Electronic Waste Analysis and Characterization Study: Management input for Highly Urbanized Cities

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Abstract – Electronic Waste (E-Waste) is said to be any electrical or electronic device that have reached the terminal of its useful life. The major issues are the volume and the raw materials used in crafting E-waste which are non-biodegradable and contains hazardous substances that are toxic to human health and the environment. The objectives of this study are to gather baseline data in terms of the composition of E-waste in the solid waste stream and to determine the top 5 E-waste categories in a highly urbanized city. The study utilized the data from the official 2014 WACS of Pasig City and taken the combined percentages of the special and hazardous waste from the overall waste composition. There were three major stages that were followed from the WACS process. These were; Preparation & Training, Actual E-Waste Characterization, and Data Processing and Analysis. Recommendations in managing these wastes for its reduction were provided to serve as guide for acceptance and implementation in the locality. Pasig City was the chosen beneficiary of the research output and through the collaboration of the City Government of Pasig and its Solid Waste Management Office (SWMO); the study successfully piloted the Electronic Waste Analysis and Characterization Study (E-WACS).

1. Introduction

In the world where technological evolution and competition to create innovative products are at its peak, problems on Electronic Waste (E-Waste) are now becoming a global concern. E-waste is said to be any electrical or electronic device that has reached the terminal of its useful life [1]. Based on report released by International Solid Waste Association together with other international groups, 44.7 million metric tons of E-waste was generated in 2016, or about 6.1 kilos per inhabitant on Earth. The global E-waste generation according to their estimate will reach 52.2 million metric tons by 2021[2]. Aside from its volume, another issue is the raw materials used in crafting E-waste which are non-biodegradable and contains hazardous substances that are toxic to human health such as lead, mercury, cadmium, etc. Improper E-waste management results to air pollution, ground water contamination, and negative impact to wildlife [3].

The characterization and analysis of the E-waste generation in a highly urbanized city can be performed by interpreting the collected E-wastes disposed by waste generators on a daily basis. The said activity is fulfilled by conducting the Waste Analysis and Characterization Study (WACS) – which is a mandate under Republic Act 9003. The WACS is the set of guidelines proposed by the Philippine Environmental Governance Project (EcoGov) and its LGU partners to develop a waste assessment and characterization procedures that meet the intent of RA 9003. The WACS approach upon review does not have a procedure of categorization of E-waste. This is the opportunity that the research utilized in order to come up with a process to integrate E-waste in the WACS guidelines. The activity of incorporating E-wastes in the WACS process is known to be the E-WACS or the Electronic Waste Analysis and Characterization Study.

In the review of the Waste Amount and Characterization Study facilitated by Woodfields Consultant Inc. in cooperation with the Metro Manila Development Authority (MMDA) in sixteen (16) distinct
cities in Metro Manila in 2014, it was determined that there is no specific category for E-waste in the methodology. According to the study, E-waste is classified as either Hazardous Waste or Special Waste [4]. Hazardous wastes are wastes which consist of physical, chemical or infectious characteristics that may cause serious irreversible or debilitating reversible illnesses to human health and the environment when improperly managed. This includes paint, oil filters, household batteries and etc. [5]. Special Wastes are defined as garbage, refuse, or other discarded waste that requires special administrative assessment, transportation, packaging, processing and disposal techniques due to its quantity; hence, its unique physical, chemical and biological components. This category includes medical wastes and pathological wastes [6]. This is the reason why there is no concrete data that will illustrate the quantity of E-waste in the solid waste volume.

The objectives of this study were to gather baseline data in terms of the composition of E-waste in the solid waste stream and to determine the top 5 E-waste categories in a highly urbanized city. By achieving these objectives, recommendations in managing these wastes for its reduction were provided to serve as guide for acceptance and implementation in the locality. Pasig City was the chosen beneficiary of the research output and through the collaboration of the City Government of Pasig and its Solid Waste Management Office (SWMO); the study was able to perform the Electronic Waste Analysis and Characterization Study (E-WACS).

In this study, an assumption was stated and one consideration that was explored is the effect of the community status on how households generate their E-wastes. Thus, the assumption which relates the community status of the households to the waste generation in a highly urbanized city is specified as: “The community status of the households has a significant impact in the generation of E-waste in a highly urbanized city.

2. Methods

The method that was adopted by the study was based on the Woodfields methodology. Woodfields Consultants, Inc. was the third party service provider of Pasig City with the supervision of Metro Manila Development Authority (MMDA) in the July 2014 WACS project. Similar method was used in the current study in order that the means of gathering the data is patterned to the WACS. However, to ensure a distinctive review of E-wastes, there should be a separate categorization and treatment of E-waste in the methodology. Previous tools and documentations were gathered as basis in the recreation of the methodology then integrated E-waste categorization on it.

| Waste Category          | Percentage |
|-------------------------|------------|
| Kitchen Waste           | 33.48%     |
| Plastic                 | 19.09%     |
| Paper                   | 18.47%     |
| Special                 | 13.39%     |
| Other Organic           | 4.29%      |
| Textiles                | 3.38%      |
| Glass                   | 3.20%      |
| Metal                   | 1.92%      |
| Yard Waste/ Wood        | 1.86%      |
| Rubber/ Leather         | 0.52%      |
| Other Inorganic         | 0.20%      |
| Others                  | 0.17%      |
| Hazardous              | 0.05%      |
| Fiber Glass             | 0.00%      |

Figure 1. This represents the percent composition of the Hazardous and Special waste from the 2014 WACS result of Pasig City.

The study utilized the data from the official 2014 WACS of Pasig City and taken the combined percentages of the Special Waste and Hazardous waste from the overall waste composition as shown in Figure 1. There were three major stages that were followed in conducting the E-WACS which was adopted from the WACS process. These were: (1) Preparation and Training, (2) Actual E-Waste
Characterization, and (3) Data Processing and Analysis. In the preparation and training, there were several sub-activities which were observed. These were: (a) Identification of the E-waste sources and Categorization of E-Wastes, (b) Formation and training of the E-WACS team, (c) Acquisition and preparation of tools and other resources for E-waste characterization, (d) Orientation of the cooperators, and (e) Data Processing and Statistical Treatment. The study adopted the recommended sampling method from the Philippine Environmental Governance Project (EcoGov) manual where small and medium Local Government Units should have a total sample size of at least 30. The recommended sample size was based on pre-sampling studies which made use of the standard sample size demonstration formulas and statistical tools [7]; however, the same principle was observed for other waste source categories. The National Environment Management Authority (NEMA) published a guideline for E-waste categorization and management in Kenya. The guideline served as a reference in establishing the E-waste categories [8]. In this study, there were eight (8) distinct categories of E-wastes that were implemented namely: Office and Telecommunications equipment, Household Appliances, Consumer Equipment and Batteries, Toy, Leisure and Sports Equipment, Lighting, Medical Equipment, Bulky Waste and Wires and Cables.

After completing the field activities, analysis and interpretation of the raw E-waste characterization data was conducted. The use of basic statistical tools (Percentages and Central Tendencies) was utilized in order to come up with the calculation of the E-waste composition in the waste stream of a highly urbanized city. The collected data and the outcome of the E-WACS were reviewed and recommendations were provided in relation to the top 5 determined E-waste categories.

3. Results

Through the conduct of the E-WACS, the study was able to gather the required baseline data of E-waste composition in Pasig City to represent the figures for a highly urbanized city. Figure 2 demonstrates the significant composition of each waste category following the pre-determined categorization from the SWM handbook. This also shows how noteworthy the amount of E-waste contributes in the solid waste stream of Pasig City. From the 261.44kg of average daily solid waste from the household and non-household cooperators, 1.65kg or 10.39% is composed of E-wastes. Moreover, E-waste ranks 4th among other waste categories.

![Figure 2. Illustration shows the percent composition of E-waste in the Pasig City’s solid waste stream.](image-url)

The daily domestic waste generation of Pasig City is 345, 127.24kg and out of that number, E-waste is 35,858.72kg which is represented by the 10.39% composition. Figure 3 illustrates the overall daily waste generation per person which is 0.35kg and in terms of E-waste generation, the amount is 0.04kg. The daily E-waste generation estimate was computed from the total household and non-household
population. In terms of the population count of Pasig City, there are 749,745 residents based on the 2014 Population Census conducted by the National Statistics Office [9].

Figure 3. The chart illustrates the overall daily E-waste generation and the generated E-waste per person per day.

After conducting the E-WACS, the study was able to determine the top-5 E-waste categories which comprise the solid waste of Pasig City as shown in Figure 4. The top E-waste category is the office and telecommunications equipment which comprises the 63.18% or 1.040kg of the average E-waste samples of the 41.751kg that was produced by both household and non-household waste generators. Examples of the collected telecommunication devices were cellular phones and accessories and telephones. Second in ranking are the household appliances with 0.348kg or 21.13% of the average E-waste sample. The collected E-wastes for this category were rice cookers, electric kettles, toaster, electric fan and radio.

Figure 4. Breakdown of the E-waste composition per specific category.
Third in ranking is the Lighting Devices with 0.135kg or 8.17% of the totality. The common lighting devices collected during the characterization activity were fluorescent bulbs, car signal lights, Christmas lights, solar lamps and LED lamps. Fourth was the consumer electronics and batteries category which is composed of 5.97% with 0.098kg of weight in average. The collected items for this category were DC batteries and regulators. The fifth category in the ranking is compose of wires and cables which comprises the 1.41% or 0.023kg of the average generated E-waste samples. Several collected items for this category were copper wires, earphone cables, cable adapters and UTP cable used for networking.

The analysis and characterization of the E-waste in a highly urbanized city was performed through the help of the guidelines and principles of the E-WACS. The E-WACS was deduced from the Waste Analysis and Characterization Study (WACS) which is the set of guidelines proposed by EcoGov and its LGU partners to develop a waste assessment and characterization procedures that meet the intent of RA 9003 but with the incorporation of E-waste in the methodology.

4. Discussion

E-WACS was performed with the following procedures: (1) Preparation and Training, (2) Actual E-Waste Characterization, and (3) Data Processing and Analysis. After executing these processes, the top 5 E-waste categories in a highly urbanized city were determined. The sole purpose of knowing this is to align the resolution strategies to be implemented by the governing bodies based on the current status of the E-waste in the locality. There were parameters which were not considered during the activity due to the assortment and variability of the solid waste components such as the volume composition; however, the main objective of the study was still met. The E-waste category in terms of its weight (in kilograms) was documented, the top 5 E-waste categories were determined and as well as recommendations in managing the top 5 E-waste categories were provided.

With the determination of the top 5 E-waste categories, the recommendations may be reviewed by the LGU of Pasig City and used as a guide to their future waste management plans. The concrete recommendation provided by the study is the Pasig City Waste Advantage Card shown in Figure 5; where consumers can exchange their E-wastes into points which will be stored in a card. The card can be used as privilege card wherein the cardholder can be prioritized to some of the offices of Pasig City.

**Figure 5.** Recommended process for the usage of the Pasig City Waste Advantage Card.
Moreover, card holders can also enjoy services such as – massage, health check-up, attend to concerts, etc. – given that they have adequate points in the card to redeem. Earning of points may vary depending on the junk shop prices. This information will be uploaded in the official online page of Pasig City. Cooperating junk shops will provide their pricing guide for the selected items on a weekly frequency for Pasig City to update the data base of the point’s conversion. Consumers should check the Pasig City’s online portal regularly to be aware of the updates being uploaded on the site.

The study also proposed another recommendation which is yet broader, expensive and needs involvement of renowned technology entities but may be a more effective solution for a long-term diversion of E-waste in the society. The suggested way is by conducting an Extended Producer Responsibility (EPR) Dialogue with technology manufacturers and companies. This is to encourage the technology players - either can be in manufacturing, servicing, and other related fields, in planning the retrieval and disposal of wastes within the city. Any action which may be implemented should follow the mandates of the EPR Act [10]. The steps to be conducted of the suggested method were provided in an extensive way since there would be specific activities which will be undertaken to materialize this insight.

5. Conclusions
Based on the results, income is a great contributor in the E-waste generation behavior of the households. The quality of every product is comparative to its cost and as well as the length of its functionality. It is determined that the household under the middle income class contributed significantly to the E-waste generated in the city. For barangay, the respondents under the middle income recorded 52.77% of the average collected E-waste. Hence, 59.76% was recorded for the subdivisions and 32.29% for the condominiums. Second to the middle income class in terms of E-waste generation is the low income class. This class contributed 18.89% for the barangay, 24.03% for the subdivision and 50.55% for the condominium in reference to the total E-waste generation per residential type. Ranked last is the class under high income. Its contribution is the least of the three class types where 28.34% was collected for the barangay, 16.21% for the subdivision and 17.15% for the condominium.

The interview results supported the assumption that consumers tend to buy high quality-based equipment and appliances if they have adequate money to purchase them. These devices have longer end-of-life compared to the low-quality ones which means that households would be able to use these devices in a long period of time. This can be the key reason why the high-income household class has the least E-waste generation rate. The middle-income household class tends to buy combinations of high quality and low-quality electronics due to the limited resources that they have; hence, they typically prefer the low-quality ones and just buy another to function as backup when the first one becomes defective. This may be the result in the increase in the generation of E-waste for this class. On the contrary, households with low income tend to buy low quality electronics. Due to lack of resources, they go to repair shops when these devices became defective. This method prolongs the life of these devices which might be the case why the E-waste generation of the household with low income comes second in the ranking.

These findings still need to be proven through thorough behavioral research and surveys to get the common denominator of their responses. Also, there are many other reasons of their methods in purchasing and disposing their wastes but what were enumerated above are the key takeaways from the house-to-house interviews conducted in this study.

6. Recommendations
A method of getting the volume of E-waste needs to be reviewed and be taken into consideration since the weight is only a portion that represents the entire data. The measurement of the volume will greatly help in the analysis to have not just a singular element for review in coming up with recommendations. The population or sample for the non-household sectors such as schools, industry, institutions, street sweeping and public market should have a margin and be streamlined so that outliers in the data will be prohibited and comparisons can be validated. Proper training needs to be steered for the E-WACS team prior to the activity for each member to be well oriented of the objective
and their roles in the analysis and characterization of the wastes. This should be well observed to avoid the waste of time and resources during and after the E-WACS activity to obtain accurate results. Consistent update to the point conversion system in the online Pasig City page related to the recommended initiative (Pasig City Waste Advantage Card) is needed to effectively notify the card holders about the junk shop prices and exchange rate of the recyclables and E-waste.

7. References

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