., Akram, A.B., Nesa, M. and Happell, J, Study on e-waste – Bangladesh Situation, *Environment and Social Development Organization-ESDO*, Dhaka, Bangladesh.
- Ikhlayel, M., Differences of methods to estimate generation of waste electrical and electronic equipment for developing countries: Jordan as a case study, *Journal of Resources, Conservation and Recycling*, 108, pp. 134–139, 2016.
- Ikhlayel, M., An integrated approach to establish e-waste management systems for developing countries, *Journal of Cleaner Production*, 170, pp. 119-130, 2018.
- Kottapalle, S., Malpani, A. & Joshi, S. E-Waste Management – A Suggested Model, *International Journal of Research in Advent Technology*, E-ISSN: 2321-9637, 2015.
- Laissaou, S., Rochat, D., Technical Report on the Assessment of E-Waste Management in Morocco. *Moroccan Cleaner Production Center & Empa, Casablanca*, 2008.
- Linear trend forecasting, Available: <https://www.kbmanage.com/concept/linear-trend-forecasting?fbclid=IwAR1AE1fl-THs1JHogFZmjYovcu6X4aohNvOVDp6mXTMGuluhQXhzyzZkq>, 2018.
- Muller, E., Schlupe, M., Widmer, R., Gottschalk, F. and Boni, H. Assessment of e-waste flows: a probabilistic approach to quantify e-waste based on world ICT and development indicators. In: Proceedings of R'09 World Congress, Davos, 14 September. Available at: http://ewasteguide.info/Mueller_2009_R09, August 27, 2009.
- Rahman, M. H., Abdullah, A. & Aziz, Z., E-Waste Management in Bangladesh, *The 26th International Conference on Solid Waste Technology and Management*, 2011.
- Riyad, A.S.M., E-waste recycling practices in Bangladesh, *International Journal of Renewable Energy and Environmental Engineering*, ISSN 2348-0157, Vol. 02, No. 03, 2014.
- Sajida, M., Syed, J.H., Iqbal, M., Abbase, Z., Hussain, I. and Baiga, M. A., Assessing the generation, recycling and disposal practices of electronic/electrical-waste (E-Waste) from major cities in Pakistan, *Journal of waste management*, Vol. 84, pp. 394-401, 2019.
- Shagun, Kush, A. and Arora, A., Proposed Solution of e-Waste Management, *International Journal of Future Computer and Communication*, Vol. 2, No. 5. 2013.
- Terazono, A., Murakami, S., Abe, N., Inanc, B., Moriguchi, Y., Sakai, S.-i., Kojima, M., Yoshida, A., Li, J., Yang, J., Wong, M.H., Jain, A., Kim, I.-S., Peralta, G.L., Lin, C.-C., Mungcharoen, T. & Williams, E, Current status and research on E-waste issues in Asia. *Journal of Material Cycles and Waste Management*, 8, 1-12, 2006.
- Yang, JX., Lu, B. and Xu, C. WEEE flow and mitigating measures in China. *Waste Management* 28: pp. 1589–1597, 2008.
- Yoheeswaran E., E-Waste Management in India, *International Global Research Analysis*, Volume: 2, Issue: 4, April 2013, ISSN No 2277 – 8160, 2013

Biographies

Professor Dr. Mohammad Iqbal is currently serving as a Professor at Shahjalal University of Science and Technology (SUST), Sylhet-3114, Bangladesh under the Department of Industrial and Production Engineering. He is the founder lecturer of Department of Industrial and Production Engineering, SUST. He served as the Head of the Department for 13 years. Dr. Iqbal was the Dean of School of Applied Science and Technology for two years. He was the Head of Petroleum and Mineral Engineering Department, SUST for one year. He was a member of Peer Review Committee on Engineering & Applied Science, Ministry of Science, Information and Communication, Republic of Bangladesh Government for the financial year June 2006-July 2007. His affiliations as researcher has contributed more than 24 publications in peer-reviewed national and international journals. He has more than 80 national and international publications in conference proceedings. He is a member secretary of IEB Sylhet Centre, Bangladesh. Dr. Mohammad Iqbal is also the Conference Chair of IEOM society of Bangladesh.

Abdullah-Al-Nadim has graduated from the Department of Industrial and Production Engineering in Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh. His research interests include operations research, simulation, reliability, scheduling, manufacturing, and lean. At present Mr. Abdullah-Al-Nadim is involved in a research project with Professor Dr. Mohammad Iqbal, department of Industrial and Production Engineering in Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh.

Hasin Ahmed has graduated from the Department of Industrial and Production Engineering in Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh. His research interests include manufacturing, product designing, scheduling, and lean. At present Mr. Hasin is involved in a research project with Professor Dr. Mohammad Iqbal, department of Industrial and Production Engineering in Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh.

Shahrin Iqbal is an undergraduate student of the department of Electrical and Electronics Engineering, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh. Her research interests include supply chain, automation, machine language and industrial safety management.