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E-Waste Generation and their Impacts on Health and Environment: A Study Over Gazipur District, 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 consumption, e-waste from electrical and electronic equipment (EEE), has become the fastest-growing waste stream in the world. This study helps to quantify the existing generation rate, health, and environmental impacts of e-waste. A structured questionnaire has been processed in Gazipur and existing literature was reviewed. A total of 1200 households were interviewed using structured questionnaires. The results revealed that several income families used different types of electronics products. E-product consumption depends on an individual's income and e-waste generation depends on warranty policy and product life cycle. The health consequences of both direct exposures during recycling and indirect exposures through environmental contamination are potentially severe but poorly studied. E-waste concepts are relatively new in Gazipur as a result this study revealed, 840 households were aware of health and environmental impacts. E-waste minimization, reuse, or recycling is necessary but it should be conducted in a safe and standardized system. Recycling stations should be established with maintaining safety measures for workers and to conserve the environment from being contaminated. The government should involve in waste management by establishing rules and regulations specific to health safety and environmental issue relating to e-waste.

Keywords:- *E-product consumption and e-waste generation, E-waste recycling, health, and environmental impacts.*

I. INTRODUCTION

The production, distribution, and consumption of Electrical and Electronic Equipment (EEE) is strongly linked to global economic and communication system development. With the fast advancement of innovation, manufacturers currently produce superior TVs, new and more brilliant cell phones, and gadgets at an expanding rate (Babu et al., 2007). People are getting involved in the use of what innovation brings, communicating on their advanced mobile phones or tablets, and observing top-quality motion pictures on their TVs at home. As an ever-increasing number of electronic items are delivered to satisfy the necessities of individuals around the world, more assets are utilized to create these things. Thus, the fast development of electrical and electronic devices is driving the ever-expanding creation of electronic waste (Mmereki et al., 2016). Electrical and electronic equipment (EEE) waste or e-waste is the discarded electric products, one of the fastest-growing solid waste streams around the world today. This situation prevailed everywhere and it's hard to survive in this world without machines. Humans are fully influenced by machines that make our lives more comfortable. To satisfy the requirements of the people who need electrical goods are getting popular day by day and they get crowded in the market. Finally, these goods result in the generation of e-waste (Herat & Agamuthu, 2012).In 2019, the world produced a noticeable 53.6 megatons (Mt) of e-waste, a normal of 7.3 kg per capita. The worldwide generation of e-waste increased by 9.2 Mt since 2014 and is projected to increase to 74.7 Mt by 2030 – nearly multiplying in just 16 years. Asia created 24.9Mt of e-waste which is the highest amount over the world. Americas (13.1 Mt) and Europe (12 Mt), while Africa and Oceania produced 2.9 Mt and 0.7 Mt, individually (Adrian et al., 2020). In 2016, 44.7 million metric tons of e-waste was generated (Balde et al., 2017). Malaysia (0.8 to 1.3kg) per capita (Mmereki et al., 2016), Europe 16.2 kg per capita, and America 13.3kg per capita e-waste generate (Balde et al., 2017). European Union (EU), e-waste is growing at a rate of 3% to 5% per annum, or approximately three times faster than other individual waste streams in the solid waste sector (Schwarzer et al., 2005). Developing countries like Bangladesh are projected to generate twice as much as e-waste for the next 6-8years as industrialized countries (Yu et al., 2010). Bangladesh generates almost 2.7 million metric tons of e-waste every year and even generation rate increasing every year. Shipbreaking yard, television sets, and Information Technology (IT) sector generate e-waste 2.5 million metric tons, 0.182 million metric tons, and 31751.5 metric tons respectively (Alam & Bahauddin, 2015). This brings about a significant threat to public health and the environment (Afroz et al., 2012). The EEE industry is responsible for 10%–20% of the worldwide environmental impact related to the depletion of non-renewable resources (Cruz-Sotelo et al., 2017). As a consequence, electronic wastes have become a new policy priority around the globe and decision-makers have the challenge of handling the waste of electrical and electronic devices to minimize health impact in an economical and environmentally friendly manner (Araceli & Dios, 2015). In the past, most e-waste regulations are prompted by and focused on environmental protection. Recently, e-waste

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guidelines have been adopted and enforced to ensure public health and environmental safety (Grant et al., 2013). The adoption of the legislation on EEE prompts basic changes in the field of electronic piece reusing. Besides, political decisions and legitimate selection will impact the advancement of the EEE treatment framework (Barba-Gutiérrez et al., 2008). Basel Convention (1989), which has been ratified by 181 countries, prohibits the export of e-waste (Bergesen et al., 2019). Despite export guidelines, this convention has a loophole that permits e-waste exportation if it is intended for "re-use." This detail leads to a large quantity of near end-of-life EEE being exported. These older electronic products have short life spans, if any in the least, once they reach the export countries. As a result, the e-waste designated for "re-use" only ends up contributing to the e-waste problem in the developing, recipient countries (The Lancet, 2013). Within the EU, the Waste Electrical and Electronic Equipment Directive requires manufacturers and importers within member states to require back their products from consumers and ensure sound environmental methods are used to dispose of the e-waste (Perkins et al., 2014). However, this study aimed to measure generation scenario of e-waste, and their health and environmental hazard over Gazipur city, Bangladesh. This study promoted more preciously regarding e-waste and its chemical pollutants and will in a helping way to increase the proper e-waste management practices that can reduce the human health and environmental hazard.

II. METHODOLOGIES

➢ *Study area:*

This study was conducted over 1200 households of the Gazipur district (Figure 1) which were randomly selected for the study. Gazipur is one of the longest districts in the Dhaka Division with population 3403912 and Gazipur located in between 23°53' and 24°21' north latitudes and 90°09' and 92°39' east longitudes. It is bounded by Mymensingh and Kishoreganj districts on the north; Dhaka, Narayanganj, and Narsingdi district on the south; Narsingdi district on the east and Dhaka and tangail districts on the west.

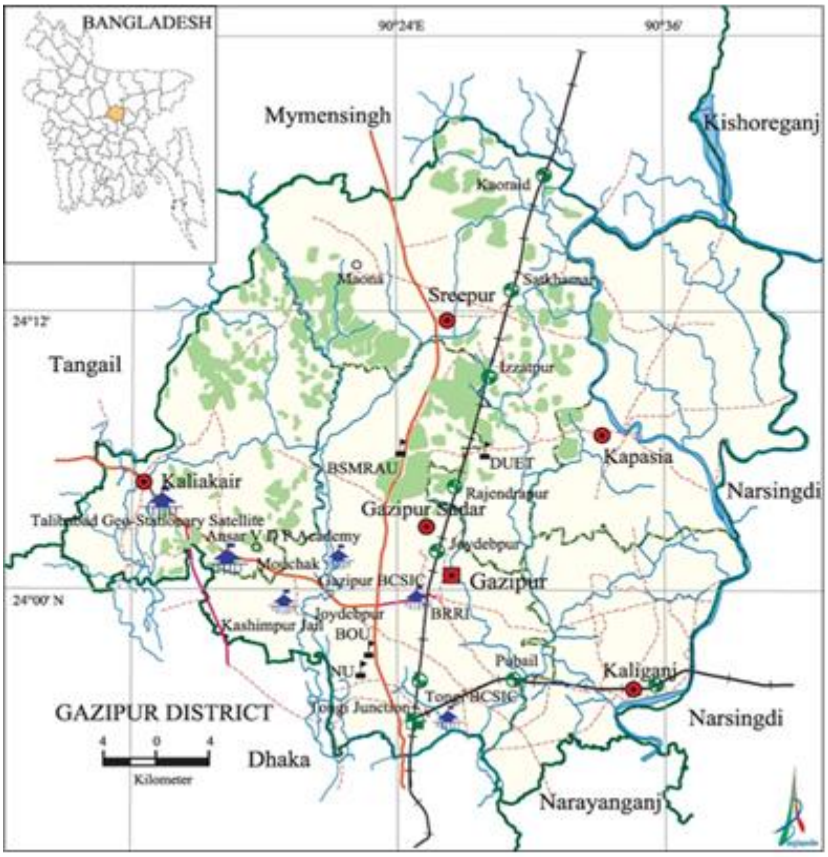

Fig 1:- Geographical Location map of the study area (Gazipur District).

➢ *Data Collection:*

To identify the generation, sources, health, and environmental impacts of e-waste in the study area, a self-exploratory questionnaire was used for the study. The experimental data represented here were collected from the Gazipur district. Data were collected from selected 1200 households once in every month from January 2015 to January 2020 total 60 times then averaged to calculate consumption and e-waste quantification. The questionnaire was developed to evaluate e-product consumption, e-waste generation, health, and environmental impacts within the Gazipur. Data gathering techniques included observation, semi-structured questionnaires survey, and informal dialogue with household members and workers who handling or recycling e-product.

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➢ *Data Analysis:*

For the analysis of collected data, Microsoft Excel (2013) software was used. Data were input in the excel sheet software and percentages, average (mean) of the relevant were showed by mostly in tabular forms along with graphs and tables.

III. RESULT AND DISCUSSION

➢ *Socio-economic condition and status of EEE consumption.*

Economic goods consumption, repairing, and waste generation depend on Socio-economic conditions, education level, and gender (Rahman et al., 2020). Quantitative study over EEE consumption and repairing requires information relating to the life cycle of products and recycling of EEE influenced by rules and legislation. This study conducted over 1200 family, one person from each family were male was 82%, and female 18%. The age of the respondents was grouped into five classes (figure 2).

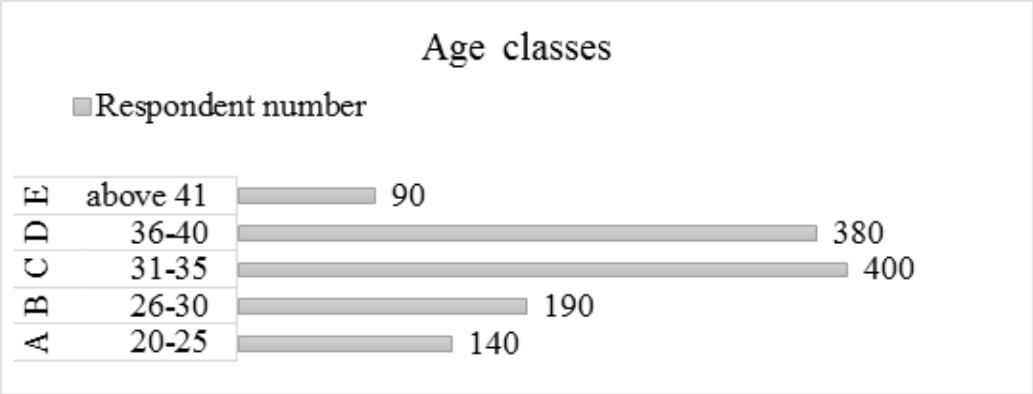

Fig 2:- Age classes of the respondent from each household

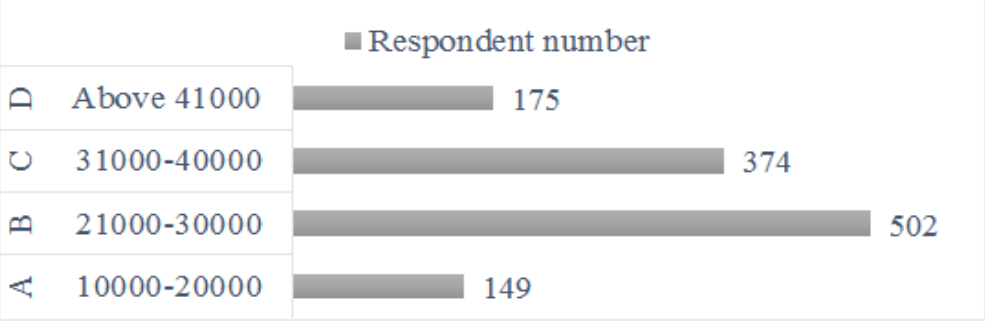

Fig 3:- Income level of Households

Education is an important factor in developing countries like Bangladesh, ensuring the economic condition of the household's improvement and changing the lifestyle, motivations, and Electrical home appliances. This study found respondents completed primary, secondary, higher secondary, and graduate in number 60, 80, 160, and 900 respectively (Figure 4). Education also influences for better employment opportunities and social establishments. Higher educated have better possibilities for income higher income (figure 5).

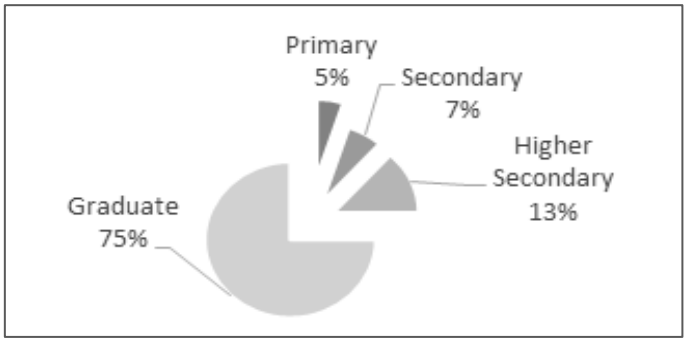

Fig 4:- Education level of the respondents.

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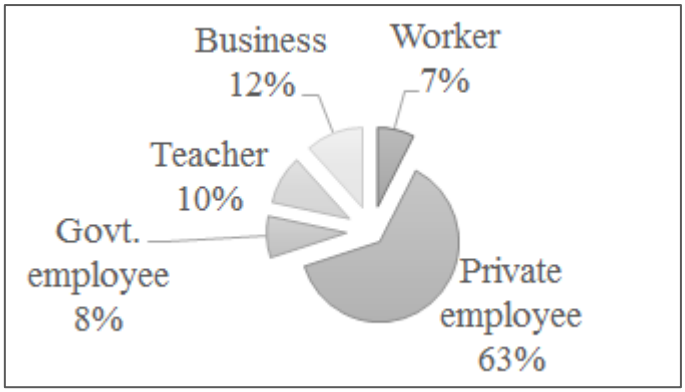
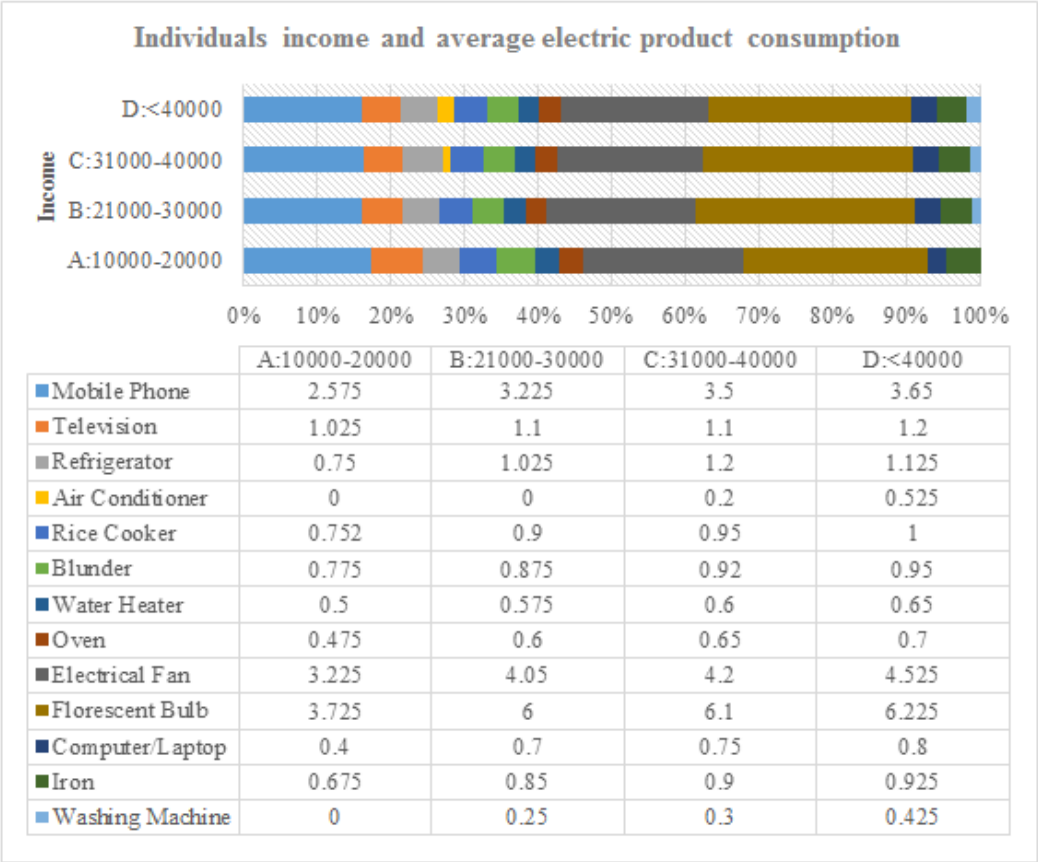


Fig 5:- Occupational variations of the target population.

According to the study, a considerable number of the respondents 175,374,502 and 149 monthly income above 41000, 31000-40000, 21000-30000, and 10000-20000 BDT respectively (Figure 3).

The occupational variation is also found, where private employees, businesses, teachers, workers, and government employees are 63%, 12%, 10%, 7%, and 8% respectively.



	A:10000-20000	B:21000-30000	C:31000-40000	D:<40000
Mobile Phone	2.575	3.225	3.5	3.65
Television	1.025	1.1	1.1	1.2
Refrigerator	0.75	1.025	1.2	1.125
Air Conditioner	0	0	0.2	0.525
Rice Cooker	0.752	0.9	0.95	1
Blunder	0.775	0.875	0.92	0.95
Water Heater	0.5	0.575	0.6	0.65
Oven	0.475	0.6	0.65	0.7
Electrical Fan	3.225	4.05	4.2	4.525
Florescent Bulb	3.725	6	6.1	6.225
Computer/Laptop	0.4	0.7	0.75	0.8
Iron	0.675	0.85	0.9	0.925
Washing Machine	0	0.25	0.3	0.425

Fig 6:- Relationship between an individual's income and average EEE consumption by a household in 2019.

Economic conditions, education levels, and occupations are interlinked and affect the EEE consumption amount. The high income of a household determined by education level and electrical equipment consumption increase by increasing the income of individuals (figure 6). The study showed that, high-income families using more electronic products than middle and low income. Luxurious electronic products such as air conditioners, washing machines, oven, and computers are not available in a low-income household. In high-income level contained air conditioner (0.525), oven (0.7), and washing machine (0.425). Fewer amounts of these products are available in a middle-income household. Mobile phones, electronic fan, bulb, rice cooker, blunder are common products all of the household. Though television, refrigerator, computer are luxurious products these are available in all, on average where high levels contain television (1.2), refrigerator (1.125), computer (0.8), middle level carried television (1.1), refrigerator (1.025), computer (0.7). Fluorescent bulbs are the products which are larger volume in high and

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middle than low. Mobile phone (3.15), fluorescent bulb (5.32), electronic fan (3.94) (on average per household) is the most dominating electronic product overall household in the Gazipur city corporation area. It was found that iron, blunder, rice cooker are also common e-products in the overall household but high-income households consume a larger amount of e-product than others.

➢ *E-waste generation status from households.*

Electrical and electronic equipment consumption, repairing and replacing tendency of e-products by a new one depending on the socio-economic conditions, the life cycle of EEE, size of the family, availability of the product, and warranty policy. Investigation of 1200 family shows nearly 60%, 30%, and 10% family has family members 0-5, 6-10, and over 10 people respectively. The study also showed that when electronic products are not repairable these are taken to the repairing shop and the damaged parts of electronic products are replaced by new ones considered as e-waste.

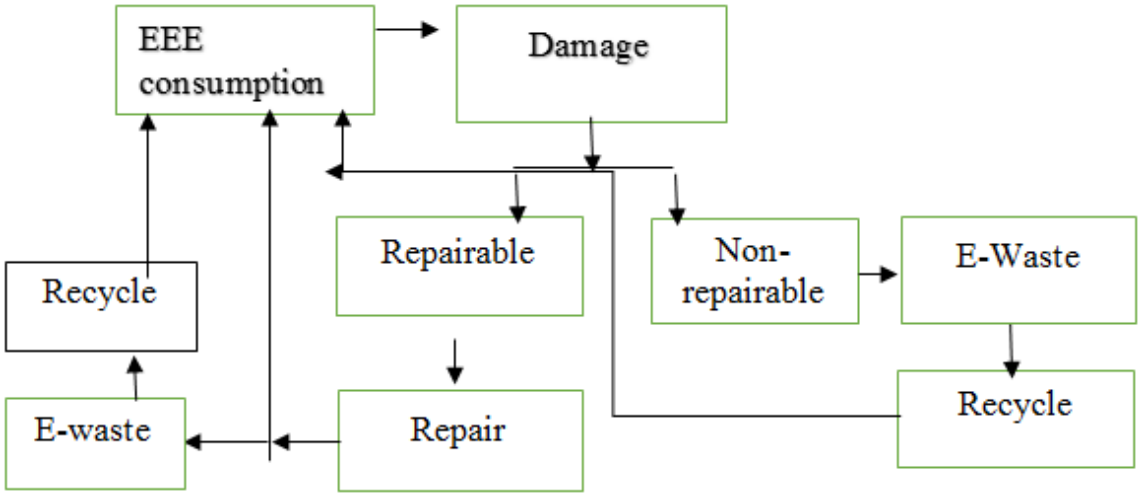

Fig 7:- EEE consumption and e-waste generation cycle in the study area.

E-waste generates from discarded electronics appliances such as televisions, personal computers, telephones, air conditioners, cell phones, electronic toys, etc. In 2019, a larger portion of the e-waste generated by the bulb (1.35g) generated than any other products and mobile phones generated the second-largest amount of e-waste (1.025g). Respective amount of e-waste also generated by the rice cooker (0.567g), blunder (0.167g), electronic fan (0.35g), television (0.25g) and refrigerators (0.225g) in per household. Similarly, from 2015 to 2019 bulb (4.30g) was also the first position in e-waste generating, and the mobile phone (2.242g) contain every household. The comparatively fewer amount of e-waste generated by refrigerator (0.34g), electronic fan (0.484g) last five years than this year (0.225g), and (0.35g) (table 1). The amount of e-waste generation from non-repairable e-products is higher than repairable e-product in a specific period (Table 2).

Electrical and electronic equipment's (EEE)	E-waste generation rate, gram/households (2019)	E-waste generation rate, gram/households (2015-2019)
Mobile Phones	1.025	2.242
Televisions	0.25	0.492
Refrigerators	0.225	0.34
Air Conditioners	0.067	0.092
Rice Cooker	0.567	1.1625
Blunder	0.167	0.192
Water Heater	0.375	0.32
Oven	0.084	0.1584
Electrical Fan	0.35	0.484
Fluorescent Bulb	1.35	4.3
Computer/Laptop	0.15	0.2584
Iron	0.175	0.22
Washing Machine	0.117	0.175

Table 1:- Average e-waste generation from non-repairable e-products of households in Gazipur City.

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E-Products	Year-2019			Years- 2015-2019		
	High-class households. (income: <40000)	Middle-class households. (income: >40000 but <21000)	Low-class households. (income: >20000)	High-class households. (income: <40000)	Middle-class households. (income: >40000 but <21000)	Low-class households. (income: >20000)
Mobile Phones	0.575	0.25	0.05	1.075	1.025	0.125
Televisions	0.35	0.29	0.22	0.75	0.35	0.025
Refrigerators	0.25	0.75	0.15	0.4	0.3	0.1
Air Conditioners	0.1	00	00	0.25	00	00
Rice Cooker	0.25	0.65	0.4	0.75	0.5	0.25
Blunder	0.15	0.15	0.75	0.05	0.25	0.35
Water Heater	0.375	0.45	0.3	0.35	0.51	0.12
Oven	0.05	0.01	00	0.02	0.01	00
Electrical Fan	0.35	0.25	0.15	0.075	0.025	0.05
Florescent Bulb	1.1	1.7	0.55	1.45	4.25	3.35
Computer/Laptop	0.15	0.02	0.075	0.35	0.25	0.15
Iron	0.17	0.13	0.05	0.7	0.3	0.1
Washing Machine	0.02	0.01	00	0.24	0.12	00

Table 2:- Average e-waste generation rate from repairable e-products of households in Gazipur City.

➢ *Health and environmental impacts of e-waste.*

E-waste concepts are relatively new in Gazipur as a result this survey revealed, only 70% of the households (in number 840 households) were aware of health and environmental impacts. Remaining 30% of the respondents didn't know about e-waste before this survey. Available handling methods practiced by the households for e-waste in Gazipur were to sell e-waste to vendors or stores in the site of generation. This study found, 78% of e-waste collected by vendors transfer to recycling stations and after recycling they resell in the market place but the other 22% of e-waste stored in the site of generation considered mismanaged that pose threat environment and health as people do not know how to discard them. According to this study, about 19% respondents from 1200 households know that e-waste contains many hazardous metallic contaminants such as lead, cadmium, and beryllium and brominated flame-retardants which have toxic irreversible effects on human health and environment and only 7% of the households know that valuable materials like aluminum, gold, can be extracted from EEE by proper handling and recycling. E-waste introduced into the human body by inhalation, ingestion, or direct contact with waste or by food chain interruption. The Health and environmental effects of e-waste in the study area observed are listed in (Table 9).

Compositions of e-waste	Health effects observed in Gazipur due to e-waste*
Lead	• Central nervous systems • peripheral nervous systems • blood systems • kidney damage • effects on the brain development of children • circulatory system and kidney
Cadmium	• Toxic irreversible effects on human health • Accumulates in kidney and liver • Causes neural damage
Mercury	• Chronic damage to the brain • Respiratory and skin disorders due to bioaccumulation in fishes
Chromium	• Causes bronchitis
Plastics and PVC	• Burning produces dioxin that causes reproductive and developmental problems
Copper	• Stomach cramps • Nausea • liver damage

Beryllium	• Carcinogenic (lung cancer) • Inhalation of fumes and dust causes chronic beryllium disease
Lithium	• Lithium can pass into breast milk and may harm a nursing baby • Inhalation of the substance may cause lung edema

*Source:(Grant et al., 2013)

Table 3:- Health risk from e-waste compositions to human and animal health.

Harmful environmental effects also observed in Gazipur due to e-waste mismanagement such as toxic chemicals are released into the air or when electronic waste is thrown away in landfills their toxic materials seep into groundwater, affecting surface water and land and degrade soil quality.

IV. CONCLUSIONS

E-waste management should be a priority issue amongst competing needs in the community facilities. Present recycling facilities in the study area are not healthy and environment friendly. Even recycling of e-waste not maintaining health and safety measures. The results of the study estimated that the average e-waste generation from 2015-2019 and factors that influence a generation. The e-waste generation in the coming years would be even greater because of increasing consumption rate and socio-economic condition improvement. This growth has significant health and environmental impact. This study will be a reference to identify impacts from e-waste and the quantitative volume of e-waste generated from households. E-waste recycling should follow proper health and safety measures and e-waste should not treat as a municipal solid waste for worker's safety and environmental conservation. The government should establish strict rules, regulations and encourage general people to hand over e-waste to local recycler with minimum cost as encouragement money.

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